Collaboration, Coordination, and Computer Support

An Activity Theoretical Approach to the Design of
Computer Supported Cooperative Work

Jacob E. Bardram

Ph.D. thesis

Aarhus

May 1998

Summary

The present thesis presents a theoretical foundation for the design of Computer Support for Cooperative Work (CSCW).

Background

This thesis reports on work done within the Industrial Research Education (EF 577) established between the University of Aarhus, Kommunedata (KMD), and the University Hospital of Aarhus. The initial focus of the project was to investigate ways of supporting the extensive cooperation taking place within a hospital.

Objectives

The theoretical objective of this work is to apply activity theory as a theoretical foundation for CSCW research and to focus on the issue of *design* within CSCW. Furthermore, the applicable and developmental objectives of the Industrial Research project are to provide design *principles* as well as design *methods* for the development of computer support for coordination and cooperation within hospitals. These principles and methods can be applied at KMD in other software development projects.

Methods

The methodological basis for this project lies within the Participatory Design approach, as developed in Scandinavia. The methods applied within this project have been empirical, experimental, and theoretical. The empirical work has taken place within several hospitals in Denmark and has applied different qualitative methods, such as interviews and ethnographic workplace studies. The experimental work involves software design and construction, which has been developed and evaluated through extensive prototyping. The theoretical work includes literature studies of related work and investigation of activity theory as a possible candidate for CSCW research.

Contributions of the Thesis

The thesis establishes activity theory as a *theoretical foundation* for CSCW design. A framework for designing *collaboration artifacts* is presented and *methods* supporting the design of such collaboration technologies are developed, deployed, and evaluated. Six papers (of which 5 have been published) elaborate upon this theoretical approach to CSCW research. The papers illustrate how this theoretical foundation can be used to *analyze* cooperative work activities supported by computer technology, how it can be used to *design* collaborative computer technologies, and how it can be used to develop and understand *methods* for designing collaborative computer technology.

The applicable contributions of the present work also include several *design principles* for computer technological support for coordination and cooperation within a hospital setting. Proof of concepts of these design principles is made in the prototype called the PATIENT SCHEDULER, which has been evaluated in numerous design meetings with different healthcare workers.

Resumé (Danish Summary)

Nærværende afhandling præsenterer et teoretisk fundament for design af edb-støtte til samarbejde (eng.: Computer Supported Cooperative Work, CSCW).

Baggrund

Afhandlingen afrapporterer arbejder udført inden for rammerne af erhvervs-forskeruddannelsen (EF 577), etableret mellem Aarhus Universitet, Kommunedata (KMD) og Århus Universitetshospital. Den oprindelige problem-stilling for dette projekt var at undersøge måder hvorpå, man kunne understøtte det omfattende samarbejde, der finder sted på et hospital.

Formål

De teoretiske mål med dette arbejde er at anvende virksomhedsteorien som et teoretisk fundament for CSCW-forskningen og at fokusere på *design* inden for CSCW. Endvidere er de anvendelses- og udviklingsmæssige mål for er-hvervsforskerprojektet, at bidrage med *designprincipper* samt *designmetoder* til brug ved udvikling af edb-støtte til koordinering og samarbejde på hos-pitaler. Disse principper og metoder kan således anvendes i andre af KMDs software udviklingsprojekter.

Metoder

Det metodiske grundlag for dette projekt er funderet inden for den skandinaviske tradition for brugerinvolvering i systemudviklingen. Metoderne der har været anvendt i dette projekt har været empiriske, eksperimentelle, såvel som teoretiske. Empiriske undersøgelser har fundet sted på flere hospitaler i Danmark, hvor forskellige kvalitative metoder, såsom interviews og etnografiske arbejdspladsundersøgelser, har været anvendt. Det eksperimentelle arbejde har involveret software design samt konstruktion, som er blevet evalueret og udviklet gennem udpræget brug af prototype afprøvninger. Det teoretiske arbejde inkluderer litteraturstudier af beslægtede arbejder og undersøgelser af virksomhedsteorien som en mulig kandidat for CSCW-forskningen.

Afhandlingens forskningsmæssige bidrag

Afhandlingen etablerer virksomhedsteorien som et *teoretisk fundament* for design af CSCW teknologier. En begrebsramme til brug ved design af *samarbejdsartefakter* præsenteres og *metoder*, der understøtter designet af sådanne samarbejdsteknologier er blevet udviklet, anvendt og evalueret. Seks artikler (hvoraf 5 er publiceret) uddyber denne teoretiske tilgang til CSCW-forskningen. Disse artikler illustrerer hvordan dette teoretiske fundament kan anvendes dels til, at *analysere* edb understøttet samarbejde, dels til *design* af edb-baseret samarbejdsteknologi og dels til at udvikle og forstå *metoder* til design af edb-baseret samarbejdsteknologi.

De anvendelsesmæssige bidrag fra dette arbejde inkluderer endvidere flere *designprincipper* vedrørende computerteknologisk støtte til koordinering og samarbejde i et hospitalsmiljø. Disse principper er blevet anskueliggjort og bevist realiserbare gennem udviklingen af prototypen kaldet "the PATIENT SCHEDULER", som er blevet evalueret gennem adskillige designmøder med medarbejderne på hospitalerne.

Acknowledgments

I am especially indebted to the support provided by the steering committee for the project: Martin Sølvkjær, Susanne Bødker, and Nils Birkegaard, who made the whole project possible in the first place, and who provided invaluable support throughout the whole project. I want to thank Nils for his continuous support and help in bridging the gab between academia and 'realworld' software construction. I wish to thank my supervisor Susanne for talking me into doing this Ph.D. in the first place, and for her constant support in doing this work. And, I wish to thank Martin for creating the opportunity to do research within the hospitals.

I want to thank the numerous people engaged in the project at the different hospitals and departments involved in the project. I hope I have been able to give back something to these departments.

I also want to thank Jonathan Grudin, who invited me to stay 6 months at University of California at Irvine. At Irvine I had the privilege to participate in the work of the CORPS and Software Groups, and to discuss and present my work there.

I owe several people grateful thanks for their constructive (and patient) reading and commenting on a final draft of thesis. In alphabetic order: Thea Borgholm, Susanne Bødker, Andy Crabtree, Marianne Iversen, Kaj Grønbæk, Preben Mogensen, Christina Nielsen, and Henrik Røn.

Finally, but not least, I want to thank the people in the DEVISE group at the

Department of Computer Science at the University of Aarhus. As John King once said: "If you want to do high quality research, then position yourself among people who do high quality research." I have been fortunate enough to be in such a position – time will tell, whether I have done high quality research.

Contents

II 101

List of Figures

Overview of the Thesis

This thesis consists of a collection of five published papers, one submitted paper, and an introductionary part, which provides a background and overview of the present work. The thesis is divided into two parts: part one provides an overview of the problem addressed, presents the empirical and theoretical background for the work, and sums up the conclusions. Part two consists of the included papers.

In part one, **chapter 1** introduces the Industrial Research Education, which forms the background for the present thesis, and subsequently presents the research objectives and approach. **Chapter 2**, "Empirical Background", presents the SAIK project, which is a Danish abbreviation for "Collaborative Informatics in Clinical Practice". The chapter outlines the methods applied, and presents the PATIENT SCHEDULER, which is the prototype developed during the project. **Chapter 3**, "Activity Theory and Design" motivates the use of the human activity approach as a theoretical foundation. The chapter outlines the human activity theory, focusing on its applicability for understanding cooperative work and shows how my theoretical work extends from the work of other activity theorists. **Chapter 4**, "An Activity Theoretical Approach to CSCW", presents a theoretical approach to understanding cooperative work practices as mediated by computer artifacts. The chapter discusses the notion of coordination and presents the notion of a collaboration artifact. **Chapter 5**, "Designing for Collaborative Activities", sums up the consequences for designing computer systems for cooperative work. This summary is based on the theoretical understanding of activity theory and the experiences from the SAIK project. **Chapter 6** concludes part one, outlining the main achievements of the present thesis, and possible directions for future work.

In general, scientific work of others that is related to the present thesis is *discussed throughout part one in relevant places.* Hence, the thesis does not contain a chapter entitled "Related Work" as such, because I have found it more valuable to cite the work of others where it is relevant.

Part two consists of the six papers included in the thesis. They are included in their original form (including the original British English spelling in the first paper), only the layout has been changed to make a coherent graphical appearance. Publication details can be found after this overview. References to these papers in the first part of the thesis are made by using square brackets, i.e. "[...]".

Paper 1: Organisational Prototyping: Adopting CSCW Applications in Organisations

This paper presents the design method called "Organizational Prototyping" and discusses how it facilitates a process of adopting computer technology within an organization. Adoption is discussed as a dual process of adapting both the computer technology to the work and adapting the organization of work to the technology. Based on empirical work done within a large engineering company Organizational Prototyping (OP) is discussed and the paper concludes by giving practical guidelines concerning; *who* should participate in such an OP session, *when* in the design process OP should be applied, how the *work practices* should be approached in an OP session, and what role the *prototype* plays in an OP session.

Paper 2: Organizational Prototyping: Adopting CSCW Applications in Organizations

This short paper discuss the use of Organizational Prototyping (OP) within a hospital setting. The paper initially presents the OP method (as in [1]) and then discusses two cases of using OP in the SAIK project. These two cases were initiated in order to investigate the potentials and limitations of two rather bold design ideas: (i) sharing resources for directly booking examinations across departmental boundaries, and (ii) planning future examinations and operations according to a workflow model. One of the direct outcomes of the last OP session was a re-construction of the work practices concerning

planning of operations at a surgical department.

Paper 3: Plans as Situated Action: An Activity Theory Approach to Workflow Systems

This paper presents activity theory as a foundation for CSCW research. In order to illustrate the strengths of activity theory, the paper addresses one of the most topical theoretical issues within CSCW: the status of plans in work. This issue is rather fundamental because the whole notion of workflow and its associated technologies rely on the idea that plans hide work. The paper demonstrates how activity theory solves the "planning paradox" of CSCW and how this insight can be applied to design computer technology embedding plans for work.

Paper 4: I Love the System – I just don't use it!

This paper uses activity theory to analyze work practices within a hospital. Special attention is given to understand the work practices supported by computer technology and to compare this with the same type of work practices not supported by computers. The paper presents and discusses the variety of strategies that healthcare professionals have adopted in order to coordinated their widely distributed activities.

Paper 5: Scenario-based Design of Cooperative Systems

This paper presents the methods of Scenario-based Design and Analysis Patterns, which were developed and used in the SAIK project. It describes how collaborative scenarios can be used in the design of cooperative computer systems and what such collaborative scenarios should contain. The paper concludes that such scenarios were useful in bridging the gab between understanding collaborative work practices through field studies, and designing collaborative computer systems.

Paper 6: Temporal Coordination: On Time and Coordination of

Collaborative Activities at a Surgical Department

Based on activity theory, this paper discusses temporal aspects of coordinating work. Activities always take place in time, and coordination of such activities hence always has a temporal aspect to consider. Thus, time plays an important role when designing computer support for coordination. Based on in-debts studies of the socio-temporal aspect of coordination of cooperative work at hospitals, the paper defines and explores the notion of *temporal coordination*. This definition helps identify some of the highly intertwined temporal problems, constraints, interests, and conflicts, which arise when work unfolds in time. The paper concludes by pointing to the benefits of applying computer technology for temporal coordination.

References to Papers Included in the Thesis

1. Bardram, Jakob E. (1996): Organisational Prototyping: Adopting CSCW Applications in Organisations. In *Scandinavian Journal of Information Systems*, vol. 8, no. 1, p. 69–88.

2. Bardram, Jakob E. (1997a): Organizational Prototyping: Adopting CSCW Applications in Organizations [Position paper for workshop on "Introducing Groupware in Organizations" at CSCW'96]. In *SIGGROP Bulletin*, vol. 18, no. 3, p. 41–45.

3. Bardram, Jakob E. (1997b): Plans as Situated Action: An Activity Theory Approach to Workflow Systems. In *Proceedings of the 5th European Conference on Computer Supported Cooperative Work (ECSCW'97)*, Lancaster, UK. Kluwer Academic Publishers, p. 17–32.

4. Bardram, Jakob E. (1997c): I Love the System - I just don't use it! In *Proceeding of GROUP'97, ACM Conference on Supporting Group Work*, Phoenix, Arizona, USA, New York: ACM Press, p. 251–260.

5. Bardram, Jakob E. (1998a): Scenario-based Design of Cooperative Systems, In *Proceedings of the 3rd International Conference on the Design of Cooperative Systems (COOP98)*, Cannes, France.

6. Bardram, Jakob E. (1998b): Temporal Coordination: On Time and Coordination of Collaborative Activities at a Surgical Department. Paper submitted to the *Journal of Computer Supported Cooperative Work*.

Part I

Chapter 1

Introduction

The present thesis addresses the design of computer systems supporting co-operative work. The thesis is based on work within an Industrial Research project and this chapter presents the background, objectives, and approach of this research project[1].

1.1   Background and Motivation

The initial problem setting for this Industrial Research project was to investigate ways of designing computer support for the cooperative work taking place within Danish hospitals. From a societal perspective this is a highly topical question, and something which has been drawing increased attention from healthcare authorities, hospital management, IT suppliers, and from the media and press in Denmark. The highly influential "Dybkjær report" (Dybkjær & Christensen, 1994), for instance, states as the 10th principle that the Danish society must *"aim to exploit the outstanding possibilities within the area of health for better service and more efficient and quicker patient treatment by the use of IT for communication and registering of personal and clinical data."* The empirical research was to be situated in the University Hospital of Aarhus, which is the third part in this Industrial Research

---

[1]This chapter resembles the Final Education Plan for the Industrial Research Education for EF project no. 577 as formulated in December 1995.

3

project.

For Kommunedata (KMD), the industrial partner in this project, designing computer support for cooperative activities within hospitals is of central importance to their core business. KMD's Green System (GS) is the most widely used Hospital Information System in Denmark, but its support for cooperation and coordination between departments and hospitals has not been exploited to its full potential. Furthermore, KMD's recent uptake of creating Electronic Patient Records has created the need for KMD to extend its domain from the administrative aspects of hospital work to include clinical work. This has created a need for KMD to understand and design for the intense cooperation taking place between the numerous healthcare professionals involved in patient treatment and care.

From a scientific perspective, the design of computer systems supporting intense cooperation and coordination of work within complex organizations has drawn increasing interest during the last decade. The research field of Computer Supported Cooperative Work (CSCW) emerged during the 80s as a multi-disciplinary community trying to understand the use and design of computer technology for complex cooperative work setting, drawing on related research disciplines such as computer science, informatics, information systems research, human-computer interaction, psychology, sociology, etc.

The community of CSCW has primarily been made up of experimental computer scientists and sociologists. The former have been creating experimental computer prototypes, illustrating how distributed computing can be utilized to support cooperative work activities, and the latter have been investigating the subtle detail of cooperative work within organizations, and how it is affected by computer technology. This separation between experimental computer scientists and sociologists has been referred to as the "great divide" of CSCW (c.f. COMIC D2.1; Bowker, et al. (eds.), 1997). The community of CSCW has not been especially focused on the issue of design, or in other words, focused on the process of getting from one side of the division to the other. Within the numerous workplace studies made within CSCW it is often argued, that one of the main strengths of an ethnographic approach is that detailed analyses of social work can provide rich material on which to base recommendations for the design or re-design of a computer system. However, there is a big distance from having a good understanding of existing work practices to creating design solutions for a future computer system, which is

intended to *change* these work practices.

Another recurrent problem of CSCW concerns the whole notion of the term in the first place – nobody seems to agree upon a common definition of CSCW (Bannon et al., 1988; Bannon, 1993; Bannon & Schmidt, 1991; Hughes et al., 1991; Kling, 1991; Grudin & Poltrock, 1997). Because we do have a pretty good idea of what is meant by "computer support" this confusion mostly lies in an understanding of what is meant by "cooperative work". And, as argued by Bannon and Schmidt (1991), as long as we intend to support "it" with computers, it probably would be a good idea to know what we are talking about, as certainly at present the label "cooperative work" seems to be applied to just about anything. This lack of a common notion of "cooperative work" stems from the agglomeration of communities involved in CSCW, and even though this in itself might not be a problem – this diversity of background might even be advantantageous, as argued by Bannon (1993) – it still leaves problems in fostering an internal and external discourse of ideas, which the term CSCW is dedicated to.

1.2 Research Objectives

Summing up on the discussion above, we can identify the following scientific, developmental, and applicable objectives for the Industrial Research project, as described in the Final Education Plan.

1.2.1 Scientific Objectives

The scientific aim of the project is to provide a *theoretical foundation for the design of computer systems, which support cooperative work*. This theoretical foundation should on one hand help us address the notion of "cooperative work" and how this work, and the people engaged in this work, can be supported by computer technology. On the other hand, this theoretical foundation should incorporate a *design focus*, in order to help bridge "the Great Divide" in CSCW. An important part of achieving this goal is to provide practical design methods, which address the special problems within the design and evaluation of CSCW applications.

1.2.2   Developmental Objectives

KMD is currently in the process of porting the Green System into a client-server architecture. By looking into the nature of cooperative work and at the same time making prototypes for supporting this collaborative work, this Industrial Research project is an input for the design and implementation of the different client applications which provide the necessary support for collaboration within the distributed work at a Danish hospital.

1.2.3   Applicable Objectives

The knowledge obtained through the investigation at the University Hospitals will be integrated directly in relevant development projects at KMD. The two central projects are the re-design of the Green System and the design of Electronic Patient Records.

1.3   Research Approach

The research approach taken in this work is both empirical, experimental, and theoretical, and the work done within the project has been a continual alternation between these three ways of approaching the problem. This research approach aligns with the research tradition within the DEVISE center at Aarhus University, as evident in other scientific dissertations from this institution (e.g. Bødker, 1991; Grønbæk, 1991; Mogensen, 1994; Kyng, 1996; Christensen, 1992; Sørgaard, 1988b) and projects undertaken recently. For example, the AT project (Bødker et al., 1993), the EuroCODE project (Grønbæk et al., 1993; Grønbæk et al., 1997; Kyng, 1995), and the Dragon project (Christensen et al., 1998).

The empirical background for this thesis has a double origin. Firstly, the design of computer support for cooperative work has been taking place within a hospital setting in Denmark. This design project – called the SAIK project – has focused on a re-design of the Green System's support for cooperation within hospitals. The SAIK project is described in greater detail in the following chapter. Secondly, at KMD the SAIK project has been viewed as

a pilot study, trying out new design methods and techniques in their design practices. Hence, an important part of the empirical background for the present work is the use of the presented methods and techniques for design in the re-design of the Green System at KMD.

The need for an experimental approach in research on design of computer systems originates in the very nature of the activity of design. Design is inherently a practical endeavor and in order to understand design it is necessary to *explore* and *do* design. This experimental approach to understanding design aligns with the methodological position of the Participatory Design (PD) tradition, within which this work is rooted. On a methodological level of research, the basic theme for PD has been described by Kyng in his doctor scientiarum dissertation (1996) as "an insistence on concrete experiences as the basis for theoretical work – both within research and system development" (p. 30). Hence, action research and experimental system design projects has been the prevailing research methods within PD, and for this project as well.

Even though this thesis is based upon an extensive empirical research of hospital work practices, as well as considerable practical design and software construction, the focus of the present thesis is on providing a *conceptual foundation* for the design of computer support for collaborative work activities. A scientific approach to design must apply and/or develop specific concepts, which are relevant and useful in doing design. But what, then, does such a conceptual foundation address? It has to address the 'thing' we are designing, which, in this case, is computer technological support for cooperative work. Based upon activity theory, this thesis develops such a conceptual framework providing an understanding of human collaborative activities and how these activities are mediated by artifacts.

It is, however, important to understand what is meant by 'theory' here. Activity theory views theories (including itself) as special kinds of artifacts (cf. Kaptelinin, 1996). According to this view, the presented activity theoretical framework is what Jensen (1989) calls a "theory-in-practice". This means that a theory is to be judged upon its contribution to a systematic expansion of possible actions within a particular practice. The crucial question is not whether the theory provides an 'objective representation' of reality, but whether the particular practice in question can be *informed* – in the original sense of the word of 'give character or form to' – by using the general

7

propositions of the theory. Hence, the relevant question to ask is whether the practices concerning the design of computer support for cooperative work have been, or can be, informed by the presented activity theoretical framework, and in what way. The scientific aim of this thesis is to demonstrate, that the presented conceptual framework have helped inform the design made within this project, and hence hopefully can inform other design endeavors as well.

Chapter 2

Empirical Background

This chapter describes the empirical work that I have done in this Industrial Research project. This empirical work has been named the SAIK project (see also Bardram & Sølvkjær, 1996). SAIK is a Danish abbreviation for "Collaborative Informatics in Clinical Practice." (In Danish: "SAmarbejdsInformatik i Klinikken"). The chapter describes the SAIK project, outlines the methods used within this research, and describes the prototype developed in the project – the PATIENT SCHEDULER.

2.1 The SAIK Project

The objective of the SAIK project was to investigate how network-based computers could improve cooperation and coordination of patient treatment, across professional and departmental boundaries within hospitals. The project had two main strands: (i) ethnographic inspired workplace studies of the co-operative nature of work within hospitals, and (ii) a participatory design process developing the PATIENT SCHEDULER.

2.1.1 Background: Hospitals in Denmark

Resembling the development in other western countries, the hospitals in Denmark have undergone substantial centralization and specialization within the

last 30 years – a process that has not peeked yet[1]. The centralization has lead to fewer but larger hospitals, with more and bigger departments. The specialization has been characterized by extensive functional specialization, segmentation of professional positions and roles, and separation in both space and time (Vallgårda, 1992). This centralization and specialization is a result of an urge to concentrate the knowledge and research within the different areas of medicine, to make the treatment and care more effective, and to utilize the increasingly expensive equipment (e.g. radiology equipment) necessary for making new treatments. The specialization is reflected in the organizational structure of the hospital, which consists of departments functionally divided according to the medical specialization, which again often is divided according to the human anatomy. Such specialization, segmentation, and separation makes medical work inherently distributed among many healthcare professionals within different departments. This distributed nature of medical work in turn creates a need for extensive coordination in space and time, among the many activities involved in patient treatment and care, and among various other activities within and outside the hospital.

At the University Hospital of Aarhus these problems of specialization, segregation, and increasing coordination overhead have been approached by trying to implement the concept of a "Patient Focused Hospital" (PFH). The core idea in PFH is that the general focus on specialization is inefficient and costly, and following Gailbraith (1973) it is argued that an effective way of meeting information needs is to reduce the need to process information through the creation of self-contained organizational units (Louw, 1996). A significant new way of viewing healthcare is to replace the emphasis on specialization and centralization with the notion of multi-skilling, cross-training, and de-centralized centers of treatment and care according to the illness of the patients, instead of the specialization of the doctors. At the University Hospital of Aarhus the SAIK project was viewed as an opportunity to inves-

---

[1]As these words are being written, a new governmental proposal has just been put forth for further centralization of the hospital sector in Denmark. This has immediately coined a heated debate in the press and media between advocates and opponents of the idea. The arguments used in the debate resembles in great detail the arguments used historically, as described by Vallgårda (1992). The arguments for centralization concerns economy of scale, efficiency, better opportunities for research and medical specialization, and thereby better treatment of special deceases. The arguments against concern the well-beings of patients, their ability to have visits from family and relatives living nearby, and that most (80%) of all deceases are so trivial that small distributed hospitals easily can handle them.

tigate the possibilities for better collaboration using computer technology, and to incorporate IT in the re-organization of work according to PFH ideas. Furthermore, spin-offs in term of work process analysis and improvements were expected as well.

2.1.2 Activities

The purpose of the SAIK project was to investigate how coordination and planning of patient care happens today – both with and without computer support – and based on these investigations to suggest how this coordination can be supported by computer technology. The PATIENT SCHEDULER (PS) is a prototype that illustrates how this coordination of healthcare work can be supported by computers. The SAIK project took place over a period of two years, involving five different hospitals in Denmark. The scope of the investigations is illustrated in figure 2.1. There are four characteristics of the

Strand	Type of Departments
Field studies: • 5 hospitals, • 11 departments	• Medical departments: Wards and outpatient clinics • Surgical departments: Wards, operation theaters, outpatient clinics • Radiology departments • Microbiology laboratory • Oncology radiation clinic • Hospital porters
Participatory De-sign: • 2 hospitals • 3 departments	• Medical department: ward + outpatient clinic • Surgical department: ward + operation theaters • Radiology department

Figure 2.1: The scope of investigations in the SAIK-project.

investigations of cooperative work made in the SAIK project:

1. Cooperation is investigated both *within* and *across* departmental boundaries

2. As a way to *generalize* the obtained experiences, studies were made

11

at different hospitals and types of departments in order to understand differences and similarities

3. *Longitudinal* studies of the same setting was made over a longer period of time

4. Due to the goal of re-designing the Green System (GS), special emphasis was put on investigating how the present version of this system was used. For the sake of comparison, these studies of work practices supported by GS were supplemented with studies of the *same* type of work practices, *not* supported by GS.

These four characteristics also describe where the SAIK project differs from other CSCW research projects done within hospital settings (Bjerknes & Bratteteig, 1988; Egger & Wagner, 1993; Schneider & Wagner, 1993; Symon et al., 1996). The investigations made in the SAIK project do not consider the cooperation and coordination solely within one department, such as a surgical clinic in Austria (Egger & Wagner, 1992) or a radiology department in the UK (Symon et al., 1996), but look at the coordination of work *between* the distributed service departments and clinics within a hospital. Hence, when Egger & Wagner (1992) state that "the event 'surgical operations' ends with [. . .] the patient's transport back to the ward or an intense care bed (*whose availability has to be ascertained*)" (p. 161; my emphasis) this ascertaining of intense care beds is within the range of the cooperation investigated and designed for in the SAIK project. As I have argued extensively [4, 6], it is exactly this coordination across departmental boundaries which is the crux in coordinating patient treatment in hospitals, and hence poses the greatest challenges in the design of computer support for collaboration.

The intention to obtain generalized experiences across several types of hospitals and departments had two reasons; first the Green System has to be used at all hospitals in Denmark, and second, the design has to be "sensitive" to the work in both ends of the cooperation between departments. It was therefore crucial to understand the workings of the different types of departments; the aim was not to design computer support for work in one department alone (e.g. at a ward), but to design computer support that could be used across several departments. It was necessary, however, to limit the participatory design process to 3 departments, each representing the major

types of departments within any Danish hospital: a medical department, a surgical department, and a radiology department.

The third characteristic reflects that the SAIK project has been investigating the same setting (a medical department) over a period of one and a half year in total. Even though the primary focus of the present thesis is not to understand the development and change of work practices over time, this longitudinal setup has provided a necessary foundation for understanding the dynamics of cooperative work (Bardram, 1998).

The fourth characteristic of the SAIK project was its emphasis on re-design of existing technology. Traditionally, design has not been especially concerned with investigating existing technology. Today, however, most organizations already make heavy use of information technology, and computers are, as such, an intrinsic part of most work practices. Approaching design as re-design stresses a concern for investigating the problems with, and benefits of the existing system as a starting point for further development.

2.2 Methods for Design

The SAIK project was carried out as an experimental system design project, trying out new as well as established ways of supporting the design process. The methods used can be divided into three groups: qualitative methods for understanding cooperative work, design methods for creating visions of future computer support based on an understanding of the present work, and object-oriented methods for modeling and creating the computer system.

2.2.1 Qualitative Methods

Understanding the users' work practices is clearly a pre-condition for designing computer systems. This has been emphasized extensively in the tradition of Participatory Design as evident in the "Design at Work" book (Greenbaum & Kyng, 1991) and in the MUST method, which relies on ethnographic approaches to understanding work practices (Kensing et al., 1996). In the SAIK project qualitative methods were the methodological basis for investigating the work at the different departments and hospitals. Furthermore, as

stated above, an important part of re-designing the Green System involved understanding the benefits and problems of the existing version. Qualitative methods were used for this purpose as well [4].

Traditional qualitative methods, such as semi-structured interviews with subsequent transcription were used (Patton, 1990). Furthermore, inspired by the extensive focus on ethnographic workplace studies as the basis for CSCW design, the bulk of the investigations were carried out as detailed workplace studies[2]. This involved participant observation, in-situ question-asking, the investigation of written documents and other artifacts, the study of specific work-settings, patterns of communication and coordination, photographic and video recording, etc.[3] Most of this participant observation was done in a white coat.

2.2.2   Design Methods

A central methodological focus in the SAIK project, has been to try to combine methods of understanding with methods of designing. Hence, emphasis was put on describing the insights obtained during the workplace studies in ways, in which such descriptions could become useful in the design of computer support. For this purpose, the work practices in the different departments were documented using *scenarios*[4], which later were directly used to support design decisions and hence constituted the design rationale for the PATIENT SCHEDULER [5]. However, these scenarios were not only used in design but also in different PD sessions with users. Hence, scenarios describing different cooperation and coordination problems were used as a background

---

[2]The word 'inspired' is important here. I do not by any means claim that I have been doing ethnography. Field studies within ethnography takes years and ethnographers are trained in doing this. Furthermore, ethnography is not about data collection, but about representing the observations grounded in the empirical data (c.f. Anderson, 1994; Strauss & Corbin, 1994).

[3]References to descriptions of ethnography, which has provided the background for the work done in the SAIK project includes: Anderson (EEM), Blomberg et al. (1993); Strauss & Corbin (1994); Hodder (1994); Jordan (1996); Hughes et al. (1994); Suchman & Trigg (1991); Sommerville et al. (1993); Vidich & Lyman (1994).

[4]Normally the work scenarios is used to denote hypothetical descriptions of future work practices. However, I use the word scenario to cover descriptions of concrete instances of current work practices as well.

for future workshops (Kensing & Madsen, 1991). Furthermore, scenarios were used in different prototyping sessions (Bødker & Grønbæk, 1991) where the scenarios together with the prototype documented new work practices. However, traditional prototyping sessions normally address single-user situations, where the designer cooperates with one user concerning the applicability of the prototype for certain work practices. Since the aim for the present work was to design for collaborative work settings, a new prototyping method – called organizational prototyping – was developed and applied twice in the SAIK project [1,2].

2.2.3 Object-Oriented Methods

Object-Oriented methods were used in the SAIK project to create the Patient Scheduler. In particular the Danish method of OOA&D (Mathiassen et al., 1993; 1995) was applied combined with inspirations from OMT (Rumbaugh et al., 1991). Object-Orientation is basically used to model the computer system. Object-Oriented Analysis (OOA) aims at "building a model of the object system, i.e. of the future users perception of their work practices." (Mathiassen et al., 1993; p. 11, my translation). OOA starts from a "precise, overall definition of a specific proposal for a computer system, expected to be present from a pre-analysis" (ibid.). Object-Oriented Design (OOD), on the other hand, aims at modeling the computer systems as such, i.e. the technical construction of software (Mathiassen et al., 1995). In other words, OOA models the computer system from the outside, OOD from the inside. There are some conceptual overlaps and confusions to watch out for here. The concept of 'design' in this thesis means to outline the overall structure and appearance of a computer system, and to address its future use and embedding within some organizational work practices. Hence, the use of the concept of 'design' in the present thesis does not align with the use of the concept in OOD. Design, as used in this thesis, points to activities taking place in what is called pre-analysis above and during OOA. However, more technical opportunities and limitations, normally. modeled in OOD, can influence the design of a computer system, and are therefore also considered in design activities.

As a pilot project trying to develop design principles for the design of cooperation at hospitals in Denmark in a more general sense, two ambitions were

central to the SAIK:

1. In order to create a system to be used at several hospitals in Denmark, it was important to *generalize* experiences obtained in the different hospitals involved in the project.

2. In order to inform the design of computer technology at KMD, it was important to be able to *reuse* the design principles in other projects at KMD.

To meet these objectives, the design of the anal version of the PATIENT SCHEDULER was documented using *Analysis Patterns* [5]. Analysis Patterns resemble the widespread use of Design Patterns in the OO-community (Gamma et al. 1995). But in contrast to Design Patterns, an Analysis Pattern is a solution to a recurrent problem within an *organizational* context, not within construction of software. An Analysis Pattern is an object-oriented solution that represents a common construction in some business modeling – in this case within hospitals as an organization (see also Fowler, 1997). The real-world problem, that each Analysis Pattern is attempting to solve, is represented as a generic scenario, which works as an inspiration for the analyst in the future. Examples of such generic types of activities are paper-based requisition of radiology examinations and scheduling incoming requisitions. These generic scenarios provided the background for extracting the general design knowledge embedded in the PATIENT SCHEDULER, which could be reused in other projects at KMD. The Analysis Patterns used in the PATIENT SCHEDULER are documented in Technical Report no. 4. The use of scenarios in Analysis Patterns, as suggested in [5], is new and it turned out to be a useful way to document OOA knowledge for later reuse. The idea of Analysis Patterns coupled with rich scenario descriptions are currently being adopted in other projects at KMD.

$$* * *$$

In total, 109 scenarios describing current work practices, 43 of these describing work practices surrounding the use of the Green System, and 23 scenarios describing future work practices were constructed. 4 future workshops were conducted. The PATIENT SCHEDULER went through 3 main cycles of iterations, involving 14 prototyping sessions and 2 organizational prototyping

16

sessions. 3 technical reports (numbered 2 through 4) have documented the design of the Patient Scheduler, the final report containing in total 12 analysis patterns.

2.3   The Patient Scheduler

The Patient Scheduler was developed during the SAIK project[5]. From a research perspective, the Patient Scheduler has primarily served three purposes:

1. Its design is the experimental and empirical foundation for the theoretical discussion on design, following this chapter.

2. As a concrete illustration of how cooperation and coordination within a hospital can be supported by computer technology, it has been an important vehicle for discussing new ways of organizing hospital work. The Patient Scheduler has thus been an important instrument in the experimental research approach taken in this research project

3. It has been an evolving crystallization of the design results obtained during the Participatory Design process at the hospitals, illustrating design solutions to some of the more difficult aspects of cooperation across departmental boundaries. Some of the design principles and rationales embodied in the prototype are now being applied in other projects at KMD.

Basically, the Patient Scheduler helps to plan patient treatment across professional and departmental boundaries through requesting, scheduling, and booking appointments for some action in the treatment of a patient. The Patient Scheduler is divided into 4 modules: (i) an *organizational module*, (ii) a module handling *communication*, (iii) a module handling *planning* and *scheduzing*, and (iv) a *sharing* module. Numbers in brackets refer to the numbers i figure 2.2 and names in `courier font` are the core analysis patterns in the OOA model.

---

[5]The Patient Scheduler is programmed in MS Visual Basic, runs under Windows 95/NT using a ODBC compliant database (either MS Access or MS SQL Server) as persistent store. It contains 31 forms (windows) and 9385 lines of source-code.
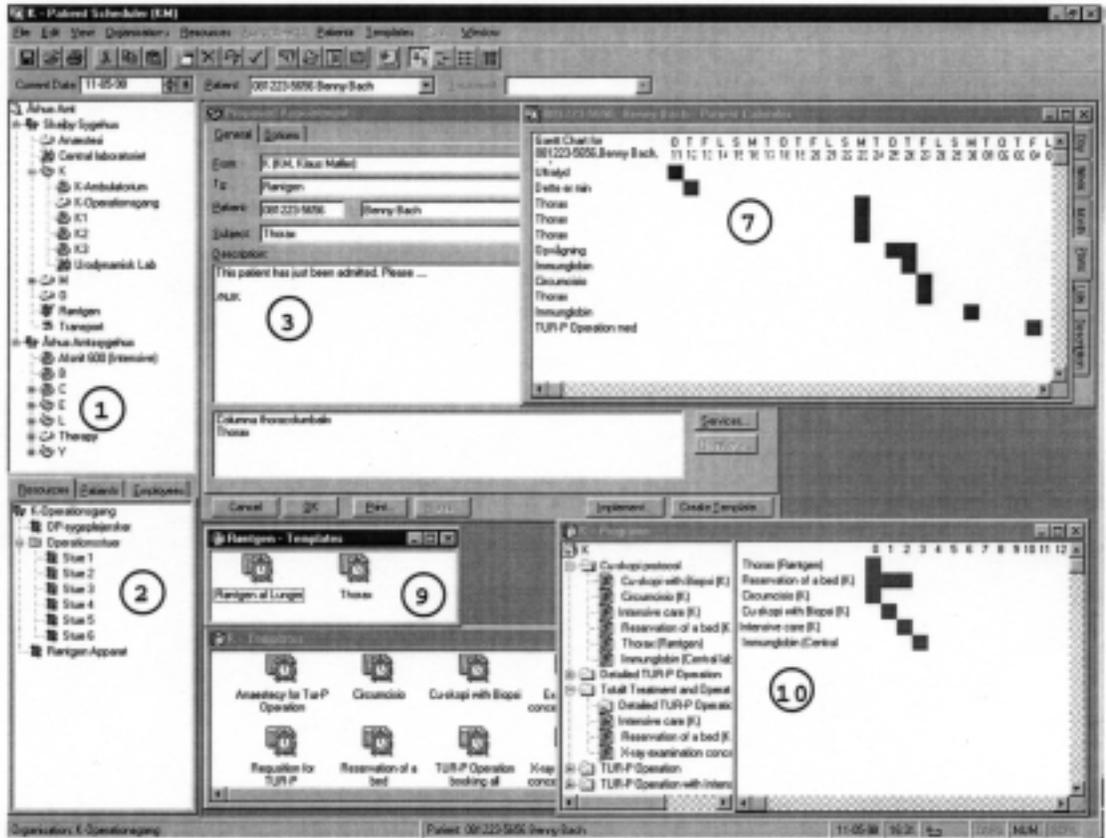
Figure 2.2: The PATIENT SCHEDULER. Typical workspace for a clinical (surgical) department (K).

The organizational module contains a hierarchy of `organizational units` (1), each of which "owns" a set of `resources`, and has `employees` and `patients` (2). Employees and patients are considered resources as well (they inherit the generic resource class). Resources are organized in hierarchical `resource groups`, and can either be a temporal resource, or a consumable resource. An organizational unit can perform certain `services`, each potentially linked to one or more resources needed to perform this particular service.

The communication module supports sending a request (termed a `proposal`) for a `patient appointment` from one organizational unit to another (3).

Depending upon the recipient, different services can be chosen. The sender can ask for different `notifications`, such as "Tell me if this appointment has not been scheduled before 12-03-98", and/or a suggested time for the appointment can be stated on the request. An appointment has three main stages: (i) proposed, (ii) implemented (or scheduled), and (iii) completed. Furthermore, a `note`, as an ordinary email message can be send between organizational units, or can be attached to appointments or other objects. In- and out-going appointments, notes, and notifications are handled in a `communication center` (4), with the ability to create a hierarchy of `folders` and to set up different kinds of `filters` – similar to many ordinary email systems.
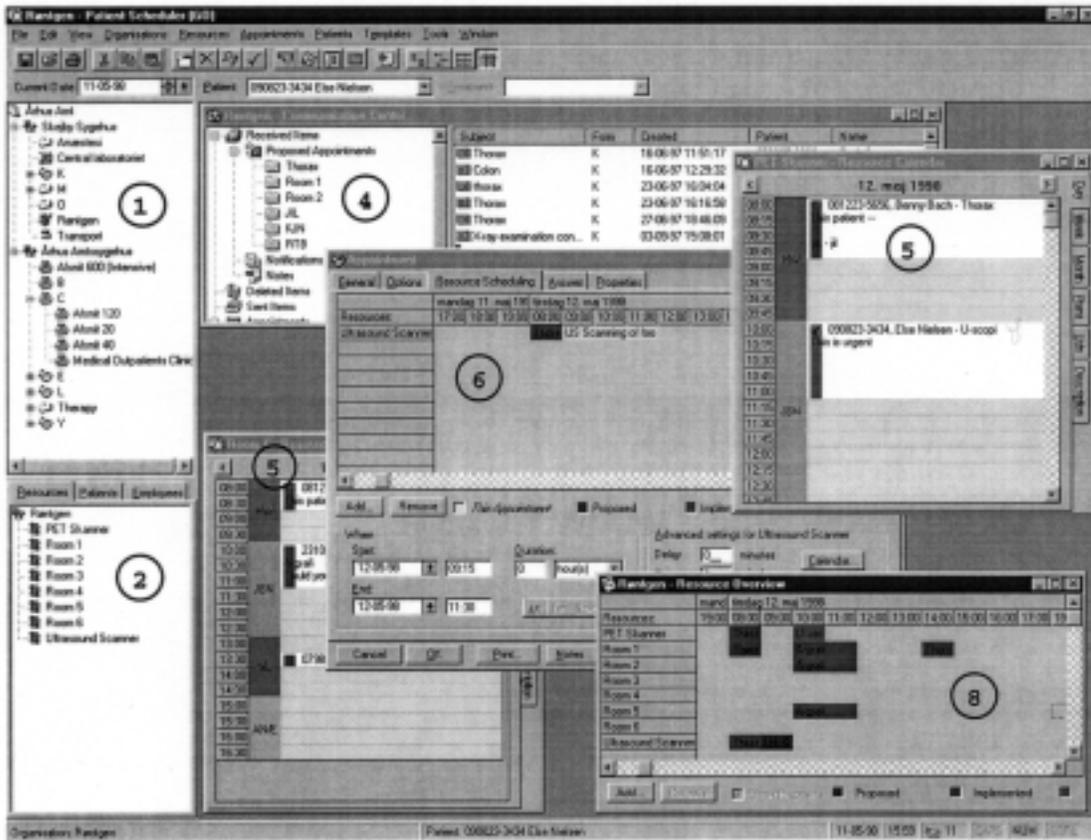
Figure 2.3: The PATIENT SCHEDULER. Typical workspace for a service (radiology) department ("Røntgen").

19

The scheduling and planning module helps the different departments to plan their work by scheduling in-coming and their own appointments on different `resource calendars` (5) made up of different `timeslots`. An appointment can be scheduled on several resources, and a `semi-automatic scheduling mechanism` helps the user to find a timeslot, where all selected resources are available (6). Each temporal resource has a calendar designed to support easy drag-and-drop scheduling and re-scheduling, and to support different kinds of overviews; day, week, month, Gantt charts. Treating the patient as a resource means that the patient has such a calendar as well, termed a `patient calendar` (7). Such a patient calendar turned out to be of big importance in the attempt to support the PFH ideas. Several resources can be compared and juxtaposed in a `resource overview` (8). The planning module also supports saving "best practices" through the creation of `appointment templates` (9) and `programs` (10). If a certain appointment has a recurrent pattern, a template can be made. For example, requesting an X-ray examination of the chest (Thorax) occurs frequently at any hospital, and a template containing all the details for this examination can be made and used whenever a Thorax examination is needed. These templates can be combined into a program, which is a list of appointment templates needed for a certain treatment. For example, an unraveling program for a diabetes patient is a list of X-ray examinations and laboratory tests that have to be made in order for the physician to diagnose the degree of diabetes.

The sharing mechanism of PS lets the owner of a certain object (resource, timeslot, note, appointment, folder, etc.) specify the level of access (none, view, read, write, delete) for different users and/or organizational units. Three important types of objects are shared in PS: (i) resources, (ii) folders, and (iii) templates and programs.

If a department owning a *resource* has granted a user (or the user's organizational unit) read-access to it, the user can look into the resource's calendar and pick a spare timeslot, and send a proposal to have this slot. If the user has write-access, (s)he can schedule the appointment on his/her own. This kind of "directly booking" on other department's resources turned out to be an extremely efficient way of coordinating work across departments, but also a form of cooperation which touched upon deeply-rooted political issues

within hospitals in Denmark (c.f. [2, 6])[6].

Sharing *folders* in the communication center enables an efficient cooperation within a department, resembling much the way cooperation is achieved without computers. Placing appointments and notes in a specific folder, is a message for someone to take over the case.

Sharing of *templates* and *programs* enables a department to 'publish' templates and programs to be used by other departments. Hence, instead of having each department within a hospital creating their own Thorax template, they can use the Thorax template published and shared by the radiology department. This has the positive effect that the template is made and maintained by the ones that have to attend to the proposals made by applying the template, thereby enabling them to specify how an examination should be requested. However, in order for other departments to use a template provided by e.g. the radiology department, they cannot 'take' or copy the template and use it in their programs – then it would not reflect the changes made to the original template, and the benefit just described would vanish. Therefore, they need to refer to the template. Thus, a program is actually not made up by templates but is made up by `template references` to templates. Similar, programs can be shared, and a template reference can point to another program. Hence, programs are hierarchical and can contain programs within programs, some of the programs belonging to your own department, others to other departments.

---

[6]Danish healthcare authorities and IT vendors have, however, an increasing awareness of the benefits of using systems for electronic booking within hospitals, and in the healthcare sector in general (Sundhedsministeriet, 1998).

Chapter 3

Activity Theory and Design

The aim of this thesis is to provide a theory about computer support for cooperative work as a part of a theory of human work activities. For this purpose activity theory is especially well suited. Firstly, because activity theory provides an philosophical framework for understanding collective human work activities as embedded within a social practice (e.g. an organization), and mediated by artifacts, including computer-based artifacts. Secondly, by building on a dialectical notion between doing and developing work, activity theory provides a foundation for understanding both the dynamics of cooperative work changing over time, and for understanding changes in work caused by employing new technology. Thirdly, because extensive work within understanding design of computer artifacts from an activity theoretical perspective has already been done, the present framework for CSCW fits into, and builds upon, this existing work. From a design perspective I find this latter argument for using activity theory especially important. By using activity theory in the design of collaborative computer systems, shifts between reflecting upon issues of the user interface, issues concerning the support for cooperative work activities, or issues concerning the design process can use the same conceptual basis. This in turn enables the design practitioner to overcome the artificial segregation of design in different research fields and to work with the same conceptual basis whether addressing collaboration support or user-interface design.

This chapter starts with a short review of the existing work using activity theory for conceptualizing the design of computer artifacts. This review fo-

cus on pointing out where my work extends this previous work. This section is followed by a section that provides a basic introduction to activity theory in general, which is again followed by a section describing the activity theoretical understanding of cooperative activities. This last section introduces parts of activity theory that have not been introduced nor used within design of computer artifacts before. Finally, the presented activity theoretical approach to CSCW is related to relevant other scientific foundations suggested within CSCW.

3.1 Activity Theoretical Approaches to Design of Computer Artifacts

In a philosophical investigation into the nature of computer systems and human activity, Raeithel (1992) argues that the design of real-world software needs to incorporate a knowledge of how working communities regulate their joint activity, and that activity theory, as a social psychological theory on human self-regulation, is a well suited epistemological foundation for design. Applying activity theory to understand the activity of design itself has been made by Bisgaard et al. (1989), and Bødker (1991) has used activity theory to describe the design activity as an anthropological phenomenon. Bertelsen (1998) has applied activity theory to understand design artifacts, i.e. artifacts that mediate the design activity. The purpose of this thesis is, however, not to describe the design process as an activity as such, but to use activity theory as a theoretical basis for understanding the cooperative work activities, which we intend to support by computers.

The first step in providing an activity theoretical approach to computer design was taken by Bødker in her Ph.D. thesis from 1987 (published 1991). The focus of Bødker's work is on designing the user interface, and she provides a conceptual basis for understanding individual activity directed towards computer artifacts on the operational level, and for design of userinterfaces. This theoretical foundation for human computer interaction has been extended and refined by numerous other authors (c.f. Nardi, 1996a), including myself (Bardram & Bertelsen, 1995). This work, however, only focus on human-computer interaction as the operational part of an activity and is hence not sufficient to understand cooperative work activities supported by computers.

24

Kuutti has in his Ph.D. thesis (1994) provided an activity theoretical perspective on Information Systems (IS) and cooperative work. Kuutti provides 10 arguments why activity theory is a good foundation for understanding CSCW – "the concept of *work activity* fulfills nicely most of the demand stated for the basic unit of analysis, [. . . which is] needed in order to analyze a cooperative work situation for design purposes" (Kuutti, 1994; p. 50, 56). I shall not reiterate these arguments here, but kindly refer the reader to Kuutti's thesis. Unfortunately, however, Kuutti's work seems to reach an end before it gets really interesting in terms of providing a conceptual basis for the design of CSCW technologies. First, Kuutti argues himself (ibid., p. 57) that although activity theory obviously is a promising starting point when an analysis of new work situations is considered, it leaves much to be desired when it comes to detailed analysis of practical work situations. Kuutti mentions, for example, that activity theory has no description of the flow of work processes, no description of the resources available and the sharing of them, or no description of the division of work among actors as related to the object of the work. This limitation is, however, not completely true – it is only a limitation in the work of Kuutti because he relies solely on the work of the Finish activity theorist Yrjö Engeström and his work, especially his dissertation from 1987. In this thesis, I shall extend the work of Kuutti to provide a conceptual basis for a detailed understanding of collaborative work processes. Second, Kuutti's focus is purely to "*analyze* a cooperative work situation for design purposes" (ibid., p. 50; my emphasis). Hence, he provides no conceptual understanding of the benefits of computer artifacts in cooperative activity, nor does he provide any conceptual basis for designing such collaborative computer artifacts.

In summary, this thesis provides a theoretical framework for the design of computer support for cooperative work based on activity theory. In comparison to the work already done within activity theory and the design of computer applications this work is new and unique by providing a conceptual foundation for:

- analyzing *cooperative work activities* in detail, describing the different types of cooperation and the dynamic transition between these types (this chapter)

- understanding how collaborative work is *interdependent, coordinated,* and *mediated* by artifacts (chapter 4)

- a framework for understanding *collaboration artifacts* supporting collaborative work (chapter 4)

- how collaborative computer artifacts can be *designed* to mediate collaborative work activities (chapter 5)

This conceptual basis can be used to *analyze* how collaboration artifacts in general, and computer based artifacts in particular, mediate a collaborative activity, as it is done in [4] and [6]. It can be used to understand how to *design* collaborative computer systems, which transgress current limitation in conceptualizations on cooperative work and coordination, as it is done in [3] and [6]. And it can be used to develop *methods* for designing collaborative computer artifacts, as it is done in [1], [2], and [5].

3.2 Activity Theory: Some Basic Concepts

This section shortly describes the basic notions of activity theory.

Human activity:

The fundamental unit of analysis in activity theory is the human activity (Russian: deyatel'nost'). A. N. Leont'ev defines an activity as:

> "Activity is a molar, not an additive unit of the life of the physical, material subject. In a narrower sense, that is, at the psychological level, it is a unit of life, mediated by psychic reflection, the real function of which is that it orients the subject in the objective world. In other words, activity is not a reaction and not a totality of reactions but a system that has structure, its own internal transitions and transformation, its own development." (Leont'ev, 1978; p. 50).

The category of activity has to be viewed as a whole with its internal components and its specific dynamics. These internal components and dynamics cannot be analyzed separately without violating the very essence of human

activity. These components are: an *active subject* (S) who directs his activity towards an *object* in the world (O), *mediated* by an *artifact* or a tool (T). This schema is illustrated in figure 3.1.
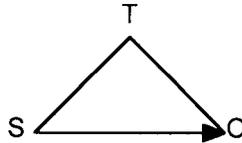
Figure 3.1: The basic structure of mediated human activity

Object-orientation of specific activity:

Every activity is specific and each activity is distinguished from one-another by their respective *objects*. It is the activity's object that gives it a specific direction, i.e. is the *objective* of the activity (Leont'ev, 1981; p. 59). The notion of object in activity theory is not limited to the physical, chemical, and biological properties of entities. Socially and culturally determined properties are also objective properties that can be object for an activity, and hence also be studied with objective methods. An example of a cultural object is the highly prestigious position as a neurosurgeon.

The object is connected to the *motive* of the activity, hence a person's activity is motivated by the object and we thus call the activity *object-oriented* (not to be mistaken for the programming paradigm). Becoming a neurosurgeon can hence be an motive for a medical student. There can be no activity without a motive: "Unmotivated activity is not activity devoid of a motive: it is activity with a motive that subjectively and objectively concealed." (Ibid., p. 59). This also means that people may not always be consciously aware of the objective of the activity in which they participate. This *subjective concealment* of the objective of an activity plays an important role in understanding why work for some people in an organization can become routinized.

Social embedding of human activity:

The purpose that Leont'ev had by introducing the concept of activity was, however, concerned with the social institutional milieu in which psychological processes occur. The concept of activity is fundamental social in this sense and hence provides an excellent foundation for a further discussion of cooperative work activities.

> "Human psychology is concerned with the activity of concrete individuals, which takes place either in a collective – i.e., jointly with other people – or in a situation in which the subject deals directly with the surrounding world of objects – e.g., at the potter's wheel or the writer's desk. However, if we removed human activity from the system of social relationships and social life, it would not exist and would have no structure. With all its varied forms, the human individual's activity is a system in the system of social relations. It does not exist without these relations."
> (Leont'ev, 1981; p. 47).

This social nature of human activity has been further elaborated by Engeström (1987), who in addition to the tool mediating the subject's activity towards the object, identifies two other mediators: (i) rules and norms mediating the subject's relation to the work community and (ii) a division of work mediating the community's relation to the object of work.

Mediation of human activity by artifacts:

The social nature of an activity also helps us understand the concept of an *artifact* and its role as both a mediator and a product of human activity. The concept of a mediating artifact originates in the work of Vygotsky.

> "Vygotsky identified two main, interconnected features [of human activity /jb] that are necessarily fundamental for psychology: its tool-like ("instrumental") structure, and its inclusion in a system of interaction with other people." (Leont'ev, 1981; p. 56).

28

This basic idea has several consequences in the analysis of human activity. First, tools are functional extensions of the human body ("functional organs") and hence shape the way humans interact with reality – "you see the world through your tool". This is true not only for the interaction with the world of objects but also with other people. Second, tools are developed in the course of activity. An artifact is made to mediate a certain activity and the mediating characteristics of an activity is therefore *crystallized* into these artifacts, and through use, the artifacts are continuously modified and shaped to meet the evolving changes of the activity. Third, this social embedded crystallization implies that a tool reflects the accumulated cultural-historical experiences of other people who tried to solve similar problems before and invented or modified the tool to make it more efficient and useful. This experience is accumulated in the structural (natural) properties of the tool (size, shape, and material) as well as in the knowledge of how the tool should be used, i.e. the tool's cultural-historical properties (Mammen, 1993). Fourth, by applying tools in activities, humans' activity assimilates the experiences of humankind (Leont'ev, 1981; p. 56). This last property of tool mediation is critical for activity theory, because it means that a person learns about the very essence of being a human being, namely the cultural-historical properties of the embedding social system, by applying its tools to mediate his or hers activity.

Vygotsky extended the notion of mediation by tools to mediation by signs. He specifically differentiated between technical tools and psychological signs where psychological signs are means of controlling human behavior – both one's own and others. Hence systems of signs mediate the coordination of one's effort with others and the self-regulation of the activity. There is thus an *instrumental* as well as a *communicative* side of any activity. When speaking of mediation, the term *sign system* are used rather than the term language, because it should encompass all kinds of human interaction, including indexical, symbolic, iconic, and conceptual communication (Wertsch, 1981; p. 24).

The structure of an activity:

One of the most important parts of Leont'ev's work was his analysis of the structure of the activity. Activity theory differentiates between three func-

tionally subordinated hierarchical levels of components: *activity* (Russian: deyatel'nost'), *action* (Russian: deistvie), and *operation* (Russian: operatsiya). The characteristics of the activity as motivated, object-oriented, mediated, and social have already been described. Actions are goal-directed processes that are carried out to achieve different results. These results then in turn realize the object of the activity and the actions are hence subordinated to the overall activity. The goal and result are for the action what the motive and the object are for the activity. For example, the request of an X-ray examination is an action in the diagnosing activity of the physician. Actions are conscious; people are aware of their goals. Goals can be broken into lower level subgoals, e.g. the request for the radiology examination can be broken into filling in a request form, handing it to the radiology department, and later on look for the result of the examination. As we shall return to, the actions that realize an activity might have internal dependencies and therefore have to be ordered in some sense. The activity and the action cannot be reduced to each other; they are genuinely different components that explain the activity at two different levels: the activity explains *why* the activity is taking place (the motive) and the actions explain *what* must be done to achieve this objective (the goals).

An action has its own components, namely the operations, which are the processes that carry out the action. This operational level of the activity explains *how* the activity is performed. Moving down the hierarchy from actions to operations we cross the border between conscious and automatic processes. Operations are carried out automatically accordingly to the *conditions of the situation* and thus do not have their own conscious representation.

Humans have a *repertoire* of actions and operations to apply in different situations and for different purposes. Hence, one and the same action can be instrumental in realizing different activities, and one and the same operation can be used in several different actions. For example, the radiology examination is used in the diagnosing activity as well as in the activity of monitoring the progress of a treatment. Similar, the operations necessary for filling in the order form are applied in many other circumstances. This means that the activity is *'content-free'* in the sense that it is not tied to a particular set of structural defined steps, but can be realized in many different ways (Wertsch, 1981; p. 20).

Another important aspect of this three-level hierarchy of an activity is the

constant transformation that takes place between its levels – both vertical and horizontal. An activity can loose its motive, whereupon it becomes an action. Conversely, an action can acquire an independent, energizing force and become an activity on its own. Actions transform into operations when they become routinized and unconscious with practice. The other way, an operation can be conceptualized into an action; either deliberately as a way of enhancing them (e.g. in athletics) or involuntary in "those cases in which the action is performed under conditions that make it difficult to carry it out with the help of operations that have been formed earlier" (Leont'ev, 1981; p. 66). This is what Bødker (1991) following Winograd and Flares (1986) calls a *breakdown*.

A fundamental characteristic of human actions is that "one of the actions involved in an activity in one situation may be considered to be an entire activity in another situation" (Wertsch 1981 p. 19). The analysis of activities depends on the subjective stance in the web of activities. Thus, for the intern assigned to provide a diagnosis of a patient this might be at the level of an activity, whereas for the senior physician in charge of the overall treatment, the diagnosing is but the first action in a long line of interdependent actions that he has distributed onto other actors within the hospital.

3.3   Distributed Collective Activity

So far we have looked at the activity of an individual person, his object, motive, tool, and how the activity is situated in some social setting, the community. This emphasis on the situatedness of the activity in a social context does not as such describe cooperative work activities – or collective activities as they are called in activity theory. This section describes how activity theory conceptualizes *distributed collectiue activity*. This has *not* been addressed in any design approaches based on activity theory. These lines are thus the demarcation between what has already been done within activity theory and design of computer artifacts and my conceptualization, as based on activity theory.

3.3.1 Collective Activity

The problems and theories of collective activity have especially been addressed by A. V. Petrovsky (1983; 1985) and D. A. Leont'ev (1992)[1]. The concept of a *collective subject* (Russian: *kollektivnyj subjekt dejatelnosti*), or co-subject, was introduced by Petrovsky to account for the processes of communication and coordination between individuals engaged in a collective activity (Kaptelinin, 1996). The strength of this conceptualization of collective activities is that they can be analyzed and understood along the same lines of activity theory in general:

> "Using this approach [the co-subject /jb], the general psychological conception of objective activity is expanded as a result of the inclusion of the concept of collective activity." (Petrovsky, 1985; p. 101).

Hence, we can identify the collective activity's components (motive-object, goals-results, and conditions); find the artifact(s) used to mediate the activity (both technical tools as well as sign systems for self-regulation); and trace the general development and transformation of the activity and its mediating artifacts. Furthermore, the concept helps us understand that a collective activity exists in a context of a community in general that shapes and defines the motive of the activity, and are potential producers of artifacts and consumers of products of the collective activity (Mammen, 1993).

Petrovsky's notion implies that the co-subject – which is made up of several individual subjects – must act as *one* subject. Hence, the involved subjects must act in common; they must have a *common motive* directed towards a common object of the work; they must have a common understanding of the sub-goals of the actions, and how they can be reached supported by different artifacts; they must have a common sign system, etc. The interaction and self-regulation of the collective activity is mediated by this common understanding of the activity, and is termed *activity-oriented interaction*. The explanatory potential of the concept of co-subject is though somewhat limited since there definitely are interactions that do not fall into the category of activity-oriented interactions between members of a team pursuing a common

---

[1]Please note that D. A. Leont'ev is not the same as N. A. Leont'ev. The former is the grandson of the latter.

motive (Kaptelinin, 1996). Petrovsky calls this 'strictly personal communication' and pays no further attention to it. The assumption about common motive is rather essential. Therefore, in order to make a clear distinction between personal and collective motives, I use the word *motive* to denote a personal motive, and *objective* to denote the motivation of a collective activity.

D. A. Leont'ev (1992) applies Petrovsky's notion of a collective subject to define the "elementary, irreducible, basic type of interaction between two participants in joint activity" (figure 3.2a). The model underscores that a collective activity both realizes subject-object relations, mediated by a second subject, and subject-subject relations (i.e. activity-oriented interaction), mediated by the common objective.
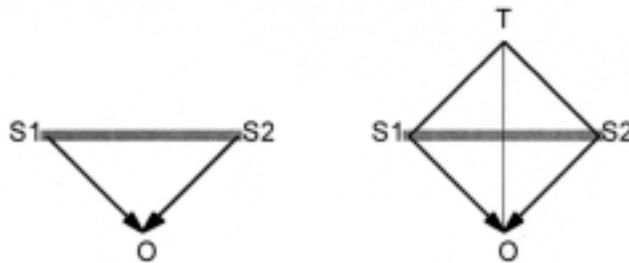
Figure 3.2: **a:** Collective joint activity realizing subject-subject and subject-object relationships. **b:** Collective activity mediated by a tool.

A collective activity is mediated, as illustrated in figure 3.2b (adopted from Mammen, 1993). The model illustrates the relationships between the different components of an activity. The objective (e.g. arriving at a diagnosis of a patient) is not just recognized in its immediate appearance for the subject (the physician), but is also, at the same time, recognized in relation to the tools available (e.g. the stethoscope or the X-ray picture). For example, if the diagnosis cannot be arrived by physical examination it might help to perform an X-ray examination. The objective is also seen in relation to other subjects. For example the diagnosis is written in a specific way (in Latin) in order to make it a precise instrument for fellow physicians even though it is pure nonsense for the patient. Hence the other subjects for the physician include in this case his colleagues but not the patient. Subject 2, the other subjects in a community, are not just immediately appearing subjects. They

are actual or potential consumers of objects, and they are actual or potential producers of tools. Hence the object and the tool mediate my relations with my fellow human beings (Mammen, 1993; p. 37).

3.3.2 Actions as the Main Component of Distributed Collective Activity

In activity theory the concepts of activity and operation apply for humans as well as animal psychology. However, the concept of actions realizing activities solely belongs to the human activity. As A. N. Leont'ev writes:

> "The appearance of goal-directed processes or actions in activity came about historically as the result of the transition of man to life in society. The activity of participators in common work is evoked by its product, which initially directly answers the need of them. The development, however, of even the simplest technical division of work necessarily leads to isolation of, as it were, intermediate partial results, which are achieved by separate participators of collective work activity, but which in themselves cannot satisfy the workers' needs. Their needs are satisfied not by these intermediate results but by share of the product of their collective activity, obtained by each of them through forms of the relationships binding them one to another which develop in the process of work, that is, social relationships." (Leont'ev, 1978; p. 63).

Hence, the notion of action is fundamental when addressing cooperative work because it is both a prerequisite for, and a result of the human division of work – *collective activity can be realized through a distribution of actions to different individuals.*

The ability to divide an objective into several conscious goals is a prerequisite for dividing the work among several individuals. Leont'ev uses the example of the battue where there is a division of labor between hunters and beaters. If the beater cannot conscious reflect that scaring the food away from him is a sub-goal in an overall line of goals, and that the food will be caught by others, who will share it with him, he would never be able to engage in the hunt in this way. In this example we also see the fundamental role that the

common objective plays in the collective activity as described by Petrovsky. If the beater did not share the objective with the hunters, he would not understand *why* he should chase the animals in a certain direction and he might end up doing something counter-productive according to the overall collective activity. Hence the sharing of a common objective is essential if each of the involved actors is to align and coordinate their individual actions according to each other. The subject—subject interactions (processes of communication) that are part of the collective activity serve as a means of *coordinating its participants* and ultimately ensure the *integration of the individual actions* distributed among the participants in a joint activity.

One difference between individual and collective activity is that a structural component of a collective subject can be a subject too, with his or hers own goals and motives (Kaptelinin, 1996). Hence, the intern in charge of establishing a diagnosis, has motives of his own, and there might be a *conflict* between the different activities that he is undertaking – e.g. a conflict between taking the time to do a good job of diagnosing and the need for studying for an exam. In the same vein, a particular important aspect of human activity is the *poly-motivated* nature of actions. Two or more activities can temporarily merge, motivating the same action, if the goal is part of reaching the motives of several involved activities simultaneously. For example, the radiology department, and the hospital in general, have the responsibility of educating younger radiologists. Therefore, the action of making an X-ray examination serves the purpose of both providing some medical information to the requesting ward as well as educating younger radiologists. The concept of poly-motivated actions helps to understand how people can engage in collaborative activities and still maintain separate agendas.

3.3.3   Levels of Collaborative Activity

Activity theory provides useful concepts for analyzing different levels of a collective activity, according to the status of the activity's objective, i.e. whether it is common to the participants or not, or whether it is stable within the activity, or subject for change and development. These levels help us distinguish different types of collaboration. I change terminology from collective to *collaborative activity* here, in order to underline that collaboration does not always need to have a common objective, which often is implicit assumed

in the term collective activity.

Following Fichtner (1984), Engeström (1987), Engeström et al. (1997), and Raeithel(l996) we can identify a three level hierarchical structure of a collaborative activity. These are labeled the *co-ordinated, co-operative*, and *co-constructive level of activity*, and correspond to the level of operation, action, and activity respectively.

Co-ordinated Activity:

The first and most rudimentary form of inter-subjective collaboration is called co-ordinated work activity:

> "Individuals are gathered together to act upon a common object, but their individual actions are only externally related to each other. They still act as if separate individuals, each according to his individual task." (Engeström, 1987; p. 333)

In coordinated work the various actors are following their scripted roles, each concentrating on the successful performance of the assigned actions according to the *conditions of work*. The script is coded in written rules, in plans, in schedules or in tacitly assumed traditions and norms. These scripts coordinate the participants' actions as if from behind their backs, without being questioned or discussed (Engeström et al., 1997). In this sense the co-subjects are passive participants – not active subjects but "wheels in the organizational machinery" (Kuutti, 1994; p. 58). Co-ordination ensures that an activity is working in harmony with its surrounding activities. Characterizing the relationship among the activities as *external* means that each actor might actually be working together to achieve a common objective, e.g. treatment of a patient, but *they are not aware* of this common objective of their activity. The subject (or the co-subject) only realizes the whole of the activity from the point of view of an individual activity. Hence, there is a subjective concealment of the common objective of the work and the individual actor performing his action does not see this action as part of a bigger picture.

Co-operative Activity:

Co-operation is a mode of interaction in which the actors focus on a common object and thus share the objective of the collective activity, instead of each focusing on performing their assigned actions and roles.

> "The common aim resp. the common task are placed above the individual actions and their aims; they may only be attained in co-operation. [...] Each individual has to relate the over-individual task to the individual aim of the action and he has to maintain this relationship. With regard to the common task, he has to balance both actions and action results of his partner with his own actions and their results. In addition to this, he must influence actions and results of his partner if necessary, again with regard to the common task." (Fichtner, 1984; p. 217)

In cooperative activity the object is stable and generally agreed upon. However, the *means* for realizing the activity might not be present or known. Such means are primarily the script revealing a distribution of the activity into several actions and actors, and the mediating artifacts. This does not mean that the artifact necessarily has to be constructed (fabricated) as such. It merely means that an artifact is not recognized as a mediator in the action but merely exists as an object in the world. As a part of realizing a cooperative activity these means have to be established, i.e. finding an appropriate distribution of the activity and finding appropriate artifacts that can be turned into mediating tools.

The important difference between coordinated and cooperative work is the common objective, which enables the participants in the distributed activity to relate to each other and make corrective adjustment to own and other's actions according to the overall objective of the collective activity. In this sense the participants are active subjects within the collaborative activity (Kuutti, 1994; p. 58). In a hospital, for example, the collaboration between the ward and the kitchen concerning the food for patients can take form as both coordinated as well as cooperative work. If the kitchen only responds to the requests from the ward, without taking into consideration the objective of the health-care professionals of treating the patient, we talk about coordinated work activities. However, if the kitchen shares the objective of

37

treating the patient with the ward we talk about cooperative work. In the latter case, the kitchen can adjust their activity not only to the request but also according to this overall objective. Hence, if the ward orders the normal dinner for a patient with a cardiological illness and the kitchen knows that the menu is rather fat, the kitchen staff is able to make an ad hoc correction of the request or contact the ward to discuss whether this is a good diet according to the overall objective of treating the patient.

Such kind of ad hoc or situated adjustments have been subject to intense focus in the field of CSCW (c.f. Suchman, 1987) and are central within hospitals as well (Symon et al., 1996) [3, 4, 6]. However, any sensible form of situated and ad hoc adjustment of an activity needs to be done according to the overall objective of the activity – such as when the kitchen adjust the menu according to the treatment of the individual patient. In such cases, where many actors are involved in an activity, this means that these actors need to have this objective in common, if their individual situated actions are not to result in chaos. This insight has some fundamental implication for design of computer support for collaborative work activities.

Co-constructive Activity:

The third and final level of collaborative work is called co-construction following Raeithel (1996). Engeström (1987; Engeström et al., 1997) calls this level reflective communication following Fichtner (1984) and writes:

> "By reflective *communication* [i.e. co-constructive activity /jb] we mean interactions in which the actors focus on reconceptualizing their own organization and interaction in relation to their shared objects. Both the object and the script are reconceptualized, as is the interaction between the participants." (Engeström et al., 1997: 373).

At this level of collaborative activity the object of work is not stable – or is not even existing – and hence has to be collective constructed, i.e. co-constructed. The community asks questions like; "What is the meaning of this problem in the first place? Why are we trying to solve it – and who benefits from its solution? How did the problem emerge – who created it and

for what purpose? Is it relevant or has it become obsolete?" Transitions to the co-constructive level of collaboration are rare in the ongoing flow of daily work actions (Engeström et al., 1997).

Attempts to re-organize and re-construct work typically take place on an organizational level. For instance, by introducing the concept of "Patient Focused Hospitals" (PFH) at the University Hospital, the patient treatment and care were being re-conceptualized from a rational administrative-economic model of patient treatment organized around separated departments to a more holistic and systemic oriented model of patient treatment organized around teams of healthcare professionals. External intervention from e.g. action researchers or consultants can provide the platform for a development and co-construction of a working community by e.g. introducing new computer technology.

In the analysis of collaborative activities according to these three levels it must be emphasized that an activity cannot be said to exist on one level alone. The levels of co-ordinated, co-operative, and co-constructive activity are *analytical distinctions* of the *same* collaborative activity. This means that an analysis of even the most routinized work, seemingly only realized as co-ordinated individual actions, must also be analyzed in terms of co-operation and co-construction. Hence, the routinized work has been constructed by someone at some point of time as a way to achieve an objective through collaboration. There are examples of work actions that seem totally without purpose and without any common objective – for instance, filling out forms in a bureaucracy. But this does not mean that the levels of co-operation and co-construction do not exist. It only means that the common objective and the means for work have achieved a tacit status within an organization. This also emphasizes the need for analyzing collaborative activities in a *cultural-historical perspective* in order to reveal its different components, and how the common objective, the means for work and the use of these means are established within a community over time.

3.3.4 Dynamic Transformation between the Levels of Collaborative Activities

Central to the notion of hierarchical levels of an activity is the notion of dynamic transformation between the levels. The transformations are tied to the stability of the means of work and the object of work. Basically, the upward transformation is a reflection on the means for doing the work or reflection on the object of work itself. Such reflections can be sparked either because of a breakdown or by deliberate shift of focus. The downward transformation is caused by resolving contradictions and problems, and re-embodying the resolution in the lower level. The dynamics are illustrated in figure 3.3.

Co-construction

Reflection on the   ↑ ↓   Implementation: Stabilizing
Object of Work   the Object of Work

Co-operation

Reflection on the   ↑ ↓   Routinization: Stabilizing
Means of Work   the Means of Work
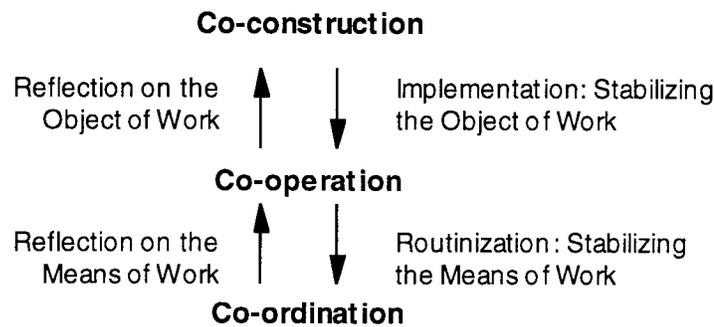
Co-ordination

Figure 3.3: The dynamics of a collaborative activity.

Reflection on the means of work:

The coordinated flow of work, where each actor relates only to the externalized actions of his fellow actors, relies on stable means of work – i.e. stable scripts, rules, and artifacts. However, these means of work might need to be cooperatively re-established according to the object of work – either because of a *coordination break-down* or because of deliberate re-conceptualization of the way the work is achieved currently. At a hospital, for example, most requests for X-ray examinations were routine cases (e.g. simple X-ray picture of the skeleton), merely based on the information written at the requisition. In some problematic cases, however, a closer cooperation between the physi-

cian and the radiologist was necessary in order to establish exactly what kind of radiology examination would provide the best means of establishing an exact diagnosis.

Routinization

works in the opposite direction by re-establishing co-ordinated work where the means for collaboration are stabilized, i.e. the way that collaborative actions are distributed within a community, the rules guiding the work, and the mediating tools realizing the actions. In this transformation it is essential to ensure that everybody knows their part of the script and how to coordinate their work with others. For example, introducing new requisition forms or computer-based systems are new means of work, and hence need to be incorporated in the co-ordinated flow of routinized work.

Reflection on the object of work:

Co-ordinated and co-operative work relies on a stable work objective. Transformation to the co-constructive level of collaboration is necessary when the objective becomes unstable within the collaborating ensemble – as a result of either a *cooperation breakdown* or because of deliberate re-conceptualization of the object of work. At hospitals, for instance, the close cooperation among the physicians and nurses at a medical department sometimes breaks down as a result of divergent viewpoints on the nature of the treatment of patients. Cooperation breakdowns often occur due to limited resources or conflicting motives. For example, balancing the needs for patient treatment, administration, and the obligation to conduct research can cause breakdowns in the cooperation at a hospital. Such breakdowns cause a department to reconceptualize their objects of work and try to resolve conflicting motives and viewpoints among the employees.

Implementation:

Stabilizing such controversies in the co-construction of a common objective is essential, if the object is to be realized. Answering a question like "what

are we doing, and why?" needs to be resolved before the cooperation can proceed. Fostering and leading this process of *implementation* through stabilizing the common objective is often the responsibility of management within an organization (or a leader of a group). For example, the degree to which the individual physician should attend to the social background of the different patients was established in the managerial conferences at the hospital and was often a matter of balancing such concerns with the limited amount of resources in terms of physicians, nurses, beds, radiology timeslots, money, etc. When a common objective is stabilized it is ready to be shared by the participants in the community. This creates the need for communicating and ensuring commitment to this common objective.

3.4 Related Theoretical Approaches within CSCW

After having introduced some of the basic tenets of activity theory, it might be appropriate to stop and shortly reflect upon similarities and differences to other theoretical approaches suggested as a foundation for CSCW research.

3.4.1 Situated Action

A highly influential conceptual approach to CSCW research is the notion of "situated action" as put forth in the book *Plans and Situated Action* by Suchman (1987). The book extends Suchman's earlier work on applying an ethnomethodological perspective in understanding cooperative work processes (Suchman, 1983). This ethnomethodological perspective has been an inspiration for numerous other sociologists in CSCW. The basic argument is that human action is not predetermined nor controlled by predefined plans (as normally argued in Anglo-Saxon cognitive science) but is highly situated and *ad hoc*, because they are a result of peoples' intelligibly moment-to-moment sense-making of the current working conditions. Hence, Suchman argues that "plans are inherently vague" (p. 185) and are therefore to be viewed as "resources for action rather than [...] controlling structures" (p. 186). Furthermore, because people working in an organizational setting are

held accountable for their actions, plans are often "representations of actions in the form of future plans and retrospective accounts" (p. 51).

Philosophically speaking, there are some fundamental differences between ethnomethodology and activity theory (see e.g. Jensen, 1989). However, in [3] I have argued that this insistence on the situated nature of human actions corresponds with the activity theoretical notion of realizing actions through operations, accommodated to the conditions of the environment. The paper furthermore discusses *how* a plan can work as a resource for work, which Suchman does not discuss in any detail. But most importantly, the activity theoretical approach helps us analyze and understand how plans as representations guiding an activity are *developed* during the activity. This helps us understand the *dynamics of collaborative work*, which are not addressed by Suchman.

3.4.2 Distributed Cognition

Another theoretical approach to CSCW research is "Distributed Cognition", especially as developed by Hutchins and his colleagues at the University of California, San Diego (Hutchins, 1995; Hutchins & Klausen, 1996; Rogers & Ellis, 1994). In many respects, distributed cognition resembles activity theory – or to use the more precise words of Cole and Engeström (1993); distributed cognition is a rediscovery of the social nature of mind so fundamental to the cultural-historical school of psychology (p 1).

In his latest book *Cognition in the Wild* (1995) Hutchins provides a detailed ethnographic account for the navigation of a large Navy vessel and in doing so, he describes how computational techniques of representations and re-representations are distributed among humans and tools. The similarities between distributed cognition and activity theory include the notions that (i) cognition is mediated by tools, (ii) by being embedded in practical human activity, cognition is social in nature, and (iii) a person interacting with a tool can be viewed as a functional system. However, these insights were accomplished by activity theorists more than 50 years ago, and have been elaborated beyond Hutchins' discussion. For example, the notion of tool in activity theory is more than the instrumental, materialized tool discussed by Hutchins, and the notion of a functional organ in activity theory goes beyond

Hutchins' narrow definition of a functional system.

Hence, to some degree distributed cognition and activity theory align. However, and most important, the conceptualization of the human being in distributed cognition differs radically from activity theory. First, Hutchins – as an American cognitive scientist – still refers to the human as a "symbol-processing system", even though Hutchins is attempting to situate the origin of symbols in the world (and culture) rather than in the mind. Second, distributed cognition insists that people and things are fundamentally the same, and thereby that the same language can be used to describe how people and things behave, and that both are similar parts in a larger computational/cognitive system. Nardi (1996b) has provided a fundamental critique of this assumption and has outlined its deeply problematic consequences – which includes stripping away motives, intentions, and responsibilities from human actors, and leads to a view on humans compared to "dumb ants". Third, as noted by Latour (1996) in his review of the book, Hutchins seems to concentrate solely on applying routine knowledge in work, and not the production of new knowledge. Hence, in activity theoretical terms, distributed cognition only analyses activity at the co-ordinated level of collaboration. Even though Hutchins discusses learning, he describes it as "useful adaptation to a changing environment" (p. 349). This leaves the initiative for change with the conditions of the environment and not the participants of an activity trying out new means for work (the co-operative level) or even reconceptualizing their view on the world (co-constructive level). This has the consequence that Hutchins misses the cultural historical development of the artifacts used by the navigators (Latour, 1996).

3.4.3 The Social Action Framework

A third candidate for a theoretical foundation for CSCW research is Habermas' theory of social action, also known as the theory of communicative action. The use of Habermas' theory in IS research was originally proposed by Lyytinen in his dissertation from 1986. Later, Ngwenyama and Lyytinen (1997) have proposed the theories of Habermas as a framework for analyzing groupware technologies.

The paper by Ngwenyama and Lyytinen starts out by discussing other theo-

retical approaches to CSCW research, including activity theory, and argues that the fundamental limitation of activity theory as a framework for CSCW is that "it reduces groupwork to instrumental activity and largely ignores symbolic interaction" (p. 73). They argue that their framework – in contrast to other framework, including activity theory – (i) links instrumental activity with symbolic group interaction, (ii) deals with the organizational context in which these activities take place, and (iii) deals with conflicting issues in cooperative work. To be frank, I do not recognize this critique. Activity theory does not ignore symbolic interaction – on the contrary; it has elaborate concepts for understanding communicative as well as psychological mediation and regulation of activities. Furthermore, activity theory insists that any activity is embedded within a social practice of a cooperating ensemble, which clearly, when addressing work activities, includes a focus on the organizational context of these activities. Finally, activity theory is based on the Hegelian notion of dialectical contradiction as a foundation for development and the Marxist notion of dialectical materialism, which has been developed to a large extend by Engeström. Thus, stating that activity theory does not address conflicting issues in work is definitely wrong.

The paper by Ngwenyama and Lyytinen (1997) has been subject to criticism by Sharrock and Button (1997), who argue that "CSCW champions of Habermas often overlook the fact that his theory can be criticised in its own rights", and "Ngwenyama and Lyytinen's [...] categories of analysis are both arbitrarily constructed and applied" (p. 369). One of Sharrock and Button's objections to the focus on communicative action is that "this characterisation will perhaps be artificial insofar as 'operations on artefacts' are often means of mediating relations with other people" (p. 379). Hence, focus on communicative actions as means of cooperation and coordination tends to overlook what I have termed "instrumental coordination" of work, which we shall define and discuss in the next chapter.

Chapter 4

An Activity Theoretical Approach to CSCW

This chapter contains my conceptualization of Computer Supported Cooperative Work (CSCW). Based on the activity theoretical framework presented above, I develop a framework, which can be a theoretical foundation for the design of CSCW technologies. The chapter starts by defining CSCW from an activity theoretical perspective and it subsequently discusses the concept of *coordinating work* within a working ensemble in greater detail. Then my framework for understanding *collaboration artifacts*, i.e. artifacts mediating collaborative activities, is presented, and the chapter ends by discussing similarities and differences of this activity theoretical framework with related CSCW frameworks.

4.1 Re-conceptualizing Computer Supported Cooperative Work

Based on activity theory, Computer Support for Cooperative Work (CSCW) can be defined as *Collaborative Work Activities Mediated by Computerbased Collaboration Artifacts.*

A *Collaboration Artifact* should hence mediate the collaborative work activ-

ity, by providing means for realizing the activity's objective under certain conditions. Furthermore, a collaboration artifact should aid cooperation despite the distributed nature of a collaborative activity, and thus help avoid fragmentation and segmentation – i.e. help avoid that the cooperative activity reduces to a co-ordinated activity, seen from the point of view of the different actors. Therefore, a collaboration artifact should also support *coordination* (i.e. self-regulation) within the cooperating ensemble of actors, in a way so that the different actors can relate their individual actions to the overall activity and its objective.

It is difficult to say anything general on how to create artifacts for mediating the instrumental side of the activity – that depends entirely on the object of work. Based on activity theory, it is however possible to develop a more general framework for conceptualizing the coordination of a collaborative activity, which is the subject for the next section.

4.2 Coordination of Collaborative Activities

Central to activity theory is the notion that the object of an activity can be another activity. Hence, coordinating[1] activities is in itself an activity mediated by different artifacts (see also [6]). Often, however, coordination is not an isolated activity, but is achieved as actions or even operations within the overall collaborative activity. As any other activity, coordination of collaborative activities can be achieved in collaboration, and can thus be analyzed in terms of their three levels and the transitions between them: *Co-ordinated coordination* takes place as routine, according to fixed, established norms, rules, procedural scripts, heuristics, etc. within a work setting. *Co-operatiue coordination* takes place when the actors relate the coordination to the objective of work, trying to find the best way of coordinating work according to the concrete situation. This is normally termed *ad hoc* articulation of work within CSCW. *Co-constructiue coordination* takes place when actors reflect upon the object of coordination, i.e. reflect upon the best ways of

---

[1]Please note that *coordinating* activities is an activity in itself and should therefore not be mistaken for the level of collaboration called coordinated collaborative activity. I differentiate between the concepts of *coordinated activity*, as the lowest level of collaborative activity, and the *coordination* between distributed actions and activities that takes place at all three levels of the collaborative activity.

coordinating the collaborative activity in question ([2] provides an example of a workshop that attempted to co-construct coordination at a surgical department).

The following sub-sections identify (i) three basic types of coordination, (ii) the dependencies in work, which have to be coordinated, and (iii) three aspects of a collaboration artifact, which can mediate coordination.

4.2.1   Types of Coordination

In this subsection I will concentrate on how actors can integrate and adjust – i.e. *continuously coordinate* – their interdependent actions during collaborative activity. Based on my empirical studies of healthcare work, I have found it useful to divide this kind of continuous coordination into three types: *communicative*, *instrumental*, and *scripted* coordination (see [6]). Figure 4.1 summarizes these three basic types of coordination.

Communicative Coordination: The communicative side of an activity is used to control and coordinate activity. In this sense, cultural-historically developed sign systems are used as semiotic regulation of human behavior – individual as well as collective (c.f. Raeithel, 1992). Coordination of collaboration takes place through communication, including indexical, symbolic, iconic, and conceptual communication (Wertsch, 1981; p. 24). Hence, central actions in collaborative work are communicative or *semiotic actions*.

Workplace studies of Air Traffic Control (Bentley et al., 1992), and the London Underground Railway Control (Heath and Luff, 1991) have shown how sign systems are used to mediate the coordination of the highly intensive work in control rooms. At any hospital, communication as a way to coordinate work is essential. The telephone may be the most important coordination artifact within hospitals and the many conferences in which work is discussed and coordinated are fundamental to medical work. A prerequisite for communicative coordination is that the different actors share the cultural-historical meaning of the different symbols, icons, and concepts used in this communication.

Instrumental Coordination: By instrumental coordination is meant co-

Coordination Type	Description	Prerequisite	Example (taken from [6])
Communicative	Coordination through semiotic actions and/or operations using sign systems (incl. indexical, symbolic, iconic, and conceptual communication).	Shared cultural-historical system of signs	When a nurse calls the ward, asking them to bring the next patient to the operating room.
Instrumental	Coordination according to the 'readable' reflections from other actors activity.	Externalization of operations and /or results	When the surgeon sees the patient being transported to the op room, he starts preparing himself.
Scripted	Coordination according to a script of action, reflecting who is doing what when, why, etc. Typical embedded in norms, procedures, protocols, rules, division of work, etc.	A common script	The *operation schedule* used in a surgical department.

Figure 4.1: Three basic types of coordination.

ordination according to what other actors do, rather than what they deliberately signal. A person's operations and/or the results of these operations reflect what the person is doing, and another actor may take the stance of an observer, using these signals to pick up (and interpret) needs, intentions, and activity patterns. Hence, an actor can coordinate his part of the work by looking at what his fellow actors are doing or by looking at the results of their work, i.e. looking at the common object of work, or at the intermediate results. The CSCW literature contains several examples of ethnographic studies revealing how people coordinate their work according to the visible actions of others (e.g. Nardi et al., 1995; Hughes et al., 1996). Within hospitals this type of coordination is especially important because it provides a way of coordinating work without doing the 'extra' work of articulating it. The classical example from the hospital is the silent cooperation around the patient under surgery – often the surgical nurse can hand the surgeon the correct surgical instruments just by looking at what he is doing at

the moment. It is decisive for understanding coordination to recognize that *the observed actor need not be aware that his visible motions are being picked up as signs by the observer*. He can – undisturbed – keep up his work. What is important, though, is that the observed actor's motions are *visible* – i.e. that they are externalized. The need for rendering tasks visible in the London Underground control room (Heath and Luff, 1991) clearly illustrates this point. Operations need to be *externalized* – other participants cannot 'read' internal (cognitive) operations. Furthermore, results need similarly to be externalized – internal results such as heuristics cannot be used as coordination mechanisms without being externalized.

Scripted Coordination happens when each actor knows the timing of the distributed collaborative activity and hence can coordinate his or her work according to this script. For example, when a surgical operation is performed each actor knows when and in which sequence he or she is needed in the operation theater, and they can coordinate their work according to these temporal constraints. Hence, the anesthesiologist does not enter the operating room to anesthetize the patient before the hospital porter and the nurse have put him there; the surgeon does not enter the theater before the patient is anesthetized; the hospital porter does not fetch the patient before the operation has finished, etc. A prerequisite for scripted coordination is that a script exists – materialized or not – and that all participants know not only their role according to the script but also the role of the actors who they need to coordinate with. Such a script for work is embedded in a combination of rules, procedure, protocols, division of work, norms, etc.

All three types of continuous coordination take place at all three levels of collaborative activity. Communicative coordination is clearly an essential part of co-ordinated, co-operative, as well as co-constructive activity. At the level of co-operation, where actor acts according to a common objective, instrumental coordination can result in the correction of other actor's faulty actions as illustrated by the kitchen example in last chapter. At the level of co-construction, instrumental coordination takes place when one is trying to figure out what is happening in other activity systems, and not just relying on what those people say they are doing. Scripted coordination at the level of co-construction is rare, but does occur for example when one relies on other

people to stay within the law or follow some norms and rules within the community. These types of continuous coordination can be mediated by artifacts, and such artifacts are important exemplars of collaboration artifacts.

4.2.2 Dependencies in Work

Looking at the *inter-dependencies* arising between two or more distributed actions, Coordination Theory (Malone & Crowston, 1990; 1994; Crowston, 1994) has identified three basis types: (i) simultaneity, (ii) prerequisite, and (iii) shared tool. Using activity theory these can be illustrated as shown in figure 4.2 a-c. "Ob" is the objective of the activity, G are sub-goals, T are tools, R are results, and 0 are the object of the activity.
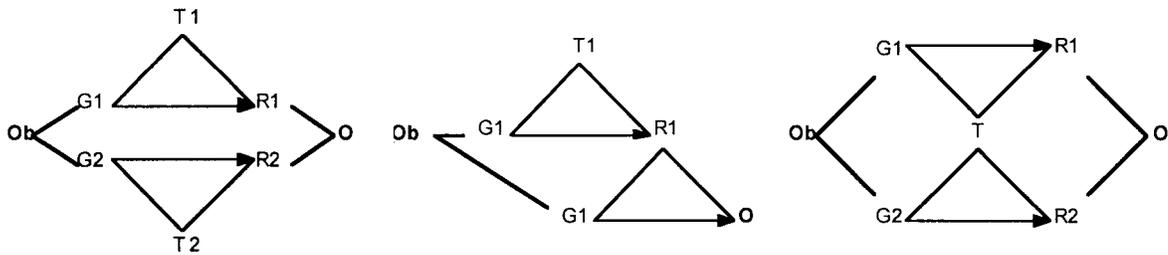
Figure 4.2: Interdependencies between actions and activities: **a:** simultaneity, **b:** prerequisite, and **c:** shared tool.

Simultaneity: The need for two or more actions to occur simultaneous is evident in Leont'ev's battue hunt example; if the beating (action 1) and the hunting (action 2) do not happen simultaneously, e.g. the beaters doing their part one day and the hunters doing theirs the next, the hunt (Ob) would obviously not be successful in capturing the bag (O). The temporal implication for this interdependency is that an appropriate timeframe has to be established, in which the different actions have to take place [6]. For example, at a hospital it is necessary to ensure that the actions of the surgeon, the anesthesiologist, and the scrub nurse take place simultaneously in the operating room.

Prerequisite: Often a division of an activity into different actions entails that the result of one action (R1) is the prerequisite for the next, and

if this result is not present the next action cannot take place. Hence there is a *sequential* interdependency between the activity's actions. At a hospital, for instance, the timing of the individual actions involved in the activity of operating a patient is crucial [6].

Shared Tool: If two or more actions are mediated by the same tool (or resource in general) its accessibility and usage have to be coordinated – e.g. scheduling the use of shared radiology machinery (T), used by all clinical departments within a hospital [4, 6]. The temporal implication for this interdependency is that the use of the shared resource needs to be divided between the different actions (actors) which creates the problem of *temporal scarcity* (McGrath, 1990; McGrath & Kelly, 1986). One actor might be forced to wait for another to finish his use of the tool. So, as a part of coordinating work one has to assure an adequate temporal priority between what is needed and what is possible.

However, activity theory help us go beyond these three interdependencies provided by Coordination Theory; we can in addition identify certain *intra-dependencies* within the actions realizing the collaborative activity. Looking at the basis structure of an action in figure 3.1, the following three dependencies within an action can be identified: (i) subject-object dependency, (ii) subject-tool dependency, and (iii) tool-object dependency.

Subject-object: There is a dependency between an actor and the object of the action; certain actions can be performed by a certain set of actors. For instance, certain surgical operations can only be performed by surgeons with a certain level of education.

Subject-tool: The tool is recognized in relation to the subject: an actor can, will, or may use certain tools. For instance, as a sledgehammer is too heavy for the child, most of the medical concepts of the physicians are incomprehensible for the average patient, and an MR scanner must only be operated by authorized personnel.

Tool-object: The tool is also recognized in relation to the object: certain tools are (more or less) applicable for realizing a certain job, others are not. For instance, traditional X-ray is a tool sufficient for diagnosing diabetics, whereas the telephone seems insufficient for radiology conferences.

4.2.3 Coordination Aspects of a Collaboration Artifact

As an activity, coordination is mediated (see also [6]), and a collaboration artifact thus needs to contain support for coordination. I have found it useful to characterize *3 general coordination aspects of a collaboration artifact* according to the 3 main "corners" in an activity (c.f. figure 3.1). These 3 aspects are termed (i) shared object(s), (ii) shared tool, and (iii) shared communication. This sub-section discusses these 3 coordination aspects of a collaboration artifact and uses the PATIENT SCHEDULER as an example for showing how design of such a collaboration artifact can be informed (c.f. chapter 1) by this conceptual framework.

Figure 4.3 summarizes the coordination aspects of a collaboration artifact (CA). Even though the drawings in figure 4.3 are depicted as if the two actors (S1 and S2) have different objects of work (O1 and O2), meaning that they are involved in a co-ordinated activity, these three coordination aspects are used at all three levels of a collaborative activity. I differentiate between the term common and shared. I use the term *common object* to denote an object of work that two or more actors have in common, i.e. they have a common objective of realizing this object of work, which lies within each subject's conscious focus. I use the term *shared object* to denote that the object of work is accessible to several actors for inspection, modification, relocation, etc., but that the actors not necessarily have the object of work in common.
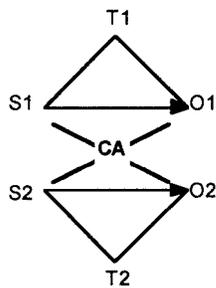
Shared object(s): Sharing objects are the foundation for instrumental coordination. The figure illustrates that Subject 1 only sees the object of Subject 2, and vice versa, and that the operations and/or the results are externalized and visible via the collaboration artifact. The absence of the subject-subject interaction in this model means there is no communication. For example, within a surgical department (S1), operation scheduling (O1) involves tight coordination with the radiology department (S2). The PATIENT SCHEDULER (CA) supports sharing both the schedule of operations (O1) and the schedule of radiology examinations (O2), and thereby enables each of these two departments to coordinate their work according to one-another. Another example of a collaboration artifact providing access to representations of the core object of work, i.e. the patient, is the medical record; by reflecting the work of one physician (S1–O1), the record (CA) helps another physician (S2) to coordinate his treatment of the patient (O2) with his colleague.

When we are providing access to a shared object we cannot always ensure that subject 1 and 2 have common objectives – they might even have conflicting ones. Hence, providing coordination support through sharing objects of work creates the need for *access mechanisms* telling who can do what with the objects given access to. To take the example of scheduling again, the surgical department and radiology do not always have complete common motives; the surgical department wants the examination as fast as possible, but radiology wants to schedule the particular examination in a series of similar examinations for efficiency reasons. Hence, it is necessary for the radiology department to control exactly in what way the surgical department can access their schedules. Support for such access mechanisms and access control is well-known within CSCW technologies and is a part of the PATIENT SCHEDULER as well.
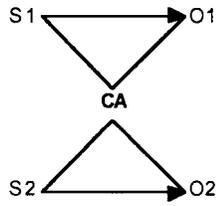
Shared tool: We have already discussed how sharing a tool – or artifact in general – creates an interdependency in work creating a need for coordinating the accessibility and usage of the artifact. But, if the artifact (CA) supports multiple users (synchronously as well as asynchronously), and if it reflects the work of other users, a shared artifact can also be used when coordinating work. The figure illustrates that the collaboration artifact mediates both the activities of Subject 1 and 2 towards their respective objects, but that the artifact also mediates Subject 1's relation to Subject 2's object, and vice versa. An important example of a shared artifact within most organizations is the script of work, which is the foundation for scripted coordination. The operation schedule (CA), as written on the wallboard at the surgical clinic (see photo in [6]) or created in the PATIENT SCHEDULER, is a shared artifact within the collaborating ensemble (S1 and S2 being e.g. the surgeon and the nurse), which is involved in the operations. By reflecting the status of the work, each actor can coordinate his/hers work using this script.

In the case where Subject 1 and 2 do not have a common objective, the shared artifact needs an *allocation mechanism*, telling who can use the artifact, when, and for what. For example, a radiology machine is a shared artifact within a hospital and can be represented as a resource with a corresponding schedule and made accessible through the PATIENT SCHEDULER for other departments to book examinations directly. However, in situations where radiology and the requesting department do not have completely common objective (which is frequent), radiology needs to have a way to specify and control the use of their resources. Hence, mechanisms for *allocation*, telling who can book examinations when, and mechanisms for *reservations*, telling what kinds of examinations can be booked, need to be in-cornorated in such a system.
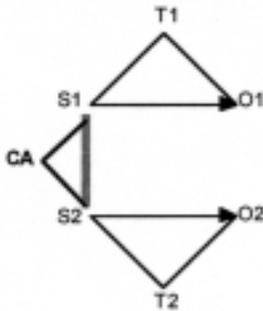
Shared communication: Finally, the most prevailing form of coordination is communicative coordination through semiotic actions, which can be supported by shared means of communication. Communication is depicted as a gray line in the figure. Examples of coordination through communication in the PATIENT SCHEDULER, are the semi-structured appointment and note, which support communication across time and space, through semi-structured written text.

Fundamental for communication and interaction in general is the interpretation of the sign systems used. Hence, it is often of great importance for the communicating partners to identify each other and to establish who they are interacting with and thereby asses their background. Hence, in communication a *mechanism of identification* is necessary and in the case of conflicting motives an authenticating of this identity is often necessary as well. Within hospitals, for example, titles and uniforms are used (as short-cuts) to identify the medical background and knowledge of your communication partner.

4.3 Related Conceptual Frameworks within CSCW

After having presented this activity theoretical approach to CSCW, it might be appropriate to stop and make some short comments on related work.

4.3.1 Coordination Mechanisms

The framework of Coordination Mechanisms[2](CM) makes an analytical division of work into (i) *cooperative work*, constituted by the interdependenties of multiple actors who interact through changing the state of a *common field of work*, and (ii) *articulation work*, which is the work done to coordinate,

---

[2]The CM framework has previously been labeled "Mechanism of Interaction". The following discussion of CM is based upon Schmidt & Simone (1996), Carstensen (1996), Schmidt & Bannon (1992).

	Description: A collaborative artifact supports coordination by...	Perquisite	Hospital example	PATIENT SCHE- DULER example
Shared Object	...sharing (representations of) the object(s) of work and by reflecting the work of each actor (instrumental coordination).	Access mechanisms telling who can do what with the object of work.	The medical record is one of the most important shared representations of the primary object of work – i.e. the patient. The record is used extensively in coordinating the treatment of a patient.	The operation schedule, which is the object of work in the collaborative activity of creating an operation plan. The patient calendar, reflecting the patient's different appointments.
Shared Tool	...sharing (representations of) a commonly used tool and by reflecting the work of others done with this tool (instrumental and scripted coordination)	Allocation mechanisms, telling who can use the tool when and for what.	The operation plan, when used as a script for action, written on the wallboard in the surgical clinic (not when made, i.e. an object of work).	A shared resource (e.g. a radiology machine)
Shared Communication	...shared communication through a common known sign system (communicative coordination)	Identification and authentication mechanisms, telling who I am communicating with.	The telephone is an artifact, which is heavily used for coordination purposes at hospitals.	The patient appointment and the note. An actor at department A can send a request for an action (e.g. examination) to department B, or can send a note.

Figure 4.3: Coordination aspects of a collaborative artifact

schedule, mesh, align, integrate, etc. the highly complexly interdependent activities in work.

Even though instrumental coordination through the common field of work is briefly addressed[3], the crux of the CM framework is to understand how to "reduce the complexity of articulation work" (Schmidt & Simone, 1996; p. 162). A Coordination Mechanism embeds a *coordinative protocol*, which is a set of procedures and conventions that – more or less strongly – stipulates the articulation of interdependent distributed activities. A CM is thus "distinct from the field of work" (ibid. p. 178). This is what I have called scripted coordination, which again is a special case of coordination through a shared artifact, and the CM framework provides an excellent approach to understand

---

[3]By using the example of a airline reservation system.

this type of coordination. However, I find that activity theory provides a more rich foundation for conceptualizing cooperative work activities and how they are mediated by artifacts. Let us look on three examples.

First, viewing articulation work as an overhead to the cooperative work excludes any developmental and dynamic understanding of work: cooperative work in one situation might be articulation in another, and vice versa. This is nicely put by Bødker and Mogensen (1993) when they, based on an analysis of the cooperation between a labor inspector and his secretary, conclude that "one woman's job is another man's articulation work" – i.e. that the same work from one perspective is viewed as coordination of the 'real work', and from another perspective is viewed as the work *per se*. I find it much more fruitful to view the semiotic self-regulation as an intrinsic part of any activity – individual as well as collective. This helps explain how some of the articulation actions of the labor inspector sometimes are distributed to the secretary. Furthermore, the dynamic transitions between the levels of a collaborative activity are not captured by the CM framework, which has a tendency to view work only at the co-ordinated level. Even though articulation work is described as recursive – management of an established arrangement of articulation work might itself be conducted as a cooperative effort, which in turn also needs to be articulated – this secondary (tertiary, etc.) level of articulation is just another activity with the first activity as object. Hence the co-operative and co-constructive aspects of *all* activities – including rigid routines – are not captured.

Second, the biggest drawback of the CM framework is, however, that the human actor seems to disappear in the framework, and with him his motives, intentions, conflicts with other actors and communities, etc. This, for instance, makes it impossible in the CM framework to answer the crucial question of whether it matters, that an actor understands the 'bigger picture' of what he is doing, or whether he just needs to follow the stipulating protocol. The CM framework emphasizes that actors will, inevitably, encounter situations leading them to deviate from or circumvent the protocol. But the framework does not help us identify why or how such deviations arise. And, more importantly, how can such deviations be incorporated in the protocol, if necessary? Or, in other words, how is a protocol *developed* based on real-world experiences of applying it in work (c.f. [3]).

Third, even though the explicit aim of the CM framework is to address inter-

dependencies in cooperative work, these interdependencies are not identified nor discussed. The activity theoretical approach to CSCW has helped conceptualize six basic dependencies in distributed cooperative work, which have to be considered in collaborative work.

4.3.2 Shared Materials

Sørgaard's (1988a; 1989) notion of *shared material* is an attempt to capture cooperation not taking place as explicit communication. A table carried by two persons is used as the prototypical example of a shared material in cooperative endeavors: "when the table is carried, the two people can follow each other's actions because the actions get mediated through the shared material. This co-ordination is not necessarily explicit" (Sørgaard, 1988a). Hence, shared materials are objects, in the sense that they have durability, and independent existence in the world. In many respects, the notion of shared material is identical to my notion of shared object, which provides the foundation for instrumental coordination of cooperative work. Sørgaard also uses the example of a medical record, as I have done. Sørgaard argues further that computerized shared material can be created through object-oriented modeling of real-world objects in the computer.

However, to illustrate this latter point, Sørgaard uses a train reservation system (cf. the flight reservation system) that models the different trains, cars, seats, etc. in great detail, including the physical layout of the car. This helps make reservations "close to the door" or "nearby the restaurant car". However, this view on "shared material" goes beyond the initial notion of shared material as an object (cf. the table). In the table-example, "shared material" is not concerned with transformation of the material, or with the outcome of the activity, but this is the case in the train reservation-example. Hence, the concept of "shared material" is, in the train example, rather a medium for transforming material into outcome – i.e. a *shared tool* (c.f. also EuroCODE D1.1). This distinction between a (shared) object of work as opposed to a (shared) tool of work is maintained in my approach.

What might be confusing in most real-world examples is, that a particular artifact can work both as a shared object as well as a shared tool. The medical record is an excellent example of this; it is both a representation of

the object of work, as well as a tool used by many healthcare professional in their work.

4.3.3 Common Artifacts

The notion of a *common artifact*, as formulated by Robinson (1993; 1997), builds upon Sørgaard's notion of implicit communication or the use of "language through an artifact" (Robinson, 1997). The requirements for a common artifact are summarized as: a common artifact should (i) be an *effective tool* for getting the job done, (ii) mediate *peripheral awareness*, i.e. help people see at a glance what others are doing, (iii) support *implicit communication* through the materials being worked upon, (iv) support *double level language*, i.e. discussion of difficulties and negotiation of compromises, (v) embed a *partial model* of the situation to be managed, and (vi) be *multi-functional*, i.e. perform other functions. Robinson concludes that a common artifact "should perform all (and at least most) of these functions" (ibid., p. 265).

Compared to my notion of a collaboration artifact there are many similarities; the support for implicit communication through actions on the object of work, support for communication at all three levels of collaboration, the need for support for doing the work, and the need for supporting peripheral awareness through externalizing operations in instrumental coordination. Robinson however points to some issues of overview and model building, which have not been addressed in my (theoretical) work.

Robinson's list has been compiled by gathering experiences obtained in numerous workplace studies, and intents to overcome some of the limitations of the notion of shared material. However, I do find the list rather arbitrary, and not easily applicable; it works more like a reminder on the different workplace studies, than a guideline for design. Who can tell, whether a 7th point, like "a common artifact should assist the planning of work" might not be important? And, why is overview so important – is detail not? This thesis tries to go beyond such pragmatic guidelines and to conceptualize and discuss what characterizes collaborative work activities and how they are, or can be, mediated by computer technological artifacts. It is my view, that such theoretical work might be more useful in discussing and informing de-

sign in areas, where empirical experiences (from e.g. workplace studies) are not available.

Chapter 5

Designing for Collaborative Activities

The purpose of this chapter is to address the notion of "design" and to provide some more operational and pragmatic conclusions concerning the design of computer-based collaboration artifacts. This chapter is a summary of design conclusions based on both the theoretical framework presented in this first part of the thesis as well as on the papers presented in the second part. My design conclusions are categorized according to conclusions concerning (i) the design of the *collaboration artifact* itself, (ii) the design *activity*, and (iii) design *methods*.

5.1 Analyzing and Designing Collaboration Artifacts

The preceding chapters have introduced the empirical design background for this thesis, and have presented and developed activity theoretical concepts for understanding *collaborative activities* and *collaboration artifacts*. A logical question to ask then is; how were (or can) such theoretical concepts be used in design of computer technology? Or, in the words introduced when discussing the role of 'theory' in design (chapter 1); how can the practices concerning the design of computer support for cooperative work be *informed* by the

presented activity theoretical framework? This question is addressed in this section by giving examples of how activity theory has been applied in the enclosed papers [3, 4, 6] to inform analysis and design in the SAIK project.

According to the framework, a collaboration artifact should mediate a co-operating ensemble's *collaborative work*, while supporting the activity-based *coordination* of this work. Let us consider this in greater detail.

5.1.1   Supporting Collaborative Work

One of the central issues of the presented framework, is the 3-level analysis of a collaborative activity. Let us consider how this insight from activity theory informed changes to the design of the PATIENT SCHEDULER. At the surgical department (called "U") involved in the SAIK project, the PATIENT SCHEDULER was designed to supports the activity of creating an operation plan. At U, the creation of the schedule is done by the "operation planner" (a secretary), who schedule the operations based on a referral letter from the general practitioner and a "dispersal note" from the surgeon in charge of the admission of patients. Normally, planning of operations takes place as co-ordinated work where both the means for work and the object of work are stable. In these routine cases, the operation planner can do most of the planning herself. Not infrequently, however, the operation planner cannot create an operation plan for a patient that meets all the constraints – often there is simply not enough resources available at U or at the radiology department within the time frames set up by the surgeon. Therefore the planner needs to engage in a co-operative effort with the surgeon in order to find another acceptable plan based on his knowledge about the operation and her knowledge of the resource constraints within the hospital. This analysis of the activity of operation scheduling helped re-design the PATIENT SCHEDULER to support such cooperation between the operation planner and the surgeon (and others at U). In this case, the ideas of notes and shared folders emerged, enabling asynchronous cooperation between the operation planner and the surgeon. In subsequent prototyping sessions, these ideas were found useful and further developed.

Hence, *a collaboration artifact should be designed to mediate the three levels of a collaborative activity, and the transitions between them.* Other exam-

ples of how the PATIENT SCHEDULER supports the transition between the three levels of a collaborative activity are provided in Bardram (1998). Because contemporary organization of work in a post-industrial era is characterized as non-routine, as cooperation, and as constant transformation and re-conceptualization of the work, I find that this conclusion is an important result of my work. The computer system needs to be able to adopt to this constant flux in collaborative work activity, and thus be able to support work, which has to shift from routine to co-construction and back again. It is important to support the upward transition from co-ordinated work to cooperation and co-construction through re-conceptualizing the means and objects of work, if not the work is to be frozen in rigid routine. Supporting the downward transition by implementing and routinizing new ways of organizing work is however equally important.

These general recommendations for adaptability of a collaboration artifact for re-construction of the means and objects of work might sound like incorporating generic tailoring functionality into the computer system. This is however not the case. The support for implementing and routinizing new work practices might be created for modest but important aspects of a computer tool. The important point, however, is to identify in what way the means and object of the collaborative activity are being changed and/or co-constructed on a *regular basis*, and hence support these aspects of the activity in the future system as well. For example, looking at the task of requesting a radiology examination, it often fluctuated between being achieved as co-ordinated work (through paper-based forms) to being achieved as cooperation (through negotiating timeslot over the telephone) [3]. This was a recurrent theme within all the hospitals visited. Therefore, a core design idea in the PATIENT SCHEDULER was the design of shared resources, which were to support such closer cooperation. Another recurrent change to the means of work, was re-allocation of radiology resources at different meetings between radiology and the clinical departments. Therefore, the PATIENT SCHEDULER supports allocating resources to different department, according to such changes [6].

5.1.2 Supporting Coordination of Distributed Activities

Another central notion of the presented framework, is the conceptualization of coordination. Thus, important information concerning the design of a collaboration artifact comes out of asking: *in what way does a collaboration artifact mediates the coordination of a collaborative activity?* Such analyses of the way coordination of collaborative work is mediated by different artifacts, have been a recurrent theme in the SAIK project. Examples of different coordination artifact analyzed includes: unraveling programs, protocols of treatments, and care plans [3]; order forms, booking calendars, and planning boards [4]; operation schedules, operation books, and the timeframes used at psychological artifacts at the surgical department [6]; and of course the Green System [4]. All of these analyses of different artifacts mediating coordination at the different hospitals, have been used to inform the design of the PATIENT SCHEDULER [3, 6].

[3] discusses the role of plans as mediators for coordination, and demonstrates how activity theory can inform the design of workflow systems. A workflow system typically supports the creating a model of the task sequence, i.e. the 'workflow', and then support the management of the flow of information and responsibility as an 'enactment' of this workflow (Georgakopoulos, et al., 1995; Grudin & Poltrock, 1997). Workflow systems are often divided into a 'workflow modeling module', for creating the models of work, and a 'workflow enactment module', creating plans for work (Schäl, 1996). This creates a separation between planning and executing work in terms of time, space, and actors. The paper shows that such a separation is not evident in hospitals; rather the plans used there are created as "situated planning". The paper discusses the drawbacks of such a separation, and argues that this separation might *prevent learning*. The models guiding the distribution of the work need to correspond with the conditions of the work itself and these models hence need to be constantly enhanced and changed to reflect the actual work. But, the only point in time you can detect whether a model corresponds to the work is when the model does not, i.e. during the enactment, when the plan based on the model breaks down. And if you have separated this enactment phase, which is the basis for learning about the applicability of the models, and the modeling phase, you have prevented the work practice from learning, and from embedding the results from this

learning in models for later use. Therefore, it should be possible to change the workflow models (i.e. plans) in the course of the activity.

Hence, *a collaboration artifact's support for planning – i.e. creating plans for coordination of work – should be an integral part of support for work.* This conclusion is supported by reports of successful use of workflow technologies, which exactly is characterized by a close connection between the workflow capabilities and the object of work. Such successful stories include, for example, the use of LinkWorks in the PoliTEAM project at GMD, which incorporate workflow support together with support for object sharing and communication (Prinz & Kolvenbach, 1996), and Configuration Management Systems, where workflow support is closely connected to the source code (Grinter, 1997). The same principle is used in the design of the PATIENT SCHEDULER, as discussed in [3].

5.1.3 Supporting Activity-based Coordination

The activity theoretical framework emphasized that coordination of work is basically activity-based interaction, and thereby reflects the object of work. Therefore, if a collaboration artifact's coordination aspects should support activity-based coordination, these coordination aspects *need to reflect the object of work.* The activity theoretical framework identified three coordination aspects of a collaboration artifact; shared object, shared tool, and shared communication. Let us consider these in turn.

Shared object(s) should reflect the object of work. If the object of work only exists within a collaboration artifact, then sharing this object will certainly always reflect the object of work. For example, the operation schedule made in the PATIENT SCHEDULER is an object of work (for the people in charge of creating it) and by sharing it, they can coordinated their work around it. However, if the object of work exists outside the collaboration artifact, the collaboration artifact, can only contain a *representation* of this object of work. In order for this representation of the object of work to support coordination, it needs to reflect relevant aspects of this object of work – relevant according to the activity that is to be coordinated. For example, within hospitals the patient is a central object of work, and the medical record contains representations of the patient. But, in order for the record

to help coordinate work, it needs to reflect relevant part of the work of the different doctors, and others involved in the treatment. What is relevant in this case, can only be established by looking at the activities of the involved actors. The checklist, used in aviation for example, is another prototypical example of such a shared object representation, reflecting certain relevant aspects of the object of work (Hutchins, 1997).

Shared communication should reflect the object of work. This means that the communicative coordination aspect of a collaboration artifact should be designed to reflect what the communication is about, i.e. the object of work. Hence, communicative coordination is achieved more efficiently when the communication reflects the work. This is equivalent with the notion of semi-structured messages. In the PATIENT SCHEDULER, for instance, the requisition form used to request an examination of a patient is designed to reflect this purpose. Similar, a note in the PATIENT SCHEDULER can be attached to an object (e.g. an appointment), which reflects that it is communication concerning this object. Communication in general can be supported by electronic mail and conference systems. However, these general communication tools are not always well-suited for communicative coordination, because they do not reflect what the communication is about. It is perfectly possible to use an ordinary email system for requesting radiology examinations (this was actually done in the SAIK project). It is however rather cumbersome to write in free text all the information needed for this request. This can be done more efficiently by filling in a requisition form with check-boxes.

A shared tool should reflect the object of work. This means that a shared tool must be used as a tool for work. For example, if the radiology schedule, as a representation of the work at radiology, is not used to guide the work at radiology and thereby reflects the 'real-world' work, it is completely useless as a shared tool, mediating coordination. Therefore, a fundamental criterion for the success of shared resource schedules in the PATIENT SCHEDULER to support coordination across departments is, that they are valid and trust-worthy, i.e. that they reflect the way in which the work actually is done. And the primary way to ensure this, is to have these schedules used as guiding tools in the daily work (see [6] for further details). [4] discusses an example of such an examination schedule maintained in the Green System, which was not used to guide the flow of examinations, but was kept for administrative purposes. This schedule therefore did not reflect the work, but merely some

administrative aspects of this work (accounting for examinations performed), and was thus useless as a coordination mechanism for other departments.

5.2 The Design Activity

Just as activity theory can inform the design of computer artifacts, the theory can be used to inform the design practices themselves, helping us to conceptualize the design activity as such. Based on activity theory, Bødker (1991) argues that the *use practices must be the origin for design*, and that users consequently must be *actively involved in design*. These conclusions align with the core notion in participatory design, which emphasizes that the design process is a cooperatiue endeavor between users and designers, taking the current and future work practices as the pivot in design (c.f. Greenbaum & Kyng, 1991; Kyng, 1996; Ehn, 1988; Kensing et al., 1996; Grønbæk, 1991).

In a similar way, activity theory can be used to conceptualize two main conclusions to be drawn from the SAIK project: First, taking the work practices as the pivot in design means that design can be approached as *re-design of existing work practices*. Second, the cooperation between designers and users can be viewed as a *co-constructiue activity*.

5.2.1 Approaching Design as Re-design

Activity theory emphasizes that an artifact is a crystallization of sociocultural ways of mediating the work activity. The use of certain artifacts can therefore reflect 'best practices' within the work setting. Thus, a fundamental method for understanding the work practices of a work ensemble is to study and understand the artifacts used in this work – instrumental tools as well as psychological tools for thinking and communication. The enclosed papers contain numerous examples of studies of existing artifacts in the SAIK project.

From a more pragmatic point of view, there are good arguments for approaching design as re-design. Especially in the SAIK project, aiming at providing design recommendations for the re-design of the Green System. The purpose of investing resources in a design effort in the first place is bound up with the

aim of devising computer support which – in one way or another – enhances and develops the work practices as compared to existing ways of working. A design process must therefore be based upon an in depth understanding of the strengths and limitations of the existing way of doing work. Today, the existing way of doing things already often involves some kind of computer support, which has some limitations in supporting an ever changing work practice. Design necessarily has to start by investigating the problems, insufficiencies, and limitations of the existing computer systems, as reported in [4]. But, design must simultaneously look at the benefits, strengths, and potentials of the existing systems, or artifacts in general. Often, failures of computer systems can be ascribed to the lack of maintaining support for 'best work practices' in the transition from one artifact (typical manual) to another (typical computer-based). Heath & Luff (1996) gives an example of this; because a new electronic medical record introduced in the UK did not support central parts of the general practitioners' old work practices, both the old paper-based record as well as the computerized one were used simultaneously.

Even though this proposition of 'sticking to the old tools' might sound like a conservative approach, it is actually a process for generating new and creative ideas. The creative process is aided by inspiration, which comes from existing work practices (Bødker & Christiansen, 1997). New design ideas emerge in the meeting and juxtaposing of the strengths and limitation of existing ways of doing things, and the knowledge of the opportunities and risks of new ways of working – for example using computers. Hence, understanding the use of existing artifacts is the point of departure for the generation of new design ideas.

In summary; *the study of existing artifacts in use – i.e. as mediators for an activity – is the key to understand the activity for the purpose of design.* Hence, there is a need for establishing methods for investigating the use – for better or worse – of existing artifacts (including computer-based ones) as a foundation for re-design.

5.2.2 Design as Co-construction of Work Practices

To view design of computer technology as a co-constructive process (c.f. chapter 3) first of all means that the construction of computer artifacts cannot disregard an obligation to consider the parallel re-construction of work practices. Secondly, it means that design is a distributed collaborative effort, involving a wide variety of different actors, with common as well as conflicting motives.

This conceptualization of the design practice, informs us that the design of computer technology is not only a matter of creating new means of work, i.e. working at the co-operative level, but is *(potentially) a process of re-conceptualizing the whole object of work*. This basically extents the notion of design as an iterative process involving two interlinked cycles of iterations: the *primary iteration* between the design of an artifact and the conditions of work, and the *secondary iteration* between re-constructing the object of work and designing the artifact mediating this work. In the individual papers, this secondary iteration is referred to as design for the "organizational perspective" [3, 4] or "organizational constraints" [6]. This double level of iteration is illustrated in figure 5.1.
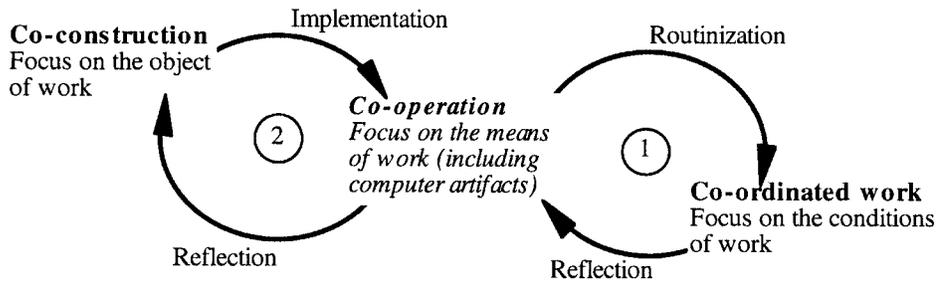
Figure 5.1: The double iterative process of design.

In the primary iteration the process of routinization turns the devised artifact into an artifact mediating work according to its conditions. This process involves situating the newly devised artifacts in a working environment, and establishing their connection to the many other means of work, actors, related activities, rules for work, norm, etc. Routinization is a process of taking the artifact into use, which is a prerequisite for the working ensemble to start applying it in their coordinated work. The suitability of the artifact for me-

diating the work – in connection with the contextual conditions of the work – is only evident at this point of time, or, as put by Bødker (1991): "the [artifact] only reveals itself, fully, *in use*" (p. 142). The second arrow in the primary iteration is the reflection (deliberate or not) upon the match between the means of work (especially the newly introduced computer artifact) and the conditions for the work. This reflection gives way for a further enhancement and change of the means for work. In a traditional iterative system development approach, this means adapting the computer artifact. However, this needs not always be the case; other means for work can be, or ought to be changed. For instance, new rules for work, new division of work, new scripts and responsibilities, new physical artifacts supplementing the computer artifact, etc.

This primary iteration between constructing means for work (typical a computer artifact) and the conditions of work has been the subject for most research on iterative design methodologies. For example, within the Participatory Design tradition focus is on "how computers are used, which [is] called the *use situation*" (Greenbaum & Kyng, 1991; p. 2). Within a user-centered design perspective, focus is on the interplay between the computer application and the organization of work (Gould, 1988; Schrage, 1996; Beyer & Holtzblatt, 1998). Such methods, where designers seek a fine-grained awareness of work practices, however tend to become *conservative* (Clement & Van den Besselaar, 1993; Ehn, 1993). Workers involved in design often focus on incremental improvements of existing practices (Grudin & Grinter, 1995). Discussing the dialectical relationship between tradition and transcendence Ehn (1993) asks: "Should the design support the traditional typographical production or completely new services, such as desktop publishing?" (p. 70). Close work with traditional typographers in the UTOPIA project led to the former (Ehn, 1988; p. 333). In order to approach this limitation I argue that a focus on the secondary iterative cycle depicted in figure 5.1 should be incorporated to a greater extend in the design process. There are several reasons for taking this view on the process of design.

Firstly, given the investment in time, money, effort, etc., which is needed to design and construct new computer technology, it is an obvious moment to stop and reflect upon the overall structure and purpose of the work and the organization of it. It is preferable to avoid freezing inexpedient work practices in a computer system. This line of argument corresponds to the

view of computer technology as the enabler for new and improved business processes and work organization, which is evident in much of the Information Systems (IS) literature, and the business literature on IT (e.g. Business Process Reengineering). In general, the age of designing IT for the sole purpose of automating existing ways of working has passed, and has been replaced by a focus on the design of IT, which on a strategic level supports a re-conceptualized way of working. In the SAIK project, for example, the design of the PATIENT SCHEDULER was incorporated in the vision of re-organizing Danish hospitals, turning the traditional bureaucratic and functionally specialized hospitals into Patient Focused Hospitals (PFHs), characterized by high cooperation in teams of healthcare workers, distributed radiology and other services, and flexible channels of communication and decision making.

Secondly, you cannot create new means for work without a strong common understanding of the object of work. However, the design process is a highly collaborative and distributed activity, involving a wide variety of actors. In the SAIK project alone – which is but a small project compared to real-world software development projects – such actors included; designers, programmers, scientists, IT suppliers, organizational development consultants, hospital management, healthcare professionals (physicians, radiologists, nurses, etc.), and official healthcare authorities. Each of these actors has different views on the object of work and does not, in any explicit or detailed sense, have the object of work in common with one another. But a fundamental prerequisite for successful design of a computer artifact mediating work must necessarily be that the involved actors agree on the common object of work. This re-conceptualization can only take place as a co-constructive reflection on the object of work involving these actors.

In this secondary iteration *implementation* means implementing the common understanding of the object of work among the actors which are dedicated to the creation of the new means for work, i.e. the computer artifact. Taking the normal division of work between the constructors and the users of IT for granted, this means that the constructors need a profound understanding of the future users object of work and the conditions under which it is realized. The efficiency of the IT constructors' cooperative effort is highly dependent upon them having the object of work in common in a way, that they can relate and coordinate their efforts according to this common understanding. Therefore, methods for 'implementing' the object of work in the ensemble

of IT constructors in a way that help sustain a focus on the users future common object of work are needed.

In summary, we can pose the claim that; *it is fundamental to understand design of computer artifacts as sitting in the middle of a double iterative process: on the one side the artifact is constructed in accordance with the conditions of work; on the other side, the artifact is constructed in accordance with co-construction of the object of work.* Hence, there is a need for establishing methods for tying the construction of a computer artifact together with the corresponding co-construction of the work practices.

5.3 Methods for Design

In this project I have primarily created and experimented with four types of methods for design of cooperative computer systems: (i) the use of detailed workplace studies in the design process, (ii) the use of scenarios, (iii) the use of prototypes in larger groups of users, and (iv) the use of analysis patterns for documenting recurrent themes in design solutions. Based on the experiences obtained by using these methods in the SAIK project, this section draws some conclusions concerning their applicability in design.

5.3.1 Workplace studies

Throughout the discussion above it has been underlined that an understanding of the work activities, the involved actors, the object(s) of work, etc. is a prerequisite for design. The discussion has especially emphasized the need for understanding the activity systems surrounding existing computer technology as the basis for a *re-design process*. For this purpose detailed workplace studies, carried out inspired by ethnography, have proved to be a valuable method. The link between workplace studies and design of computer systems is discussed in Bardram (1996) and some of the findings, applying these methods are documented in [3], [4], and [6]. The positive value – in many respects – of detailed workplace studies as a foundation for design of computer technology, is generally agreed upon within a increasingly broad range of design approaches. However, despite their value, such studies have

some limitations as well.

First of all, there is a fundamental incongruence between the aim of ethnography, which seek to *understand* existing work practices without affecting the phenomena studied, and the aim of design, which seek to create new opportunities for work, and hence seek to *change* the work practices[1]. Methods based on ethnography cannot be applied to systems that have not yet been put into use, let alone built. Secondly, the results of ethnographic workplace studies are often 'lumpy' in the sense that they provide detailed accounts of narrow, but interesting areas of work. Designers, however, need to strive for overviews and completeness in their description and analysis, in order to ensure that the computer system covers the target work domains. Furthermore, ethnography aims at grounding observations and results in concrete circumstances of the work practices. Design, however, requires abstractions, generalizations, and normalization in order to start modeling the computer artifact (Goguen, 1997). Finally, there is a danger that ethnographers work as a proxy for the users, replacing them in the design process (Kyng, 1995). This creates the problem of 'one way communication' between users and designers, meaning that information is floating from the work practices to the designers, but no information about the future technology, the use of computers, etc. is floating back to the users in the workplace (Bardram, 1996).

In summary, workplace studies seem remote from the "core activities" in design, such as producing visions, representations, and prototypes, which can be used to create the technology (i.e. in coding) and to asses its value and applicability. Based on these limitations, it might not be surprising that I can conclude that there was a skepticism within software development practices to engage in workplace studies. Wandering around in organizations for weeks and moths 'just' observing what people are doing, seemed too far away from the creation of new computer technology. Therefore, the experiences gathered in workplace studies needed to be operationalized in design and turned into tools for creating representations of the future computer systems. For this purpose, scenarios were used.

---

[1]This has been noted by many authors, especially within Participatory Design (c.f. Bardram, 1996; Grønbæk, et al., 1993; Kensing et al., 1996; Kyng, 1995) as well as within CSCW (Goguen, 1997; Shapiro, 1994; Pycock & Bowers, 1996).

5.3.2 Scenario-based Design

Scenarios played a core role in the SAIK project. They constituted the backbone of all design activities, and were created, modified, used, and discussed throughout the whole design process. Two basic categories of scenarios were used: scenarios describing current work practices, which subsequently were transformed into scenarios describing future work practices, including the future computer system used in this new work organization. The overall conclusion is that scenario-based design is indeed applicable and useful – a conclusion which is reflected in the uptake of applying scenarios at KMD. The construction and use of scenarios in the SAIK project – called collaborative scenarios – is presented in [5].

Scenarios help to maintain some representation of the activity systems and their objects of work, which is the target for the computer system under construction. In other words, scenarios help implement the common object of work within the ensemble of cooperating actors allocated to construct the computer artifact. Thereby a scenario helps tie the construction of a computer artifact together with the corresponding co-construction of the work practices.

The use of scenarios in design has drawn increasingly attention recently. Especially within Human-Computer Interaction (c.f. Caroll, 1995; MacLean, et al., 1991) and within object-oriented analysis and design[2]. Compared to these approached, the collaborative scenarios differ in two ways.

First, instead of focusing on describing isolated tasks of one actor, a collaborative scenario explicitly aims at capturing a whole collaborative activity as it plays out across departmental boundaries, actors, time, and space. Furthermore, compared to the task analysis in traditional scenarios, asking how people do things, a collaborative scenario also asks *why* people are doing what they are. By trying to capture the motives of each actor in the activity, the collaborative scenario tries to map conflicting and poly-motivated actions. Second, instead of starting with future scenarios, a collaborative scenario explicitly starts in the current work practices and then subsequently asks "how would this scenario look, using computer technology?" This provides

---

[2]The use-case approach (Jacobsen, 1992) is an intrinsic part of the Unified Methods Language (UML), which (at least according to its creators) is the de facto standard OO-method (Jacobson, 1998).

the bridge between what is and what is going to be, which later turned out to be valuable information in prototyping sessions.

There are certainly limitations to scenarios as well. Creating scenarios is labor intensive and the designer is still not working on the 'core activities of design', i.e. constructing 'sketches' of the computer system. This problem is amplified because scenarios need to be maintained throughout the whole design process; scenarios describing current work practices need to be constantly adapted to an evolving understanding of the current work, and future scenarios need to be continuously adapted to reflect the evolving design of the computer system. Second, there is an inherent paradox in making future scenarios – one that we might call the *bootstrap paradox of scenarios*; if the purpose of a future scenario is to guide design, it is a paradox that it has to be created based on some idea of how the system is going to be designed. So, one might argue, that the applicability of future scenarios as a design tool is limited, because the design necessarily has to precede the creation of the scenario. Third, the biggest limitation of scenarios is that they are descriptions of use activities detached from concrete conditions of the actual work. To describe a future use situation as a scenario does not ensure, that it actually can or will be realized in that way. If we insist (and that we do) upon design grounded in primary iteration with the conditions of work, scenarios with their corresponding computer solutions need to be *confronted* with these work conditions. This can be done in different prototyping sessions.

5.3.3 Prototyping

The use of prototyping as a design method is well-known and has been subject for much research. I shall not re-iterate the arguments for the applicability and necessity of prototyping, just note that prototyping is an indispensable part of any iterative system development effort. Prototyping sessions with users were conducted throughout the SAIK project.

The traditional use of prototyping as a method for design has however some limitations when addressing CSCW systems; (i) the primary target for prototyping has been the user-interface, or aspects of the system immediately connected to the interface; (ii) prototyping has typical been single-user situations, and (iii) prototyping has been aimed at evaluating how the computer

77

system fits the end-users working conditions. In order to overcome these limitations in traditional prototyping, the method of Organizational Prototyping was used in the SAIK project. Organizational Prototyping is basically an attempt to combine the benefits of Organizational Games (Ehn & Sjögren, 1991) and Cooperative Prototyping (Grønbæk, 1991). The method is presented in [1], and [2] describes how it was applied in the SAIK project.

Whereas a traditional view on prototyping emphasizes evaluation and/or co-design of the computer artifact, the view presented here emphasizes evaluation and/or co-construction of *work practices*. This have two implications. First, it is not the computer artifact *per se*, which is evaluated, but the future scenarios mediated by the computer artifact. In the different prototyping sessions, focus has been on enacting the future scenarios. Second, organizational prototyping tries to encompass the secondary iteration in systems design, focusing also on a co-constructive re-design of the work organizations. This means that the range of participants in such a prototyping session needs to be extended from end-users only, to include persons responsible for organizing work. A clear conclusion to be drawn from the SAIK project is that management and work organization experts need to be involved (at least) in prototyping sessions at the level of secondary iteration. Such participants bring to the table necessary skills and experiences in addressing and reconceptualizing the overall object of work and its organization. Getting the design of the PATIENT SCHEDULER to align with the ideas of re-organizing the hospitals into Patient Focused Hospitals, for instance, could only be achieved by working with both the different healthcare professionals, as well as with management and PFH consultants.

A major limitation to prototyping – traditional as well as my organizational prototyping approach – is, that prototyping sessions are *artificial*. The participants in a prototyping session are not using the computer system *in* work, even though the session tries to simulate or enact work practices. Hence, the routinization of the new means of work is limited, which confines the reflection upon the suitability of the system in real-world conditions. One conclusion to be drawn from using prototypes in the SAIK project is that CSCW prototypes need to be more complete in order to be suitable for trying out cooperative work practices, which involves several distributed actors and evolves over time. One way of creating fault-tolerant prototypes with a high degree of functionality is to make use of standard off-the-shelves software for

prototyping different aspects of the final system. In the SAIK project, for instance, a standard email system was used as a way to experiment with the communicative aspects of the PATIENT SCHEDULER.

5.3.4 Analysis Patterns

The use of analysis patterns in the SAIK project turned out to be a strong tool by serving several purposes. First, analysis patterns support the focus on design as re-design. By studying the use of existing computer artifacts, which have been routinized into the work practices, various design solutions in these artifact can be documented as analysis patterns and subsequently used in the re-design of the system. Thus, analysis patterns work as a collection of knowledge about design solutions, which have turned out to be of high quality within a concrete work environment, and which probably will be so in the future as well. To put it plainly; analysis patterns try to prevent re-inventing the wheel again. In the PATIENT SCHEDULER, for example, the design concept of a "resource" is borrowed from the Green System, and the design of "folders" and "filters" is borrowed from traditional state-of-the-art email systems (which again have borrowed the idea from the Information Lens project).

Second, analysis patterns support generalization of the design knowledge developed during the design process. This fosters a reuse of the insights achieved in one project within other projects, which in the SAIK project was important, because design ideas "buried" in the PATIENT SCHEDULER were to be transferred to other design projects at KMD. For example, the resource allocation method in the PATIENT SCHEDULER was fundamentally new, and an analysis pattern was created to document this design solution.

Third, analysis patterns proved to be a good way of coupling scenarios with design representations of the computer artifact, thereby contextualizing the design solutions. The problem of maintaining several design represen tations – scenarios, OOA&D models, prototypes, design descriptions, etc. – is not eliminated. However, in an analysis pattern these representations are not detached from each other, but are organized according to the work activity, which the pattern addresses. This gives a more logical organization of the design representations, and enables the designer to work with all relevant

design representations for one activity at the same time.

Some of the limitations to analysis patterns are the overhead of using time and effort in the present to create design representations, which *might* be useful in the future. Second, using the "old wheels" over and over again, might prevent you from "inventing a better wheel". In the SAIK project, analysis patterns have not been used to the extent, and in a timeframe, which have enabled me to analyze such cost-benefits, which prevents me from making any further conclusions on these issues.

<div align="center">∗ ∗ ∗</div>

In summary, the methods used in the SAIK project have been applied highly interlinked; detailed workplace studies have provided the basis for understanding the activity systems at the different hospitals, and the use of existing artifacts, including the Green System. This understanding was documented in scenarios, which subsequently were used both as an input for prototyping sessions as well as in the documentation of recurrent work practices in the analysis patterns. Although resource demanding, these methods have proven useful for guiding the object-oriented modeling and construction of the PATIENT SCHEDULER. At the same time, the presented methods have been shaped to support design as re-design, and have tried to extend the design process to encompass both the primary iteration as well as the secondary iteration in design. However, methods for closer interaction between the primary and the secondary iteration in a design process have been wanted, but not found. This points towards future work, which might be inspired by methods used within other disciplines of IT development.

Chapter 6

Conclusions

An activity theoretical approach to, and methods for the design of computer support for cooperative work have been presented. This concluding chapter summarizes the contributions of the presented work, it relates these contributions to the research objectives of the Industrial Research Education as stated in the introduction, and finally it discusses directions for future work.

6.1 Contributions

The major contributions of the work presented in this thesis (including the following papers) can be summarized as:

- *Design principles* for the design and construction of computer support for planning, scheduling, coordinating, and articulating cooperative work in Danish hospitals have been developed and presented. The design is illustrated in the PATIENT SCHEDULER, and the main design principles are documented as analysis patterns (Technical Report no. 4). These design principles include: (i) design for organizational structures in hospitals, including resources, employees, and patients; (ii) design for requesting and booking examinations, internally as well as between departments; (iii) design for resource sharing, including access and reservation mechanisms for controlling the use of these resources;

(iv) design for planning and scheduling, and for saving "best practices" by using templates and programs.

- Understanding the *design activity* as re-design and as a collaborative activity, involving two interrelated iterations has been argued for (chapter 5). The focus on re-design emphasized a focus on existing work practices and the use of existing artifacts as a basis for further development. The need for conceptualizing the seconday iterative process in a system development process, and the need for engaging a much wider audience in this secondary design iteration have been discussed.

- *Design methods* for understanding work practices, for cooperating with users, and for re-using design principles, have been developed and discussed. Emphasis has been put on turning "passive" understanding of existing cooperative work practices into "active" representations and activities for re-design of these work practices. For this purpose, detailed workplace studies were used as the foundation for scenarios, which again formed the basis for scenario-based design [5], organizational prototyping [1, 2], and subsequently for creation of analysis patterns. The value of these methods in a real-world setting has been evaluated and discussed (chapter 5).

- Activity theory was introduced as a theoretical foundation for CSCW research, and it has been shown how this activity theoretical basis helps inform CSCW design. This was partly done by building upon the work of Bødker (1991) and Kuutti (1994), and partly by presenting aspects of activity theory, which helps us address the notion of "cooperative work". Activity theory was related to other relevant theoretical approaches often used within CSCW, namely Situated Action, Distributed Cognition, and the Social Action framework (chapter 3).

- Based on this activity theoretical foundation, a framework for understanding coordination of collaborative activities has been developed. Generic intra- and interdependencies in distributed, collaborative work have been identified as well as different types of coordination (chapter 4) [3, 4, 6].

- Subsequently, a collaboration artifact was defined as an artifact mediating a collaborative activity, and mediating the activity-based coor-

dination of this activity. Three generic aspects of activity-based coordination were identified: shared object, shared tool, and shared communication. This definition was related to other relevant approaches to CSCW, namely the frameworks of Coordination Mechanism, Shared Material, and Common Artifact.

- It has been demonstrated how this framework can be used to design CSCW technologies, by providing several propositions concerning the design of a collaboration artifact (chapter 5) [3, 6].

6.2   Meeting the Research Objectives

The research objective of the Industrial Research Education was divided into three levels: scientific, developmental, and applicable objectives. Let us consider these in turn.

6.2.1   Scientific Objectives

"The scientific aim of the project is to provide a *theoretical foundation for the design of computer systems, which support cooperative work.* This theoretical foundation should on one hand help us address the notion of "cooperative work" and how this work, and the people engaged in this work, can be supported by computer technology. On the other hand, this theoretical foundation should incorporate a *design focus*, in order to help bridge "the Great Divide" in CSCW. An important part of achieving this goal is to provide practical methods, which address the special problems within the design and evaluation of CSCW applications."

This objective has clearly been reached. An activity theoretical foundation approaching the design of CSCW technologies has been presented, and it has been shown how its theoretical basis helps understand *design activities* as a process of re-design and as a co-constructive endeavor. Furthermore, *methods* for supporting the design of CSCW systems have been developed, deployed, and evaluated.

6.2.2 Developmental Objectives

> "KMD is currently in the process of porting the Green System into a client-server architecture. By looking into the nature of co-operative work and at the same time making prototypes for supporting this collaborative work, this Industrial Research project is an input for the design and implementation of the different client applications which provide the necessary support for collaboration within the distributed work at a Danish hospital."

The Industrial Research project has throughout its 3 years of duration been highly interlinked with the project of porting the Green System into a client-server architecture. Insights from the work practices in hospitals, and experiences with design methods discovered in the SAIK project have constantly been feed into this effort. Furthermore, the design principles in the PATIENT SCHEDULER have illustrated potential features to be included in a future version of the system, and have constantly been evaluated in the project. The overall conclusion is, that the SAIK project has raised a considerable awareness of the importance of designing for cooperation and co-ordination of medical work, and that the project has supplied concrete solutions of how to do that.

The porting of the Green System at KMD has, however, been postponed several times, and has been subject to changes in strategic decisions concerning the underlying client-server technology. Therefore, the porting has only been initialized late in the SAIK project, and the work done in user-interface design, has to be re-done. Furthermore, due to the contract-based way of developing large public computer systems, which are strictly tied to fixed requirement specifications stated in the competitive tender, the goals of KMD have primarily been to comply to the contract, regardless of the insights obtained in the SAIK project.

6.2.3 Applicable Objectives

> "The knowledge obtained through the investigation at the University Hospitals will be integrated directly in relevant development projects at KMD. The two central projects are the re-design of the Green System and the design of Electronic Patient Records."

As discussed above, the design of the PATIENT SCHEDULER and the design methods used in the project have been applied in the re-design of the Green System. The same tight contact to the development of Electronic Patient Records (EPR) has not existed – partly because the development of EPRs was at the outset of the Industrial Research project still in its initial phases. However, the insights into the cooperative nature of medical work, including the use of paper-based medical records, are directly applicable in the design of EPRs. The framework presented above helps us understand the role of a medical record as both a shared tool as well as a shared (representation of the) object of work, which helps us to design for medical cooperation through the record. Such cooperative aspects of the EPR are to a large extend overlooked at KMD at the moment, and the presented framework and methods would help design for these important sides of the record. Furthermore, some of the design principles developed in the SAIK project, as illustrated in the PATIENT SCHEDULER, can be transformed to EPRs. For example, the idea of a patient calendar would be an obvious part of an EPR, and the idea of treatment programs can be incorporated with the use of medical protocols in EPRs.

6.3   Suggestions for Future Work

Throughout the thesis several issues have been raised, but not settled. The following issues are the ones I find most pressing to address in future work.

Conceptual development. The presented framework for design of collaboration artifacts is but a start in understanding how computer-based artifacts can be used to mediate cooperation. The notion of "design for all three levels of a collaborative activity", for instance, is on a very gross level, and further development of the presented concepts needs attention.

Notations. In order to make the presented framework more operational in analysis and design of collaboration artifacts, a notational system is highly needed. We need to establish how to depict the core aspects of collaborative work, such as the distribution of work, intra- and inter-dependencies, common and conflicting motives, poly-motivation, the

dynamics of work, the three levels of collaborative work and the transitions between them, and the flow of work objects. This notation has to be applicable both as a vehicle for cooperation with users as well as in the design process.

Evaluation of methods. The usefulness of detailed workplace studies in large system development projects needs to assessed. Questions like who, when, why, and how to conduct such workplace studies need to be established. Furthermore, the usefulness of analysis patterns over time has to assessed.

Methods for identifying recurrent changes in work. The support for re-implementing of reconstructed objects of work, as well as re-routinizing new means of work has been a core argument in this work. However in order to design for the dynamic transition between the levels of collaborative work, we need methods for identifying exactly *when* such transitions take place in collaborative work, *how* often and how *important* they are.

Methods for the double iteration in design. Methods for situating the development of computer support in the middle of the primary and the secondary iteration are needed. Today methods addressing one or the other cycle exist, but methods that simultaneously help design computer systems according to both the conditions of work as well as the object of work, are needed.

A *catalogue* of useful design principles for collaboration artifacts. This final recommendation for future work is inspired by the use of design and analysis patterns. Resembling the compendiums used by construction engineers in the construction of large suspension bridges, for instance, a compendium or catalogue for construction of CSCW technologies could be maintained. Such a catalogue would contain descriptions (e.g. using analysis patterns) of how to solve recurrent aspect of cooperative work, such as handling organizational issues (employees, groups, roles, resources, organizational units, etc.), workflow, scheduling, planning, document sharing, etc.

Bibliography

[1]   Anderson, R. (1994). Representations and Requirements: The Value of Ethnography in System Design. *Human-Computer Interaction*, 9, p. 151–182.

[2]   Bannon, L. (1993). CSCW: An Initial Exploration. In *Scandinavian Journal of Information Systems*, 5, p. 3–24.

[3]   Bannon, L. & Schmidt, K. (1991). CSCW: Four Characters in Search of a Context. In J. Bowers and S. Benford (Eds.): *Studies in Computer Supported Cooperative Work*, Amsterdam, North-Holland, p. 3–16.

[4]   Bannon, L., Bjørn-Andersen, N., Due-Thomsen, B. (1988). Computer Support for Cooperative Work: An appraisal and Critique. In Bullinger, H. (Ed.), *Eurinfo'88. Information Systems for Organizational Effectiveness*, North-Holland.

[5]   Bardram, Jakob E. 1996. The Role of Workplace Studies in Design of CSCW Systems: From Passive 'Implications for Design' to Active , Cooperative Design. In *Proceeding of the 19th IRIS Conference*, Department of Informatics, Göteborg University, Sweden, p. 613–631.

[6]   Bardram, J. (1998). Designing for the Dynamics of Cooperative Work Activities. Paper to be presented at the *Fourth Congress of the International Society for Cultural Research and Activity Theory, ISCRAT 1998*, Aarhus University, Aarhus, Denmark.

[7]   Bardram, J. & Bertelsen, O. (1995): Supporting the Development of Transparent Interaction, In Blumenthal, B., Gornostaev, J. &

Unger, C. (eds.), *Human- Computer Interaction, 5th International Conference, EWHCI'95, Moscow, Russia, Selected Papers*, Berlin: Springer Verlag, p. 79–90.

[8]   Bardram, J. & Martin Sølvkjær (1996). Computer Supported Co-operative Work in Clinical Practice. In *Proceedings of The Thirteenth International Congress of the European Federation for Medical Informatics*, Copenhagen, Denmark. p. 853–857.

[9]   Bentley, R., Rodden, T. Sawyer, P. Sommerville, I. Hughes, J. Randall, D. & Shapiro, D. (1992). Ethnographically-informed systems design for air traffit control. In *Proceedings of CSCW '92, Toronto*. ACM Press.

[10]   Bertelsen, O. (1998). *Elements of a Theory of Design Artefacts: A contribution to critical systems development research.* Ph.D. Thesis, Department of Information and Media Science, Aarhus University, Aarhus, January 1998.

[11]   Beyer, H. & Holtzblatt, K. (1998). *Contextual Design: Defining Customer-Centred Systems.* San Francisco, CA: Morgan Kaufmann Publishers, Inc.

[12]   Bisgaard, O., Mogensen, P., Nørby, M. & Thomsen, M. (1989). *Systemudvikling som lærevirksomhed, konflikter som basis for organisationel udvikling [System development as learning activity, conflicts as basis for organizational deveopment]* (In Danish). Aarhus University DAIMI IR-88, Aarhus.

[13]   Bjerknes, G. & Bratteteig, T. (1988). The memoirs of two survivors: Or the evaluation of a computer system for co-operative work. In Tatar, D. (ed) *Conference on Computer-Supported Co-operative Work*, September 26–28, Portland OR, NY: ACM, p. 167–177.

[14]   Blomberg, J., Giacomi, J., Mosher, A. & Swenton-Wall, P. (1993). Ethnograpic Field Methods and Their Relation to Design. In Schuler, D. & Namioka, A. (eds.) *Participatory Design: Principles and Practices*, Hillsdale NJ: LEA.

[15]   Bowker, G., Star, S., Turner, W. & Gasser, L. (eds.) (1997) *Social Science, Technical Systems, and Cooperative Work: Beyond the Great Divide.* Mahwah NJ: LEA.

[16]   Bødker, S. (1991). *Through the Interface: A Human Activity Approach to User Interface Design.* Hillsdale, NJ: LEA.

[17]   Bødker, S. & K. Grønbæk (1991): Design in Action: From Prototyping by Demonstration to Cooperative Prototyping. In Greenbaum, J. & Kyng, M. (eds.) *Design at Work: Cooperative Design of Computer Systems*, Hillsdale NJ: Lawrence Erlbaum Associates, Inc., Publishers.

[18]   Bødker, S. & Mogensen, P. (1993). One woman's job is another man's articulation work. In *CoTech WG4: Developing CSCW Systems: Design Concepts.*

[19]   Bødker, S., Christiansen, E., Ehn, P., Markussen, R., Mogensen, P., & Trigg, R. (1993). The AT Project: Practical Research in Cooperative Design. Computer Science Department, Aarhus University, Denmark, DMMI PB – 454.

[20]   Bødker, S. & Christiansen, E. (1997) Scenarios as Springboards in Design CSCW, In Bowker, G., Star, S., Turner, W. & Gasser, L. (eds.) (1997) *Social Science, Technical Systems, and Cooperative Work: Beyond the Great Divide.* Mahwah NJ: LEA.

[21]   Carroll, J. (ed.) (1995). *Scenario Based Design: Envisioning work and technology in system development.* New York: John Wiley & Sons, Inc.

[22]   Carstensen, P. H. (1995). *Computer Supported Coordination.* Ph.D. Thesis, Department of Computer Science, Roskilde University, December 1995.

[23]   Christensen, S. (1992). *Coloured Petri Nets: Theory, Tools and Practice.* Ph.D. Thesis, Computer Science Department, Aarhus University, DAIMI IR – 112, June 1992.

[24]   Christensen, M., Crabtree, A., Damm, C., Hansen, K., Madsen, O., Marqvardsen, P., Mogensen, P., Sandvad, E., Sloth, L. &

Thomsen, M. (1998). The M.A.D. Experience: Multiperspective Application Development in evolutionary prototyping. In *Proceedings of the European Conference on Object-Oriented Programming (ECOOP'98).*

[25]   Clement, A. & Van den Besselaar, P. (1993). A retrospective look at PD Projects. *Communications of the ACM,* 36 (6), p. 29–37.

[26]   Cole, M. & Engeström, Y. (1993). A Cultural-Historical Approach to Distributed Cognition. In Salomon, G. (ed.) *Distributed Cognitions: Psychological and Educational Considerations.* Cambridge MA: Cambridge University Press.

[27]   COMIC D2.1. *Informing CSCW System Requirements.* Technical Report, Lancaster & Manchester University, October 1993.

[28]   Crowston, K. (1994). A Taxonomy Of Organizational Dependencies and Co-ordination Mechanisms. *MIT Center for Coordination Science Working Paper*, Massachusetts Institute of Technology, August 1994, (available from http://ccs.mit.edu/ccsmain.html).

[29]   DeSanctis, G. & Gallupe, B. (1987). A foundation for the study of group decision support systems. *Management Science*, 33 (5), p. 580–609.

[30]   Dybkjær, L. & Christensen, S. (1994). *INFO-SOCIETY 2000-Report from the Committee on the Information Society by the Year 2000.* København: Schultz. (available in English at http://www.fsk.dk/fsk/publ/info20000-uk/).

[31]   Egger, E. & Wagner, I. (1993). Negotiating Temporal Orders. The Case of Collaborative Time Management in a Surgery Clinic. *Computer Supported Cooperative Work, Klüwer, Dordrecht*, 1, p. 255–275.

[32]   Ehn, P. (1988). *Work-Oriented Design of Computer Artifacts.* Stockholm: Arbetslivscentrum.

[33]   Ehn, P. (1993). Scandinavian Design: On Participation and Skill. In Schuler, D. & Namioka, A. (eds.) *Participatory Design: Principles and Practices*, Hillsdale NJ: LEA.

[34]   Ehn, P. & Sjögren, D. (1991). From System Descriptions to Scripts for Action. In Greenbaum, J. & Kyng, M. (eds.) *Design at Work: Cooperative Design of Computer Systems*, New Jersey: LEA.

[35]   Engeström, Y. (1987): *Learning by Expanding: An activity-theoretical approach to developmental research,* Helsinki: Orienta-Konsultit Oy.

[36]   Engeström, Y., Brown, K., Christopher, L. & Gregory, J. (1997). Coordination, Cooperation, and Communication in the courts. In Cole, M., Engeström, Y., and Vasquez, O. (Eds.) *Mind, Culture, and Activity,* Cambridge: Cambridge University Press, p. 369–385.

[37]   EuroCODE D-1.1. *The EuroCODE Conceptual Framework,* Aarhus University, 17 June 1993. CODE-EMP-93-1.

[38]   Fichtner, B. (1984). Co-ordination, co-operation and communication in the formation of theoretical concepts in instruction. In Hedegaard, M. Hakkarainen, P. & Engeström, Y. (eds.) *Learning and teaching on a scientific basis.* Aarhus: Aarhus University, Psykologisk Institut, p. 207–228.

[39]   Fowler, M. (1997). *Analysis Patterns: Reusable Object Models.* Reading, MA: Addison-Wesley.

[40]   Galbraith, J. (1973). *Designing Complex Organizations.* Reading, MA: Addison-Wesley Publishing Co.

[41]   Gamma, E., Helm, R., Johnson, R. & Vlissides, J. (1995). *Design Patterns: Elements of Reusable Object-Oriented Software.* Reading, MA: Addison-Wesley.

[42]   Georgakopoulos, D., Hornick, M. & Sheth, A. (1995). An overview of Work-flow Management: From Process Modeling to Workflow Automation Infrastructure. *Distributed and Parallel Databases*, 3, p. 119–153.

[43]   Goguen, J. (1997). Toward a Social, Ethical Theory of Information. In Bowker, G., Star, S., Turner, W. & Gasser, L. (eds.) *Social Science, Technical Systems, and Cooperative Work: Beyond the Great Divide.* Mahwah NJ: LEA.

[44]   Gould, J. (1988). How to Design Usable Systems. In Helander, M. (ed.) *Handbook of Human-Computer Interaction*, Amsterdam: Elsevier, p. 757–789.

[45]   Greenbaum, J. & M. Kyng, (1991) *Design at Work: Cooperative Design of Computer Systems*, New Jersey, Lawrence Erlbaum Associates, Inc., Publishers.

[46]   Grinter, R. (1997). Doing Software Development: Occasions for Automation and Formalisation. In *Proceedings of the 5th European Conference on Computer Supported Cooperative Work*, Lancaster, UK. Kluwer Academic Publishers.

[47]   Grudin, J. & Grinter, R. (1995). Ethnography and Design – a commentary. *Computer Supported Cooperative Work*, 3, p. 55–59.

[48]   Grudin, J. & Poltrock, S. (1997). Computer-Supported Cooperative Work and Groupware. In *Advances in Computers*, 45, p. 269–320.

[49]   Grønbæk, K. (1991). *Prototyping and Active User Involvement in System Development: Towards a Cooperative Prototyping Approach.* Ph.D. Thesis, Computer Science Department, Aarhus University, January 1991.

[50]   Grønbæk, K., Kyng, M. & Mogensen, P. (1993). CSCW Challenges: Cooperative Design in Engineering Projects. *Communication of the ACM*, 36(6), p. 67–77.

[51]   Grønbæk, K., Kyng, M. & Mogensen, P. (1997). Toward a Cooperative Experimental System Development Approach, In Kyng, M. & Mathiassen, L. (eds.) *Computers and Design in Context*, Cambridge, MA: The MIT Press, p. 201–238.

[52]   Heath, C. & Luff, P. (1991). Collaborative Activity and Technological Design: Task Coordination in London Underground Control Rooms. In *Proceedings of the Second European Conference on Computer-Supported Cooperative Work (ECSCW'91)*. Amsterdam: Kluwer Academic Publishers, p. 65–80.

[53]   Heath, C. & Luff, P. (1996). Documents and Professional Practice: 'bad' organisational reasons for 'good' clinical records, In *Proceedings of the ACM 1996 Conference on CSCW*, Cambridge, MA USA. ACM Press, p. 354–363.

[54]   Hodder, I. (1994). The Interpretation of Documents and Material Culture. In Denzin, N. & Lincoln, Y. (eds.) *Handbook of Qualitative Research.* Thousand Oaks, CA: SAGE Publications.

[55]   Hughes, J., Randall, D. & Shapiro, D. (1991). CSCW: Dicipline or Paradigm? A Sociological Perspective. In Bannon, L., Robinson, M. & Schmidt, K. (eds.) *Proceedings of the 2nd European Conference on CSCW.* Amsterdam: Kluwer, p. 309–323.

[56]   Hughes, J., King, V., Rodden, T. & Andersen, H. (1994). Moving Out from the Control Room: Ethnography in System Design. In *Proceedings of CSCW 1994, Chapel Hill, North Carolina*, ACM.

[57]   Hughes, J., King, V., Mariani, J., Rodden, T. & Twidale, M. (1996). Paperwork and its Lessons for Database Systems: an Initial Assessment. In Shapiro, D., Tauber, M. & Traunmuller, R. (eds.) *The Design of Computer Supported Cooperative Work and Groupware Systems.* Amsterdam: Elsevier.

[58]   Hutchins, E. (1995). *Cognition in the Wild.* Cambridge, MA: The MIT Press.

[59]   Hutchins, E. (1997). Mediation and automatization. In Cole, M., Engeström, Y., and Vasquez, O. (Eds.) *Mind, Culture, and Activity*, Cambridge: Cambridge University Press, p. 338–353.

[60]   Hutchins, E. & Klausen, T. (1996). Distributed Cognition in an Airline Cockpit. In Engeström, Y. & Middleton, D. (eds.) *Cognition and Communication at Work.* Cambridge MA: Cambridge University Press.

[61]   Jacobson, I., M. Christersson, P. Jonsson, and G. Övergaard. (1992). *Object-Oriented Software Engineering – A Use-case Driven Approach.* Reading, MA: Addison-Wesley.

[62]   Jacobson, I. (1998). Objectory is the Unified Process. *Object Magazine*, April 1998.

[63]   Jensen, U. (1989). Den kulturhistoriske psykologi: Ideologisk metafysik eller objektiv teori? [The cultural-historical psychology: Ideological meta-physics or objective theory?]. In Hedegaard, M., Hansen, V., & Thyssen, S. (eds.) *Et virksomt liv [An active life].* Aarhus: Aarhus Universitetsforlag.

[64]   Johansen, J. (1988). *Groupware. Computer Support for Business Teams.* New York and London: The Free Press.

[65]   Jordan, B. (1996). Ethnographic Workplace Studies and CSCW. In Shapiro, D., Tauber, M. & Traunmüller, R. (eds.) *The Design of Computer Supported Cooperative Work and Groupware Systems.* Amsterdam: Elsevier.

[66]   Kaptelinin, V. (1996). Computer-Mediated Activity: Functional Organs in Social and Developmental Contexts. In Nardi, B. (ed.) (1996): *Context and Consciousness: Activity Theory and Human-Computer Interaction.* Cambrigde, MA: MIT Press, p. 45–68.

[67]   Kensing, F. & Madsen, K.H. (1991). Generating Visions: Future Work-shops and Metaphorical Design. In Greenbaum, J. & Kyng, M. (Eds.) *Design at Work: Cooperative Design of Computer Systems*, Hillsdale NJ: LEA.

[68]   Kensing, F., Simonsen, J. & Bødker, K. (1996). MUST – a method for participatory design. In *Proceedings of the Participatory Design Conference (PDC'96),* Cambridge, MA, USA, 13-15 Nov., p. 129–140.

[69]   Kling, R. (1991). Cooperation, Coordination and Control in Computer Supported Cooperative Work, *Communication of the ACM*, 34(12), Dec. 1991, p. 83–88.

[70]   Kuutti, K. (1994). *Information Systems, Cooperative Work and Active Subjects: The Activity-Theoretical Perspective.* Ph.D. Thesis, Department of Information Processing Science, University og Oulu, Oulu, August 1994.

[71]   Kyng, M. (1995). Creating Contexts for Design. In Carroll, J. (ed.) *Scenario Based Design: Envisioning work and technology in system development*, New York: John Wiley & Sons, Inc.

[72]   Kyng, M. (1996). *Users and Computers: A Contextual Approach to Design of Computer Artifacts.* Doctoral Thesis, Aarhus University, DAIMI PB – 507, May 1996.

[73]   Latour, B. (1996). Review of Cognition in the Wild. *Mind, Culture, and Activity*, 3 (1), p. 54–63.

[74]   Leont'ev, A. N. (1978). *Activity, Consciousness, and Personality*, Englewood Cliffs NJ: Prentice-Hall.

[75]   Leont'ev, A. N. (1981). The problem of activity in psychology. In Wertsch, J. (ed.) *The Concept of Activity in Soviet Psychology.* Armonk, NY: M. E. Sharpe.

[76]   Leont'ev, D. A. (1992). Joint Activity, Communication, and Interaction (Toward Well-grounded "Pedagogy of Cooperation"). *Journal of Russian and East European Psychology*, 30 (2), p. 43–58.

[77]   Louw, G. (1995). Reducing the need for computer-based information systems in healthcare through the use of self-contained organizational units. In Orlikowski, W., Walsham, G., Jones, M. & DeGross, J. (eds.) *Information Technology and Changes in Organizational Work,* London: Chapman & Hall.

[78]   Lyytinen, K. (1986). *Information Systems Development as Social Action: Framework and Critical Implications.* Ph.D. dissertation, Jyväskylä: University of Jyväskylä.

[79]   MacLean, A., Young, R., Bellotti, V. & Moran, T. (1991). Questions, Options, and Criteria: Elements of Design Space Analysis. *Human-Computer Interaction*, 6, p. 201–250.

[80]   Malone, T. & Crowston, K. (1990). What is Coordination Theory and How Can It Help Design Cooperative Work Systems?, In *Proceedings of the Conference on CSCW, Los Angeles, CA, USA.* ACM Press, p. 357–370.

[81] Malone, T. & Crowston, K. (1994). The interdisciplinary study of coordination, *ACM Computing surveys.*

[82] Mammen, J. (1993). The Elements of Psychology. In N. Engelsted, M. Hedegaard, B. Karpatschof, & A. Mortensen (eds.), *The Societal Subject.* Aarhus: Aarhus University Press.

[83] Mathiassen, L., Munk-Madsen, A., Nielsen, P. & Stage, J. (1993). *Objektorienteret Analyse [Object-Oriented Analysis]* (In Danish), Aalborg: Marko.

[84] Mathiassen, L., Munk-Madsen, A., Nielsen, P. & Stage, J. (1995). *Objektorienteret Design [Object-Oriented Design]* (In Danish), Aalborg: Marko.

[85] McGrath, J. E. (1990). Time Matters in Groups. In Galegher, J., Kraut, R. & Egido, C. (eds.) *Intellectual Teamwork: Social and Technological Foundations of Cooperative Work*, Hillsdale, NJ: Lawrence Erlbaum Associates, p. 173–190.

[86] McGrath, J. E. and Kelly, J. R. (1986). *Time and Human Interaction: Toward a Social Psychology of Time.* New York, Guilford Press.

[87] Mogensen, P. (1994). *Challenging Practice: An Approach to Cooperative Analysis.* Ph.D. Thesis, Computer Science Department, Aarhus University, DAIMI PB – 465, January 1994.

[88] Nardi, B. (ed.) (1996a): *Context and Consciousness: Activity Theory and Human-Computer Interaction.* Cambrigde, MA: MIT Press.

[89] Nardi, B. (1996b). Concepts of Cognition and Consciousness: Four Voices. *Australian Journal of Information Systems*, 4 (1), p. 64–69.

[90] Nardi, B., Kuchinsky, A., Wittaker, S., Leichner, R. & Schwarz, H. (1995). Video-as-Data: Technical and Social Aspects of a Collaborative Multimedia Application. *Computer Supported Cooperative Work*, 4 (1), p. 73–100.

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

[92]   Patton, M. (1990). *Qualitative Evaluation and Research Methods, 2nd edition.* Newbury Park: SAGE.

[93]   Petrovsky, A. V. (1983). Toward the construction of a social psychological theory of the collective. *Soviet Psychology*, XXI (2), p. 3–21.

[94]   Petrovsky, A. V. (1985). *Studies in Psychology: The collective and the Individual.* Moscow: Progress Publishers.

[95]   Pycock, J. & Bowers, J. (1996). Getting Others to Get it Right: An Ethnography of Design Work in the Fashion Industry. In *Proceedings of the ACM 1996 Conference on CSCW*, Cambridge, MA USA. ACM Press, p. 354–363.

[96]   Prinz, W. & Kolvenbach, S. (1996). Support for Workflow in a Ministerial Environment. In *Proceedings of the ACM 1996 Conference on Computer Supported Cooperative Work (CSCW96)*, Cambridge, MA, ACM Press.

[97]   Raeithel, A. (1992). Activity Theory as a Foundation for Design. In Floyd, C., Züllighoven, H., Budde & Keil-Slavik, R. (eds.) *Software development and reality construction.* Berlin: Springer Verlag. p. 391–415.

[98]   Raeithel, A. (1996). From coordinatedness to Coordination via Cooperation and Co-construction. Paper presented at *Workshop on Work and Learning in Transition*, San Diego, January 1996.

[99]   Robinson, M. (1993). Common Artefacts in the Design of Computer Support for Cooperative Work. In *CoTech WG4: Developing CSCW Systems: Design Concepts.*

[100]   Robinson, M. (1997). "As real as it gets ... " Taming Models and Reconstructing Procedures. In Bowker, G., Star, S., Turner,

W. & Gasser, L. (eds.) *Social Science, Technical Systems, and Cooperative Work: Beyond the Great Divide.* Mahwah NJ: LEA.

[102]   Rogers, Y. & Ellis, J. (1994). Distributed Cognition: An alternative framework for analysing and explaining collaborative working. *Journal of Information Technology*, 9, p. 119–128.

[103]   Rumbaugh, J., Blaha, M., Premerlani, W., Eddy, S. & Lorensen, W. (1991). *Object-Oriented Modelling and Design.* Englewood Cliffs, NJ: Prentice-Hall.

[104]   Schmidt, K. & Bannon, L. (1992). Taking CSCW Seriously: Supporting Articulation Work. *Computer Supported Cooperative Work (CSCW. An International Journal*, 1 (1-2), p. 7–40.

[105]   Schmidt, K. & Simone, C. (1996). Coordination mechanisms: Towards a Conceptual Foundation of CSCW Systems Design, *Computer Supported Cooperative Work*, vol. 5, pp. 155–200.

[106]   Schneider, K. & Wagner, I. (1993). Constructing the 'Dossier Représentatif': Computer-Based Information-Sharing in French Hospitals. *Computer Supported Cooperative Work, Klüwer, Dordrecht*, 1, p. 229–253.

[107]   Schrage, M. (1996). Cultures of Prototyping. In T. Winograd (ed.), *Bringing Design to Software*, New York, NY: ACM Press.

[108]   Schäl, T. (1996): *Workflow Management Systems for Process Organisations.* Berlin: Springer Verlag.

[109]   Sharrock, W. & Button, G. (1997). On the Relevance of Habermas' Theory of Communicative Action for CSCW. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, 6, p. 369–389.

[110]   Shapiro, D. (1994). The Limits of Ethnography: Combining Social Science for CSCW. In *Proceedings of ACM 1994 Conference on Computer Supported Cooperative Work*, Chapel Hill, NC, USA: ACM Press.

[111]   Sommerville, I., Rodden, T., Sawyer, P., Bentley, R. & Twidale, M. (1993). Integrating Ethnography into the Requirements engineering Process. ln *RE'93, IEEE International Symposium on Requirements Engineering*, San Diego, CA, p. 341–354.

[112]   Strauss, A. & Corbin, J. (1994). Grounded Theory Methodology: An Overview. In Dentin, N. & Lincoln, Y. (eds.) *Handbook of Qualitative Research.* Thousand Oaks, CA: SAGE Publications.

[113]   Suchman, L. (1983). Office Procedures as Practical Action: Models of Work and System Design. *ACM Transactions on Office Information Systems*, 1 (4), p. 320–328.

[114]   Suchman, L. (1987). *Plans and situated actions. The problem of human-machine communication.* Cambridge MA: Cambridge University Press.

[115]   Suchman, L. & Trigg, R. (1991): Understanding Practice: Video as a Medium for Reflection and Design. In Greenbaum, J. & Kyng, M. (eds.) *Design at Work: Cooperative Design of Computer Systems*, Hillsdale NJ: Lawrence Erlbaum Associates, Inc., Publishers.

[116]   Sundhedsministeriet (1998). *Rapport fra udvalget om ventetidsoplysniger og elektronisk booking* [Report from the commision concerning waiting time information and electronic booking systems]. (In Danish), Kobenhavn: Nyt Nordisk Forlag (tilgængelig på www.sum.dk).

[117]   Symon, G., Long, K., & Ellis, J. (1996). The Coordination of Work Activities: Cooperation and Conflict in a Hospital Context, *Computer Supported Cooperative Work*, vol. 5, p. 1–31.

[118]   Sørgaard, P. (1988a). Object Oriented Programming and Computerised Shared Material. In S. Gjessing & K. Nygaard (eds.), *Proceedings of the 2nd European Conference on Object Oriented Programming (ECOOP'88)*, Heidelberg: Springer Verlag, p. 319–334.

[119]   Sørgaard, P. (1988b). A Discussion of Computer Supported Cooperative Work: Overview Paper. Ph.D. Thesis, Computer Science Department, Aarhus University, *DAIMI PB-254*, May 1988.

[120]   Sørgaard, P. (1989). A Framework for Computer Supported Cooperative Work. *DAIMI PB-253*. Aarhus: Aarhus University.

[121]   Vallgårda, S. (1992). *Sygehuse og sygehuspolitik i Danmark: Et bidrag til det specialiserede sygehusvæsens historie 1930-1987 [Hospitals and hospital politics in Denmark: A contribution to the history of the specialised hospital sector 1930-1987]*. København: Jurist- og Økonomforbundets Forlag.

[122]   Vidich, A. & Lyman, S. (1994). Qualitative Methods: Their History in Sociology and Antropology. In Denzin, N. & Lincoln, Y. (eds.) *Handbook of Qualitative Research.* Thousand Oaks, CA: SAGE Publications.

[123]   Wertsch, J. (1981). (ed.) *The concept of activity in Soviet psychology.* Armonk, NY: Sharpe.

[124]   Wertsch, J. (1985). *Vygotsky and the Social Formation of Mind.* Cambridge, MA: Harvard University Press.

[125]   Winograd, T. and Flares, F. (1986). *Understanding Computers and Cognition: A New Foundation for Design.* Norwood, NJ: Ablex Publishing Corp.

Part II

Organisational Prototyping

Adopting CSCW Applications in Organisations

Jakob E. Bardram

Computer Science Department,
Aarhus University, Denmark

"[A] particularly central aspect of implementing groupware is ensuring that prospective users have an appropriate understanding of the technology, that, is that their technological frames reflect a perception of the technology as a collective rather than a personal tool."
- Orlikowski 1992, p. 368

Abstract

The usefulness of applications which support cooperative work depends in its very nature on the way the cooperative work practice is organised. At the same time, the adoption of new technology is difficult and complex because of the amount of people involved and their distribution in time and space. This paper explores the possibilities of addressing this adoption process in a more simplified, yet systematic way without losing the focus on the interdependencies which characterise cooperative work. The notion of adoption is discussed as a dual process of adapting both the computer support to the work and adapting the work to the computer. A method called organisational prototyping is presented which aims at facilitating this adoption process. A case illustrates how organisational prototyping was used in the adoption of a cooperative tool for managing projects within a large engineering company in Denmark.

102

1 Introduction

Within the field of CSCW it has been widely recognised that the acceptance of a system is very sensitive to the way in which it is introduced into an organisation (Erhlich 1987, Grudin 1994)[4, 7]. The process of adopting a computer application meant to support cooperative work often implies changing the work practices in order to fully utilise its new potentials. Orlikowski (1992)[12] gives an excellent example of how the cultural aspect of work practice must be taken into consideration to ensure a successful adoption of a CSCW application. Orlikowski raises the general question of "how to anticipate the required structural and cognitive changes when the technology is brand new" (p. 368). This paper provides a method for addressing this question.

Okamura *et al.* (1994)[11] answer the question by suggesting the use of *mediantors*, that is individuals who deliberately intervene with organisational authorisation in the ongoing use of CSCW technology. In this respect, "these mediators adapt a new collaborative technology to a context, modify the context as appropriate to accommodate use of the technology and support ongoing changes to the technology and context over time" (p. 56). These mediators can be very useful in introducing new technologies to an organisation, as described by Okamura *et al*[11]. But having mediators stand between developers and users may not always be useful. Because these mediators lack a deeper knowledge of the workplace, they may be insensitive to important aspects of how to organise the work (e.g., the way related tasks are handled and social dynamics in the workplace) (Grudin 1994)[6]. At the same time the interests and motives are not necessarily the same for the mediator and the users, thereby leaving behind a clarification of who is responsible for reorganising the work.

Grudin & Palen (1995)[7] found that 'evangelists', as such mediators can be characterised, did not explain the adoption of a groupware technology within the organisations they studied. Instead, they found widespread reports on peer pressure where the adoption spread according to a bottom-up pattern. Thus, groupware can succeed without managerial mandate. Helped by the technological feature of the application it can attract a critical mass of users, after which a social pressure by peers and others extends the use into an organisation. From a design perspective, ensuring that users gradually adopt

the system by providing flexible technological features seems to be generally advocated. As stated by Kreifelts *et al.* (1993)[9]: "we would like to have coordination systems that encourage *self-organisation* of cooperative work by the end-users themselves" (p. 33).

However, this strategy of relying on technological features to encourage a critical mass of people to use the system raises two questions: Firstly, how can the use of the computer system within a specific work environment be organised. Even when the adoption is spreading bottom-up, the future use of a computer system has to be established within the overall work practices at some point in the process. This means that issues of establishing a division of labour, responsibility, procedures for general use and error handling, etc. have to be addressed and socially agreed upon within the work setting. Secondly, how can we from a design perspective establish which features will mediate the acceptance of the technology within an organisation. In other words, how do we establish the functionality and central ideas of the computer system and how can computer support for cooperative work be designed and evaluated in the development process. Even when adopting standard groupware technology, the issue of design is important. The technological features of groupware systems are not static, but often need to be tailored according to the different preferences and constraints within a work setting. The notion of tailorable and flexible computer tools which do not enforce rigid ways of performing work supported by a computer has been strongly emphasised within CSCW (Trigg and Bødker, 1994)[14]. The use of such flexible tools has be organised within the specific work environment which they are to support, and the tool has to be tailored (i.e. designed) according to this organisation of work.

In this paper the process of adopting a CSCW tool in a work setting is discussed as a *dual process* of both adapting the organisation of work to the conditions of the tool, and adapting the tool to meet this organisation of work. The case reported here shows how a participatory design method, which we have chosen to call 'organisational prototyping', facilitated this two-way process of adopting a CSCW application within a social organisation of work. By applying organisational prototyping in the design of computer support for the collaborative activity of project management, the possibilities and constraints of such a tool were examined. By both addressing the design of the tool and it's use within the work practices of project mangment, or-

104

ganisational prototyping facilitated a process of both adapting the tool, and changing the organisation of work according to the conditions of the tool.

2   The Project Manager

The Project Manager was developed in close cooperation with the managers of a large engineering company, Delta Corporation (a pseudonym), which manufactures components for oil-burners, such as oil-pumps, nozzles and ignition units. A group of seven top-managers and two designers developed a prototype for a project management system during a period of 8 months. The project had a clear design objective aiming to investigate the possibilities of developing a tool to support the collaborative task of managing projects, and therefore we did not use any of the standard software packages for project management available on the market. As a research project, the project ended after the period, and the project manager remained a prototype.

The requirement for the Project Manager was explored during a participatory design process applying qualitative interviews, observations, future workshops, and prototyping (for a description of the design methods mentioned, see e.g. Greenbaum & Kyng 1991[5]). Furthermore, the different artefacts, and how these artefacts were applied in managing projects were studied. These artefacts included paper-based forms, bar charts and a computer-based system.

2.1   The background of the Project Manager

Basically, there were two kinds of projects at Delta: development of new products and modification to old ones. Both types were typically initiated by customer demands. Projects could vary from small projects involving a single employee during a week, to very large projects involving 20-30 employees lasting up to two years. Managing projects was a central activity at Delta done primarily by coordinating sub-activities at different management meetings and filling in paper-based forms. A previous attempt to support this activity was a computer-based system provided by the central computer department at Delta. This system supported registration of the economic

goals and spending of a project, and served primarily as an accounting system oriented toward the financial history of the project. The system did not support the creative planning and coordination of future activities, which was the main challenge of managing projects. Filling in all the details on expenses of a project became an extra work load which did not help keeping track of future activities in the project. The system was rejected after a period of use, and Delta returned to manage its projects through meetings and standard paper forms.

The analysis of project management at Delta became the input for a future workshop which revealed three central problems: There was a lack of *structure* in handling projects, something which the management at Delta perceived as vital for improved project handling. Projects were handled in a very ad hoc fashion at the meetings. Some were discussed because of breakdowns, others because of questions from impatient customers, and still others because of an inquiry from one of the managers wanting to know "What is going on?". This way of handling projects led to a lack of *overview*, both a general overview of all the active projects and the relations between them, and an overview within the individual project which could last several months and involve many different people. Finally, there was the problem of determining the *priority* of the projects, which was difficult because of the lack of overview and the ad hoc nature of the project handling at Delta.

Combining the experiences of using the old system and the three central problems in handling projects at Delta, it was possible to list three demands for a computer-based tool supporting the management of projects:

- The tool had to *support communication*. The coordination of activities in the projects was central to project management. This was done at various project meetings at which the different managers and their departments made commitments and agreements to handle different parts and activities in the project within certain resource limits (time, money, staff, tools and machinery, etc.)

- The tool should provide an *overview* of the projects, both within individual projects and between all projects. This overview should also support the process of prioritising the projects when necessary.

- The tool had to be *simple* with a visual representation of the status
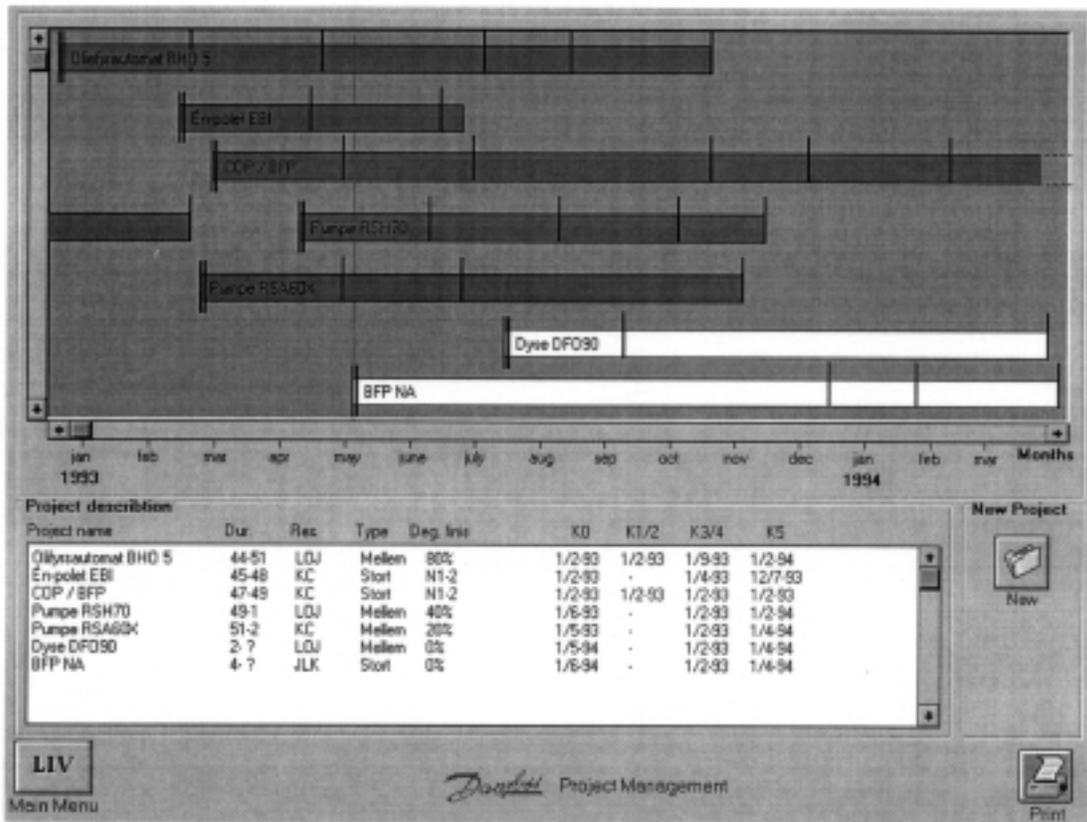
Figure 1: The project list

and with a minimum of inputs. This demand was primarily due to the experience with the old system.

These three demands were working against each other. For instance, in order to make a correct priority the managers must know the resource bottlenecks. The overview is not complete if the demand for, and use of, resources is lacking. But registration of the use and allocation of resources to a project could make project management a very cumbersome task, as in the old system. Another problem is maintaining an overview of communication. The volume of notes, requests, answers, etc. in a project can take on enormous dimensions. Keeping an overview in all the recorded communication in a project would be impossible.

107

A prototype for a Project Manager was constructed through several iterations trying to resolve these contrasting demands. The following section describes the final version.
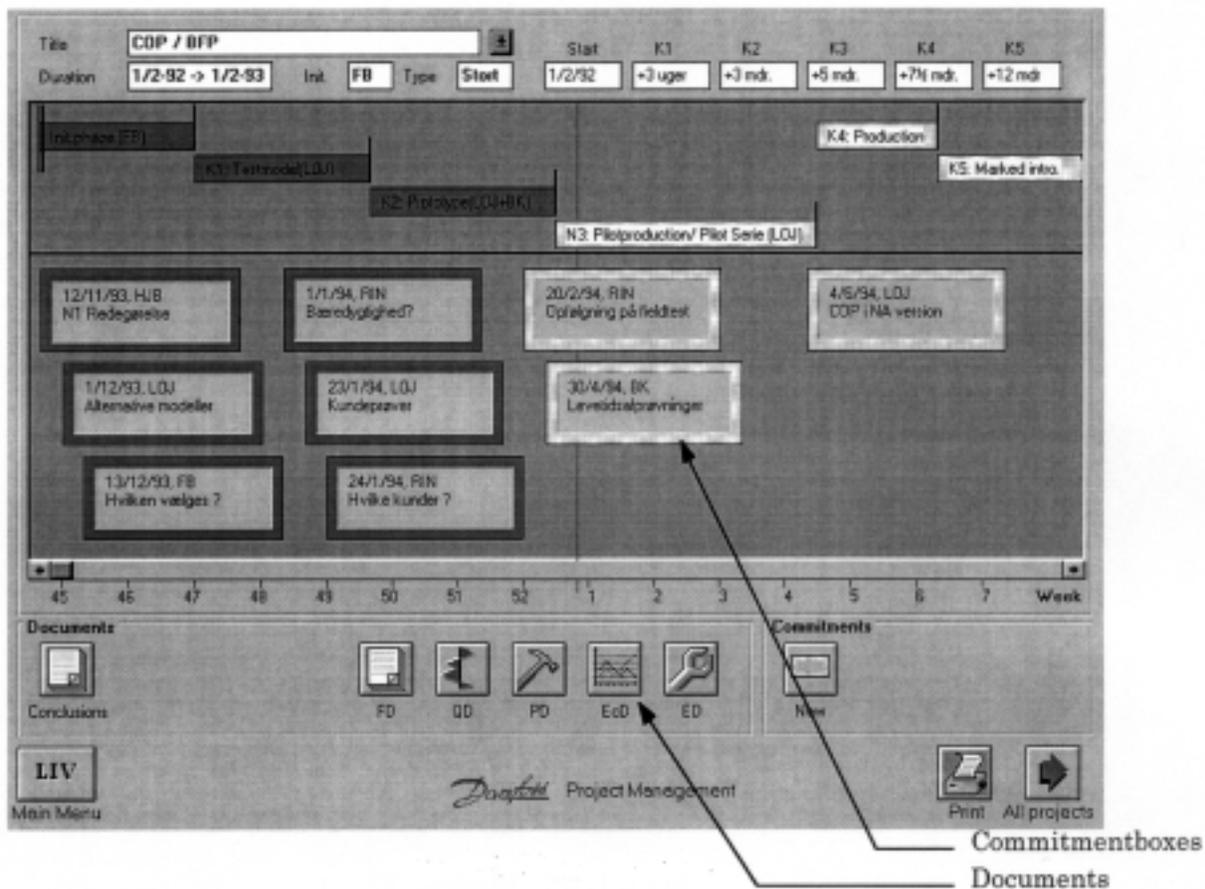
Figure 2: The project view

2.2 The basic concepts of the Project Manager.

Basically, the Project Manager is divided into two views: One view provides a list of all the projects at Delta, and the other presents a view of each individual project.

The project list (figure 1) gives an overview of all current, completed and future planned projects. This is done through a graphical representation of the temporal order of the projects (Gantt chart) and a textual list of the most important attributes: project name, duration, person responsible, project type, degree of completion and the different key points in the project. The projects can be sorted according to the different characteristics of a project: date of expiration, responsible person, type, etc. Colours are used to indicate the temporal status of the project, like red for delayed, light brown for terminated, etc.

In most cases, the project list will suffice to give the overview needed, but more detailed information on a project can be obtained from the project view (figure 2). The uppermost part of the project view displays the attributes of the project. The bars have the same colour coding as the ones in the project list. In addition to this more traditional temporal overview, the project view also gives an overview of and access to the communication concerning the project. This is done through commitment boxes and the document icons placed in the lower part of the project view.

The commitment boxes can contain any kind of relevant communication between involved persons in the project. This includes requests, offers, status reports, promises, commitments, notes of interest, answers to all these, etc. Hence, the boxes are open for any kind of communication, even communication not related to the project. The form of these messages is very similar to ordinary email with a date, a sender, a subject and some free text, except that the 'receiver' is the specific project.

The document icons represent hyperlinks to documents and drawings attached to a project. They are accessible for editing in the word processor and the CAD system used at Delta. These documents are the same as the paper-based ones previously made during a project and have been divided historically into five categories of reports: business potentials (BD), quality (QD), production (PD), economics and budget (EcD), and engineering (ED). The 'conclusion document' contains an automatically updated overview over the latest conclusions from the other five documents.

3   Organisational Prototyping

A clear shortcoming of the traditional use of prototypes is the focus on individual use of an application in terms of functionality and user interface of the tool. Prototyping sessions seldomly touch upon the cooperative context in which the tool is to be used in the future. This reflects that the evaluation process of CSCW systems is more complex than that of single user applications (Grudin, 1994[6]). Evaluation and design for cooperative work settings can be remarkably time consuming, due to the number of people involved, because most cooperative work unfolds over days and weeks, and because it is distributed across several sites. There is a variability of group composition and a range of environmental factors, which all are important factors in determining how the tool should be designed and applied within a work setting. As the purpose of CSCW applications is to support the mutual dependencies of the actors involved in cooperative work, distributed in time and place, this complexity seems unavoidable (see e.g. the work done in the COMIC project; COMIC D2.1 1993[2]). This could lead to a rejection of using incomplete prototypes and mock-ups, because it would be impossible to observe and evaluate the cooperative work, involving several persons over a longer period of time based on an incomplete prototype.

However, a method for designing and evaluating the usefulness of a computer tool which supports collaborative work was developed in the project at Delta. The method shows that the concern for increased difficulties of evaluating prototypes in collaborative work practices might not always be true. We have chosen to call this participative design session *'organisational prototyping'* according to the two main inspirations for the method: organisational games (Ehn and Sjögren, 1991[3]) and cooperative prototyping (Grønbæk, 1991[8]; Bødker and Grønbæk, 1991[1]).

3.1   The components of organisational prototyping

The adoption process mediated through the organisational prototyping is defined as *a dual process of both adapting the tool to the organisation and adapting the work practice to the conditions of the tool.* The organisational game, as described by Ehn and Sjögren, is based on the assumption that the basic problem in the domain is not technology driven but a question of

organisational change and education. However, to maintain the relationship between future organisation of work and the design of the tool supposed to support this work, the method of organisational prototyping involves a more technical focus by involving a prototype in the game. The idea is to bring people together, whose collaborative work is normally distributed in time and space, and initiate a discussion of new ways to organise work and of the technological opportunities and constraints of supporting this work by computers. The session should simulate realistic situations from the participants' daily work, trying to sustain positive aspects of the organisation of work, and at the same time clarify and improve problematic aspects.

The components of organisational prototyping are the following: (i) As a prologue to the session one or more scenarios are introducing the prototype to the work practice in question. Based on earlier analysis and investigations the prototype is designed according to certain ideas addressing certain problems and needs within the organisation. The scenario describes how the prototype can mediate the work and thus situates the prototype within the work practice. A central component of organisational prototyping is of course (ii) the **prototype** itself, containing realistic test data and providing enough functionality to illustrate and act out the different scenarios. When the session is started, the main component are (iii) the **situation cards** which introduce prototypical examples of breakdown situations. The situation cards are intended to resemble typical events and problems occurring in daily work. The cards are stacked in a pile in the middle of the participants, who draw a card on turn, read it aloud and start discussing how the problems introduced by the card can be handled. These cards are produced beforehand by the conductors of the session, based on investigations into work practices and typical problems within the organisation. In resolving the breakdowns introduced by the situation cards the participants are making *commitments* to solve the problems and the *conditions* for each commitment are discussed. These commitments and their conditions are formulated in an (iv) **action plan** for each situation card. An action plan answers the questions of *'who* will do *what, where, when, why,* and by *which means'*. Furthermore, the individual commitments made are noted in (v) a **role script** for each participant. Finally, the last component of organisational prototyping is (vi) the **playground**, which is used to save and categorise the resolved situation cards and their attached actions plans. The playground can be divided according to different work tasks, or it can be organised according to possibilities of

changing either the computer system or the organisational setting.

The outcome of an organisational prototyping session is modified and new scenarios, suggestions for redesign to the prototype, the role scripts for each participant, and the action plans for each situation card attached to the playground. The next section will illustrate how these components of organisational prototyping were produced and applied at Delta.

4 Organisational prototyping at Delta

The organisational prototyping session at Delta was set up to simulate project management as it was done at Delta, that is through meetings, use of phones and documents. The Project Manager was to assist this work as a tool for distributing messages and providing an overview of the different projects. The scenarios for using the Project Manager are illustrated in figure 3. These scenarios illustrate the outcome of the organisational prototyping session.

The situation cards were made on the basis of old project documentation and by interviewing different people about typical problems in project management. Six fictitious projects of different size, time schedule, complexity and objectives were made and represented in the Project Manager. This enabled the participants to assess the usefulness of the tool in resolving the events and breakdowns introduced by the cards. Hence, they were asked to play their normal professional roles and to make commitments to breakdowns as they would at an ordinary project meeting. The conditions for each commitment were discussed, and an action plan for solving the breakdown situation was formulated. Part of these action plans were initiated or carried out through the use of the Project Manager which was used all through the session. This placed the tool in a (simulated) work practice and thereby into a context of use. The action plans, their conditions and commitments for handling different breakdown situations were written down and put on a bulletin board representing the playground. In organisational games the playground is normally divided into the different tasks involved in the work in question. At Delta, however, the playground was divided according to the kind of changes needed to be implemented by the end of the session. These categories were made according to whether the action plan could be realised (i) with the Project Manager, (ii) without it, (iii) with a redesigned or extended version

of it, or (iv) with organisational changes in Delta. An action plan could be placed in several categories.

The organisational prototyping at Delta took a total of 5 hours which is considerably shorter than the organisational game described by Ehn & Sjögren[3]. Nevertheless, it was still possible for the users to become aware of the technical and organisational requirements for making the Project Manager work successfully within Delta. The session was video-recorded, and by quoting[1] and analysing five episodes, it is illustrated how (i) the tool was adapted to support the task of project management, and how (ii) the participants during the game became aware of the role of the Project Manager within this task. Hence, the outcome of the organisational prototyping at Delta was both a clarification of the potentials and problems of the Project Manager, as well as a positioning of the tool within the overall work project of project management.

The seven participants are identified by their professional roles: HM: Head Manager, PM1: Production Manager 1, PM2: Production Manager 2, SM: Sales Manager, EM: Economic Manager, QM: Quality Manager, PM: Purchasing Manager. The designers are identified by D.

4.1 Adapting the tool to the work practice

The organisational prototyping session addressed how the prototype should be adapted or redesigned in order to support the collaborative work. The session revealed problems and opportunities of supporting the overall work, but did not address the individual use of it. The following two episodes from the session illustrate how the Project Manager was developed to support the handling of commitments, and how a completely new type of computer support, an electronic bulletin board, was introduced during the session.

Episode 1: **How the idea of commitment boxes came about.**

[We enter the session when there is a discussion on how to use the commitment boxes which were introduced in the session as 'message boxes'

---

[1]The quoting was originally in Danish and is translated by the author. The square brackets are used for explanatory notes not said by the participants.

Starting a project: After several enquiries from customers, a decision is made to make a new type of pump. This decision is made at a project meeting. An idea phase is initiated, involving the sales manager, the production manager and the quality manager along with some of their employees. This phase is to reveal whether the pump is feasible and technologically possible. The project is represented in the ProjectManager, and a deadline for the idea phase is set. If a decision is made to develop the pump, the rest of the project will be planned when this phase is over. This decision is represented by a commitment box, and at the same time the three involved managers make a commitment to fill in the FD report represented by another commitment box.

Making changes to a commitment/deadline: At a project meeting it is discussed whether the deadline for the initial prototype of the RSA pump must be postponed, because a key constructor is occupied with another project. After looking at the other projects, it is decided that the project, on which the constructor is currently working, has a higher priority. This decision is represented in the Project Manager by dragging the marker that ends the phase for the initial prototype for the RSA pump and by creating a commitment box explaining the decision of postponing the project. Another commitment box, which describes the activities which will solve the problem (e.g. transferring the constructor to work on the RSA pump at a certain date), is also made.

Follow up on a commitment: When one of the activities represented in a commitment box is completed, the person responsible uses the Project Manager to describe the result and marks the commitment box as 'done'. This change is distributed to the other PCs in the network.

Preparation for the project meeting: When the product manager prepares for the project meeting, he makes a list of all the projects in which he is involved from the project list view. If a project needs special attention (e.g. one which is coloured red), he can go into the project view and inspect the different commitments within the project and thus remind himself of the conditions for the project.

Having project meetings: A PC running the Project Manager is located in the meeting room, providing a point of reference when it is necessary to check commitments or documents. All decisions made at a meeting are put into the Project Manager right away, but sometimes it is necessary to have the secretary fill in all the details later.

Figure 3: Scenarios for using the Project Manager

114

for general purposes]

PM1. *Today we describe it [the commitments made to a project, deadlines agreed upon, etc.] in the minutes of the meeting where these agreements were made . . . .*

D. *That can be done here [in the Project Manager]. When a message box is made, detailed information can be added afterwards. This could be any kind of description. [Enters a text to illustrate the point].*

EM. *Yes – that could be done instead of the minutes. Then we would keep everything together in there [in the Project Manager]. It must be able to contain such minutes of commitments made to the projects. Then we can have an overview of that also . . . . That would surely be useful.*

Episode 2: **Invention of the meeting bulletin board.**

[The discussion of how to use the message boxes continues]

EM: *If we had production meetings on a regular basis we could probably use them [the message boxes] to ensure that certain issues were addressed. That is, not to put up a message about 'remember to do that' but a message which reminds us to address the issue on the meeting. Then, when we go to these meetings I'll assume that you take a look at this [the Project Manager] before the meeting. Then you're sure you've seen it [the message], and know that it is going to be addressed at the meeting. That is a good way of using them [the messageboxes] if thats what is meant by the word 'message'.*
[Approx. a hour later . ..]

HM. *I've got an idea. We have these product meetings every Monday where we try to go through all our products looking at economics, sales, production, and all those things. Couldn't we have a – shall we call it a 'reminder board' for these meetings. If there is a question concerning a pump you would like to discuss at the next meeting, then you write a little yellow note and stick it to the bulletin board conerning pumps. Then everybody would immediately know that this is an issue we need to address and discuss at the meeting . . .*

Given that communication was central to project management a recurrent theme in the organisational prototyping session was how to use the message boxes. The episodes illustrate how the participants start by suggesting changing the use of the existing design and end up generating a completely new idea of using an electronic bulletin board for the meetings. There was a need for distinguishing between different kinds of communication concerning project management: on the one hand commitments mutually agreed upon, and on the other hand more loose and informal communication like questions and messages. This is achieved through redesigning the project manager to include commitment boxes in the project view and an electronic bulletin board for other kinds of messages concerning projects.

Finally, the two episodes illustrate how new ideas and innovations to the design are generated through a discussion in which all participants, including the designers, contribute. For example, in the second episode the idea of a bulletin board looks as if it came from the Head Manager, but the idea was also discussed in the initial comment of the Economic Manager. In organisational prototyping there is a mutual influence and inspiration taking place during the discussion, which gradually leads to new ideas of computer support for the work.

4.2   Adapting the work practice to the tool

Through the organisational prototyping, the participants (both the managers and the designers) obtained an insight into the nature of the cooperative task of managing projects and how the Project Manager could support this work. The following three episodes illustrate how the session triggered a discussion of project management and how the organisation of work was adapted to meet and utilise the possibilities of the Project Manager.

Episode 3: **The Project Manager is a supplement to the usual way of handling projects.**

  [PM1 is explaining how he will meet a deadline by prioritising some of the pumps]

PM1: *Maybe I won't prioritise the Japanese pumps. But then I'll attend a meeting and then SM will say that he wants his [Japanese]pumps.*

HM: *You could call him and ask in advance.*

PM1: *Then we could just as well have the meeting.*

HM: *Wait - this [the Project Manager] can't eliminate the need for communication about everything.*

PM1: *No-no . . .*

HM: *It is only to maintain the overview. You still have to call SM and tell him that you are in trouble with your pumps and ask him what to do. [. . .] We cannot leave everything to happen through the screen.*

PM1: *Yes, that is true. But that means that we sometimes have to get together and have a meeting.*

HM: *Yes of course. It is definitely a crisis to delay a project. Well have to sit down and unite our strength. But what we must provide in common is consensus and overview.*

[. . . . . .]

D: *This message from a constructor will explain why the project is delayed. Then the problem is explained.*

PM2: *But - you can't get an indulgence just by typing something into the system. [By indulgence, PM2 means to be relieved from doing anything further in the case, but to type the problem into the Project Manager.]*

These two dialogues explain by example how the management at Delta became aware of the Project Manager as a tool in the task of handling projects. The main tasks of communication, coordination and making commitments to certain activities would not be changed by the tool. Instead, it would provide an overview on time schedule, documents and communication connected to the project, which would facilitate more effective project meetings (c.f. also episode 2).

The episode illustrates how organisational prototyping adjusts the expectations to computer support. Establishing the collective use of coodination

117

technology is not just a question of revealing new opportunities (as in episode 1) but equally important to reveal the constraints of the tool. Organisational prototyping helps both users and designers to evaluate a computer tool in more authentic ways, not putting up unrealistic expectations to the wonder of new technology solving problems which belong to the way work are organised and coordinated.

Episode 4: **How to maintain an overview.**

Situation card no. 6.
The prototype for the one-pole ignition unit is not finished as scheduled. There is a message in the Project Manager from a constructor saying that the prototype is delayed for two weeks caused by 'unforeseen difficulties during the final test'. What action should be taken – if any?

[After the situation card is read, the message is shown is the Project Manager, with 'Hansen' as the sender.]

HM: *That isn't up to Hansen to decide.*

D: *No — but this only illustrates that he is the one issuing the message.*

EM: *Well, we'll have to sit down and discuss the problem […]*

QM: *But the question is, whether it is the constructor [Hansen] that sends that message […]*

EM: *No — I don't think so.*

QM: *No, it must be PM2 [Hansen's superior manager] who must send it.*

SM: *Wait a minute, It is only a message. He hasn't made any changes to any deadlines.*

HM: *The question is whether it is iteresting to know that he's behind in a project. There are maybe 20-30 people involved in a project, to take a big project. They'll all be behind at some point or another. Will they write that to us?*

118

D: *But if it is a firm deadline we all agree upon? An agreement to be held? [Illustrates the message in the Project Manager]*

PM1: *That is too detailed. It would be very confusing to have that kind of detailed information. This is a matter between PM2 and one of his employees. It has to be PM2 who gives us that information.*

PM2: *I don't think that it should be the employee who makes that kind of message.*

PM1: *We would get too much information. We would drown in information if we were to receive all that kind of small messages.*

HM: *If Hansen isn't responsible for the project he shouldn't be able to send messages.*

The situation card reflects the initial design idea of using the boxes in the project view as message boxes. This is perceived as a very bad idea by the managers, because the communication overview would be disrupted by less important and irrelevant messages and requests. It was decided that the boxes should only be used to describe commitments (and the name was changed from 'message boxes' to 'commitment boxes') and they should only be created collectively at project meetings. Because all those responsible for a project attend these meetings, a commitment from everybody is assured. This illustrates how the use of the Project Manager was adapted to the general task of handling projects without changing the design. There was no limitation to what kind of messages could be sent in the boxes built into the tool. The limits were established only in the context of use.

Episode 5: **Responsibility for maintaining the overview.**

> *Situation card no. 2.*
> The customer who ordered the pump RSA 60X under development becomes impatient and wants to know how far the project is and when the pump is likely to be marketed. Who does what in order to provide the customer with an answer?

[The sales manager (SM) is asked to start formulating the action plan to this question]

SM: Thats easy. I'll look at the screen aud tell him that it'll be finished in week 12. Well — then I'll probably call PM1 [the manager responsible for production of pumps] to ask if he's sure, because now the customer is told. [...]

HM: No — that's not the way. We have a person responsible for customer contact. It's none of PM1's business.

[...]

HM: It would be very unfortunate if we had to check over the telephone. If we don't trust that [pointing to the Project Manager] we should not have it. If those deadlines are not the ones we agree upon, then we should forget the whole thing [i.e. the ProjectManager].

SM: You're right.

HM: Don't believe it's going to be any easier to move deadlines just because of the system.

[...]

HM: It is dead serious [pointing to the computer].

EM: We are going to trust what's in the system — otherwise everything will be a mess.

HM: It's terribly important to say that everything thats in there is true.
. . .
You are allowed to assume that there is a commitment to everything there, and that its valid.

Because the users share one view of the projects through the Project Manager, the view has to be valid. This is both a matter of trust and responsibility. If the view provided by the Project Manager cannot be trusted, there is no need for having the tool in the first place. So everyone using the Project Manager has a responsibility to maintain the overview by providing the correct information. This means keeping the documentation, the status of different activities (started, ended, delayed, etc.), and the commitments

made to future activities up to date. The episode illustrates how the managers at Delta became aware of the need for discipline by everyone involved in order to maintain the Project Manager as a useful tool.

5   Lessons learned

The case at Delta illustrates how the use of organisational prototyping provides a frame for adopting technology within an organisation. In this section we summarise some of our experiences with organisational prototyping as four central questions which need to be addressed when setting up the session.

Who should participate? Several considerations within prototyping literature address the question of establishing the user group for prototyping (Pape & Thoresen, 1987[13]; Bødker & Grønbæk, 1991[1], Grønbæk, 1991[8]). Here, it is often argued that competent user representatives have to be preferred to middle or upper management because the user has the necessary knowledge and familiarity with the daily work processes. However, when moving the objective of investigation further out into the cooperative work within an organisation and trying to reveal the usefulness of a computer system on a more overall organisational perspective, the competent user shifts towards management representatives. Management both possesses the overview on the coordination and planning aspects of work, and at the same time has the opportunity to change the way things are done, i.e. has the skill and power to implement the commitments and action plan agreed upon in the organisational prototyping session. In the case at Delta, the participants were both the future end-users and the managers of Delta. This seems to be a good arrangement for an organisational prototyping session. When looking at the session afterwards, the role of the Head Manager of summing up the discussion and turning it into constructive ideas is evident (see e.g. episode 2 and 5). This may come as no surprise, after all it is the role of a manager. Nevertheless, because organising and coordinating work is the responsibility of management it is important to have them as participants in organisational prototyping, *as well as* the future users. The future users, on the other hand, should be aware that organisational changes are allowed and subject for debate.

Turning to the technological side of the adoption process, it is important to have participants with a technical insight in an organisational prototyping session. In the case at Delta, the focus was on design and the designers themselves participated, and conducted the session. As illustrated in e.g. episode 1, the designers possessed the knowledge on the constraints and possibilities of the prototype enabling them to suggest how the idea of the production manager can be realised in the prototype.

When should organisational prototyping be applied? Because prototypes can be used to reveal requirements to the design and because experimentation early in a design process is cheap, the general recommendation is to use prototypes as early as possible in systems development. This recommendation is also valid for organisational prototyping and the method was applied in this way at Delta. However, organisational prototyping, when used in a design process, aims at revealing the overall organisational constraints and possibilities for computer support for cooperative work. Organisational prototyping asks the question of *what* the system should do within an organisation, whereas a traditional interface prototyping session addresses exactly *how* it should be accomplished with the computer. Therefore, organisational prototyping is to be made as one of the early design activities in order to uncover the overall functional requirements to the computer system. Furthermore, if the design is based on scenarios (Kyng, 1995[10]) the scenarios produced as a result of organisational prototyping can become a guide during the further development process.

When turning to the organisational learning side of the adoption process the recommendation of using organisational prototyping early in the process is less valid. If a systems development project takes a year or more, the insights and commitments achieved during an organisational prototyping session early in the project will often be forgotten, because it has been impossible to implement them without the computer system. Thus, one or more 'deja vu sessions' might be appropriate as an implementation technique. This also addresses the use of organisational prototyping for adopting standard groupware technology within an organisation. Whether it is standard or tailor-made technology the organisational prototyping encourages a learning process which situates the computer tool within the cooperative work. An organisational prototyping session will also be suitable for tailoring the computer system to meet the organisational conditions. To summarise,

organisational prototyping is a method applicable both early in the design phase of systems development, and later when implementing the computer system into an organisation.

How should the work practice be addressed? The scenarios introducing the use of the prototype are mainly open ended descriptions of typical ways of applying the new tool within the work setting. The scenarios are essential as input to the prototyping session because they reveal to the participants the design ideas of the tool, how these ideas are intended to match the work practice, and how the tool is to be used. These scenarios are shortly presented to the participants as a *prologue* to the session which proceeds by applying the situation cards. An insight achieved in the case at Delta, however, was to distinguish between situation cards introducing *typical events* and cards introducing *breakdowns* - a distinction we did not made at that time. At Delta only breakdowns were introduced in the session which had the effect that the participants handled these breakdowns in the usual manner, i.e. without the Project Manager. When analysing the video-recorded session afterwards it became evident that the participants did not pay much attention to the Project Manager during the initial two hours of the session.

Our conclusion is, that these two hours might just as well have been used to act out the scenarios using the prototype. So, the recommendation. is to start the organisational prototyping by simulating prototypical ways of doing work in the future with the computer support according to the scenarios. This *first act* of organisational prototyping is mediated by situation cards introducing typical events happening during work. The first act is intended to validate the scenarios and to evaluate the computer system within the central work practices. The *second act* then moves the discussion into more peripheral aspects of work by having the situation cards introduce breakdown situations. Central to cooperative prototyping is the notion of breakdowns (as used by Winograd & Flores (1986)[15]) as an important resource for learning about unarticulated aspects of users' work and how these aspects may affect the design of a computer system (Grønbæk, 1991[8]). Thus, the second act is intended to situate the prototype in simulated breakdown situations partly to assess its usefulness in these unusual work tasks, and partly to initiate a discussion of more tacit aspects of the work practices, which have not been addressed by the scenario descriptions.

How should the prototype be applied? The recommendations of coop-

123

erative prototyping emphasise that: (i) "Users need to be actively involved in prototyping - passive participation in demonstrations and unplanned evaluations of prototypes is insufficient to get benefits from prototyping", and (ii) "Unreflected and unarticulated aspects of users' work need to be considered to design good systems" (Grønbæk, 1991[8]). Thus, to fully experience the prototype, the users need to be in control of its use for some period of time - to try it out in work-like settings (Bødker & Grønbæk, 1991[1]). This is equally true for organisational prototyping; the ideal organisational prototyping session involves users working together and realising their action plans via the computer. However, this raises two fundamental problems: Firstly, to avoid breakdowns caused by an incomplete prototype, the prototype needs to be implemented to a high degree. When supporting cooperative work, this also means that communication through networks, database management, etc. needs to be functioning if the users should experience the cooperation through the computer. Secondly, the users need to know how to use the computer, i.e. how to operate it, how the design of the system is represented in the interface, etc., which raises demands for an individual education of the users prior to the organisational prototyping session. Addressing these two problems requires substantial preparation of the organisational prototyping which contradicts the recommendation of using organisational prototyping early in the design process.

At Delta, it was decided to have one of the designers operate the computer in order to maintain the focus on the collective activity of managing a task and not on the operation of the Project Manager. This translation between the users' intended actions and the conditions of the tool was done primarily to avoid breakdowns caused by the lack of knowledge of the exact use of the tool and by the inadequacies of the horizontal (incomplete) prototype. This translation strategy also enabled a comparison of the intentions expressed by the participants with the possibilities of the prototype, thereby giving information on how the future tool should support the collaborative work of project management as agreed upon in the action plans.

Nevertheless, we argue that the users indeed were actively involved in a lively debate, as illustrated in the above cited episodes, despite the fact that the users had no direct 'hands-on experiences' with the prototype. The translation between the intentions of the users and the operation of the prototype enabled the session to focus on establishing ways of using computer support

124

in cooperative work instead of focusing on technical aspects of the computer. Furthermore, organisational prototyping strives to elevate the discussion on design and implementation from an operational level of use to an organisational level of organising work, where the issue of tacit knowledge becomes less significant.

Thus, organisational prototyping is possible with even fairly horizontal prototypes when investigating breakdowns in the organisation of work around the computer is of higher priority than investigating breakdowns in the operational aspects of its use.

6 Conclusion

The use of prototypes in design is complicated when addressing CSCW systems because of the distribution of work in time and space. There seems to be a lack of design methods which address the special problems associated with the design and assessment of computer support for cooperative work. This case has shown how organisational prototyping as a combination of prototyping and organisational game can mediate the adoption of CSCW applications within a work setting. The notion of adoption was discussed as both adapting the work practice to the tool and adapting the tool to the work practice. There are clearly different possibilities for changing either of these two sides dependent on the conditions of the application and of the organisation: more possibilities of changing an application exist in the design process than in the tailoring of standard software; and some organisations have wide possibilities of re-organising work, whereas in others work has to conform to certain organisational procedures and rules.

The case has illustrated how design of a project management tool on the one hand and establishing a collective use of it on the other, were done by organisational prototyping. The task of project management, however, might just as well have been supported by standard software like a project management tool, an email system, and an electronic bulletin board system. Nevertheless, the method of organisational prototyping provided the opportunity to deliberately organise the use of such tools in order to support the cooperative work of project management. Hence, we feel that the idea of organisational prototyping as a mutual learning process applies for both adopting standard

off-the-shelves applications through tailoring and re-organising work, and as a method for designing and taking into use new systems.

7 Acknowledgements

References

[1]   Bødker, S. & K. Grønbæk (1991) Design in Action: From Proto-typing by Demonstration to Cooperative Prototyping. In Green-baum, J. & Kyng, M.: *Design at Work: Cooperative Design of Computer Systems*, New Jersey, Lawrence Erlbaum Associates, Inc., Publishers.

[2]   COMIC-D2.1 (1993) *Informing CSCW System Requirements*, Lancaster & Manchester University, Oct.

[3]   Ehn, P. & D. Sjögren, (1991) From System Descriptions to Scripts for Action. In Greenbaum, J. & Kyng, M.: *Design at Work: Co-operative Design of Computer Systems*, New Jersey, Lawrence Erl-baum Associates, Inc., Publishers.

[4]   Erhlich, S.F. (1987) Strategies for encouraging successful adoption of office communication systems, *ACM Transactions on Office Information Systems*, 5, p. 340-357.

[5]   Greenbaum, J. & M. Kyng, (1991) *Design at Work: Cooperative Design of Computer Systems*, New Jersey, Lawrence Erlbaum Associates, Inc., Publishers.

[6]   Grudin, G. (1994) Groupware and Social Dynamics: Eight Challenges for Developers. *Communications of the ACM*, Vol. 37, No. 1, p. 93-105.

[7]   Grudin, G. & L. Palen (1995) Why Groupware Succeeds: Discretion or Mandate? In *Proceedings of the Fourth European Conference on Computer Supported Cooperative Work*, Klüwer, Dordrecht, p. 263-278.

[8]   Grønbæk, K. (1991) *Prototyping and Active User Involvement in System Development: Towards a Cooperative Prototyping Approach.* Ph.D. Thesis, Computer Science Department, Aarhus University, January 1991.

[9]   Kreifelts, T., H. Elke & Woetzel, G. (1993) Sharing To-Do Lists with a Distributed Task Manager, In *Proceedings of the Third European Conference on Computer Supported Cooperative Work*, Klüwer, Dordrecht, p. 31-46.

[10]   Kyng, M. (1995) Creating Context for Design. In Caroll, J. (Ed.) *Scenario Based Design: Envisioning Work and Technology in System Development*, New York, John Wiley & Sons, Inc.

[11]   Okamura, K., M. Fujimoto, W.J. Orlikowski, & J. Yates (1994) Helping CSCW applications succeed: The role of mediators in the context of use. In *Proceedings of the Conference on Computer Supported Cooperative Works*, ACM/SIGCHI & SIGOIS, NY, p. 55-65.

[12]   Orlikowski, W.J. (1992) Learning from Notes: Organizational issues in groupware implementation. In *Proceedings of the Conference on Computer Supported Cooperative Work*, ACM/SIGCHI & SIGOIS, NY, p. 362,369.

[13]   Pape, T. & K. Thoresen (1987) Development of common systems by prototyping. In Bjerknes, G., P. Ehn & M. Kyng, (Eds.) *Computers and Democracy*, Aldershot, UK, Avebury, p. 297-311

[14]   Trigg, R.H. & S. Bødker (1994) From implementation to design: Tailoring and the emergence of systematization in CSCW. In

Poceedings of the Conference on Computer Supported Cooperative Work, ACM/SIGCHI & SIGOIS, NY, p. 45-54.

[15]   Winograd, T. & F. Flores (1986) *Uderstanding Computers and Cognition: A New Foundation for Design*, Norwood, Addison-Wesley Publishing Company.

Organizational Prototyping

Adopting CSCW Applications in Organisations

Jakob E. Bardram

bardram@daimi.aau.dk
Computer Science Department, Aarhus University, Denmark

1 Introduction

Within the field of CSCW it has been widely recognized that the acceptance of a system is very sensitive to the way in which it is introduced into an organization [5, 6]. The process of adopting a computer application meant to support cooperative work often implies changing the work practices, in order to fully utilize its new potentials. Orlikowski [10] gives an excellent example of how the cultural aspect of work practice must be taken into consideration to ensure a successful adoption of a CSCW application. Orlikowski raises the general question of "how to anticipate the required structural and cognitive changes when the technology is brand new" (p. 368). This essay presents the idea of Organizational Prototyping as a participatory method for addressing this question [1].

Others have addressed the question of adopting CSCW technology within an organization. Okamura et al. [9] suggests the use of *mediators*, that is individuals who deliberately intervene with organizational authorization in the ongoing use of CSCW technology. These mediators can be very useful in introducing new technologies to an organization, as described by Okamura et al., but having mediators stand between developers and users may not always be useful. Because these mediators lack a deeper knowledge of the workplace, they may be insensitive to important aspects of how to organize

the work (e.g., the way related tasks are handled and social dynamics in the workplace) [6]. At the same time the interests and motives of the mediators are not necessarily the same as those of the users, resulting in a need for clarification of who is responsible for reorganizing the work.

Grudin & Palen [7] found that 'evangelists', as such mediators can be characterized, did not explain the adoption of a groupware technology within the organizations they studied. Instead, they found widespread reports on peer pressure where the adoption spread according to a bottom-up pattern. Thus, groupware can succeed without managerial mandate. Helped by the technological feature of the application it can attract a critical mass of users, after which a social pressure by peers and others extends the use into an organization. From a design perspective, ensuring that users gradually adopt the system by providing flexible technological features seems to be generally advocated. As stated by Kreifelts et al. [8]: "we would like to have coordination systems that encourage *self-organization* of cooperative work by the end-users themselves" (p. 33).

However, this strategy of relying on technological features to encourage a critical mass of people to use the system raises two questions: First, how can the use of the computer system within a specific work environment be organized? Even when the adoption is spreading bottom-up, the future use of a computer system has to be established within the overall work practices at some point in the process. This means that issues of establishing a division of labor, responsibility, procedures for general use and error handling, etc. have to be addressed and socially agreed upon within the work setting. Second, how can we from a design perspective establish which features will mediate the acceptance of the technology within an organization? In other words, how do we establish the functionality and central ideas of the computer system and how can computer support for cooperative work be designed and evaluated in the development process. Even when adopting standard groupware technology, the issue of design is important. The notion of tailorable and flexible computer tools that do not enforce rigid ways of performing work supported by a computer has been strongly emphasized within CSCW [e.g. 11]. But applying such flexible tools means that their use has to be organized within the specific work environment, and the tools as such has to be tailored (i.e. designed) according to the organization of work.

2 Organizational Prototyping

A clear shortcoming of the traditional use of prototypes is the focus on individual use of an application in terms of functionality and user interface of the tool. Prototyping sessions seldom touch upon the cooperative context in which the tool is to be used in the future. This reflects that the evaluation process of CSCW systems is more complex than that of single user applications [6]. Evaluation and design for cooperative work settings can be remarkably time consuming, due to the number of people involved, because most cooperative work unfolds over days and weeks, and because it is distributed across several sites. As the purpose of CSCW applications is to support the mutual dependencies of the actors involved in cooperative work, distributed in time and place, this complexity seems unavoidable. This could lead to a rejection of using incomplete prototypes and mock-ups, because it would be impossible to observe and evaluate the cooperative work, involving several persons over a longer period of time based on an incomplete prototype.

The method of Organizational Prototyping shows that the concern for increased difficulties of evaluating prototypes in collaborative work practices might not always be true. The name *'Orgnizational Prototyping'* comes out of the two main inspirations for the method: organizational games [3] and cooperative prototyping [3].

2.1 The components of organizational prototyping

The adoption process mediated through Organizational Prototyping (OP) is defined as *a dual process of both adapting the tool to the organization and adapting the work practice to the conditions of the tool.* The idea is to bring people together, whose collaborative work is normally distributed in time and space, and initiate a discussion of new ways to organize work and of the technological opportunities and constraints of supporting this work by computers. The session should simulate realistic situations from the participants' daily work, trying to sustain positive aspects of the organization of work, and at the same time clarify and improve problematic aspects.

The components of OP are the following: (i) As a prologue to the session one

or more **scenarios** introduce the prototype to the work practice in question. The scenario describes how the prototype can mediate the work and thus situates the prototype within the work practice. A central component of OP is (ii) the **prototype** itself, containing realistic test-data and providing enough functionality to illustrate and act out the different scenarios. When the session is started, the main components are (iii) the **situation cards** which introduce prototypical examples of breakdown situations. The situation cards are intended to resemble typical events and problems occurring in daily work. These cards are produced beforehand by the conductors of the session, based on investigations into work practices and typical problems within the organization. In resolving the breakdowns introduced by the situation cards the participants are making *commitments* to solve the problems and the *conditions* for each commitment are discussed. These commitments and their conditions are formulated in an (iv) **action plan** for each situation card. An action plan answers the questions of '*who* will do *what, where, when, why,* and by *what means.*' Furthermore, the individual commitments made are noted in (v) a **role script** for each participant. Finally, the last component of OP is (vi) the **playground**, which is used to save and categorize the resolved situation cards and their attached action plans. The playground can be divided according to different work tasks, or it can be organized according to possibilities of changing either the computer system or the organizational setting.

The outcome of an OP session is updated and new scenarios, suggestions for redesign to the prototype, the role scripts for each participant, and the action plans for each situation card attached to the playground.

3   Organizational Prototyping in Action

Organizational Prototyping has been applied within two projects in Denmark: (i) The Delta project, and (ii) the SAIK project. The Delta project is described in [1] and shows how Organizational Prototyping was used to develop a project management tool in close cooperation with the managers of a large engineering company. The Delta case shows how Organizational Prototyping was used to adapt the project management tool to the work practices of the managers, and to adapt the work practice to the possibilities

and limitations of the tool. One particular important lesson from the Delta case was that Organizational Prototyping sessions could be used to adjust the (often unrealistic) expectations of a new computer tool. Let us go into more detail concerning the SAIK project.

3.1 The SAIK project: Developing Computer Support for Clinical Work

The SAIK[1] project was launched as the experimental part of redesigning a national-wide mainframe-based Hospital Information System in Denmark. The aim is to investigate the coordination and planning of patient care within hospitals and based on these investigations to develop a prototype – called the PATIENT SCHEDULER – illustrating how coordination of patient care within hospitals can be supported by computer technology. The PATIENT SCHEDULER aims at providing flexible support for requesting, booking and scheduling examinations, tests, etc. in different departments within the hospital.

Based on investigations of current work practices within Danish hospitals [2], the PATIENT SCHEDULER introduced two rather bold ideas[2] for supporting the complex task of coordinating the increasingly specialized work of the many healthcare professionals involved in patient treatment and care, namely: (i) sharing resources for directly booking examinations, and (ii) planning future examination and operations according to a workflow model. Organizational Prototyping was applied once for each of these design ideas in order to reveal how these two central parts of the tool should be designed and subsequently used within Danish hospitals.

3.2 Organizational Prototyping I: Shared Resources

This OP session was intended to bring together (representatives from) the wards in charge of medical treatment and the service department supporting

---

[1]SAIK is a Danish abbreviation for "Collaborative Informatics in Clinical Practice"

[2]The 'boldness' of these ideas should be viewed according to the organizational and political context of hospital work in Denmark – an aspect, which the scope of this essay does not allow to describe in detail.

the treatment, such as the radiology department and the laboratory. The main design idea to be discussed was whether the ward could be allowed to directly book their own examinations at the service department. This would allow them to circumvent the rather cumbersome task of making a request, waiting for the request to be approved, and then subsequently engage in a negotiation for appropriate time-schedules. The idea was accepted broadly at both the wards and the service departments. However, when enacting the scenarios with associated situation cards, the support for shared resources turned out to be less straightforward. The Organizational Prototyping session revealed how the PATIENT SCHEDULER needed to be redesigned and how the work practices within the hospital had to undergo a considerable change. For example the OP session revealed how the service departments would lose control over their resources if they were to be shared among everybody within the hospital. This was a serious problem of the design because the service department needed to stay in charge of their resources, in order to control when the examinations are scheduled, at which type of equipment, in which sequence, etc. Otherwise, the service department would be unable to anticipate and plan their work, which in the end would lead to an escalation of their expenses[3].

Hence, there seemed to be a dilemma for the service departments of wanting to share their resources with other departments, but at the same time stay in control of their use. The PATIENT SCHEDULER was redesigned to meet these demands by implementing an advanced access control mechanism that allowed the service department to describe who could schedule which kind of examination at a particular time on a particular resource. Furthermore, a differentiation between a proposed and an implemented examination was maintained in order for the wards to schedule (proposed) examinations even though they did not have access to the resource. The OP session resulted in a consensus of how such a system should be used and how the access rights should be set up and maintained in the work practices at both the ward and the service department.

Furthermore, the discussion and resolution of this 'share-and-control' dilemma lead to a change in the current work practices at the hospital without any

---

[3]Service departments in Danish hospitals are not funded according to their activity, but according to a fixed budget. Therefore, if the service department looses control over the activity their expenses might potentially increase dramatically without any in-crease in their budget (i.e. income).

computer support. The time allocation supported by the assess mechanism was simply implemented on paper. A paper calendar revealed, for each resource, which timeslots the different wards had to their disposal and this calendar was duplicated and distributed to the different wards.

3.3 Organizational Prototyping II: Planning and Workflow support

The second Organizational Prototyping session was initiated to reveal how complex surgical operations could be planned and coordinated within a surgical department. Like the above OP session this session also revealed issued to be considered in the design of the PATIENT SCHEDULER. For example, an important part of planning a surgical operation involved considerable communication between the secretary in charge of scheduling and planning the operations, and the nurses and surgeons in change of deciding exactly how the operation should be performed. Thus, the communication module of the PATIENT SCHEDULER was extended to support this kind of asynchronous communication.

However, a more direct outcome of the OP session was a redesign of the current work process of approving and planning operations in the department. Once a week the secretary, the surgical ward's head nurse, and the senior surgeon in charge of planning had a meeting where operations were planned a week ahead. During the OP session it was revealed that the plan often was too optimistic and therefore often difficult to carry out. The fact that neither of these persons actually saw how the daily operation plan was carried out was identified as the main reason for this problem. Therefore, it was decided (among other things) to invite the head nurse of the surgical theaters to the meeting too, and to physically move the secretary in charge of planning to the operation theaters, so she could follow how the planning actually was realized. Thus, she would see, by herself, when any unrealistic planning occurred and could take this into account in future planing.

Finally, a change in organizational cultural was attempted. The OP revealed that one of the main problems in planning future operations was that the surgeon in charge was allowed to schedule his 'own patients'. Without having the 'big picture' of the overall plan this often resulted in a too tight overall

schedule with unrealistic expectation to what could be accomplished during a day. Therefore a new 'organizational rule' for the department was established during the OP session: no one was allowed to schedule operations after the 'one-week-before-an-operation-deadline' by themselves — operations within a week should be done through the secretary in charge of the planning. This rule, however, was bound to lead to trouble. A senior (or even a junior) surgeon does not take orders from a secretary. Therefore, a considerable section of the OP session was used to illustrate how this rule was of mutual interest for the whole department and how it was to be exercised.

4 Lessons learned

The cases reported here have illustrated how the method of Organizational Prototyping can aid the adoption of CSCW technology within an organization. The hospital case showed how OP on the one hand revealed crucial design considerations for the PATIENT SCHEDULER, and on the other established the future use of the technology. Furthermore, the OP sessions helped the participants to reflect on their work practices, and thereby enabled them to improve the current work processes.

Based on these experiences, we conclude by stating four central questions, which needs to be addressed when setting up an OP session.

Who should participate? Depending on the nature of the work tasks that the OP session aims to address, one should ask who of the involved persons in these tasks should be involved and how many. For example, should the participants be competent user representatives, end-users, management representatives, and/or technicians?

When should OP be applied? If, for example, the OP session is to clarify and discuss radical design ideas within a new computer system, the OP session should be carried out as early in the design phase as possible. However, if OP is used to adopt standard off-the-shelves applications, OP sessions can be applied continuously as a way of implementing the computer system into an organization through tailoring and re-organization of work processes.

How should the work practice be addressed? Before initiating an OP session one should consider what part of the work practices are addressed. This is important to ensure a focused session, which do not end up in a too broad and generic discussion. Often it is better to do several smaller sessions than one overall one. Furthermore, the balance between simulating prototypical ways of doing work in the future with the computer support according to the scenarios, versus simulating peripheral aspects of work by having the situation cards introduce breakdown situations should be established.

How should the prototype be applied? Typically, the use of prototypes stresses the importance of users getting hands-on experience with the tool.

To fully experience the prototype, the users need to be in control of its use for some period of time – to try it out in work-like settings. In the Delta case, however, it was decided to have one of the designers operate the computer in order to maintain the focus on the collective activity of managing a task and not on the operation of the computer tool. This translation between the users' intended actions and the conditions of the tool was done primarily to avoid breakdowns caused by the lack of knowledge of the exact use of the tool and by the inadequacies of the incomplete prototype. So the exact role of the prototype should be established according to whether emphasis is on the technological issues of the prototype, or on the organization of work processes.

References

[1] Bardram, J. (1996) Organisational Prototyping: Adopting CSCW Applications in Organisations, *Scandinavian Journal of Information Systems,* 8(1), p. 69-88

[2] Bardram, J. (1997) "I Love the System - I just don't use it!" In *Proceedings of GROUP'97, ACM Conference on Supporting Group Work,* Phoenix, Arizona, ACM Press, New York, N.Y.

[3] Bødker, S. & K. Grønbæk (1991) Design in Action: From Prototyping by Demonstration to Cooperative Prototyping. In Greenbaum, J. & Kyng, M.: *Design at Work: Cooperative Design of Computer Systems,* LEA Publishers, New Jersey.

[4] Ehn, P. & D. Sjögren, (1991) From System Descriptions to Scripts for Action. In Greenbaum, J. & Kyng, M: *Design at Work: Cooperative Design of Computer Systems,* LEA Publishers, New Jersey.

[5] Erhlich, S.F. (1987) Strategies for encouraging successful adoption of office communization systems, *ACM Transactions on Office Information Systems,* 5, p. 340-357.

[6] Grudin, G. (1994) Groupware and Social Dynamics: Eight Challenges for Developers. *Communications of the ACM,* Vol. 37, No. 1, p. 93-105.

[7] Grudin, G. & L. Palen (1995) Why Groupware Succeeds: Discretion or Mandate? In *Poceedings of the 4th European Conference on CSCW,* Klüwer, Dordrecht, p. 263-278.

[8] Kreifelts, T., H. Elke & Woetzel, G. (1993) Sharing To-Do Lists with a Distributed Task Manager, In *Poceedings of the 3rd European Conference on CSCW,* Klüwer, Dordrecht, p. 31-46.

[9] Okamura, K., M. Fujimoto, W.J. Orlikowski, & J. Yates (1994) Helping CSCW applications succeed: The role of mediators in the context of use. In *Proceedings of the Conference on CSCW,* ACM Press, NY, p. 55-65.

[10] Orlikowski, W.J. (1992) Learning from Notes: Organizational issues in groupware implementation. In *Proceedings of the Conference on CSCW,* ACM Press, NY, p. 362-369.

[11] Trigg, R.H. & S. Bødker (1994) From implementation to design: Tailoring and the emergence of systematization in CSCW. In *Proceedings of the Conference on CSCW,* ACM Press, NY, p. 45-54.

Plans as Situated Action

An Activity Theory Approach to Workflow Systems

Jakob E. Bardram

Computer Science Department,
Aarhus University and Kommunedata I/S,
Denmark

Abstract

Within the community of CSCW the notion and nature of workflow systems as prescriptions of human work has been debated and criticised. Based on the work of Suchman (1987)[18] the notion of situated action has often been viewed as opposed to planning work. Plans, however, *do* play an essential role in realising work. Based on experiences from designing a computer system that supports the collaboration within a hospital, this Paper discusses how plans themselves are made out of situated action, and in return are realised *in situ*. Thus, work can be characterised as *situated planning*. This understanding is backed up by Activity Theory, which emphasises the connection between plans and the contextual conditions for realising these plans in actual work.

1 Introduction

The issue of workflow systems has been addressed by several authors as ways of routing information objects among users, and to specify automatic actions to be taken in that routing tribally according to certain process models (Medina-Mora et al., 1992[12]; Abbott and Sarin, 1994[1]; Schäl, 1996[14]).

139

A process model is typically understood as a computerised (i.e. formal) representation of work procedures that controls the order in which a sequence of tasks are to be performed. These workflow systems for the coordination of activities in organisations have drawn much attention, but have been subject to much controversy and criticism for their rigid representation of work in process models (Suchman, 1994[19]; Winograd, 1994[23]; Bowers et al., 1995[6]; Heath and Luff, 1996[7]). The potential danger with current workflow systems is that their design is predictated entirely by formal procedures — ignoring (and even damaging) the informal practice (Symon et al., 1996[20]).

Suchman (1987)[18] shows the importance of differentiating between work and representations of work like plans and process models. Plans are representations of situated actions produced in the course of action and therefore they become resources for the work rather than they in any strong sense determine its course. Suchman emphasises action as essential situated and *ad hoc* improvisations, which consequently make plans rational anticipations, before the act, and *post hoc* reconstructions, afterward. The theoretical work on situated action, and the studies underlying it, seems to have attained so much attention that the importance of plans and protocols as guidance of work has been neglected. Recently, at the CSCW '96 conference in Boston, Suchman herself commented that an unfortunate, but typical, misreading of her work was that plans do not exist. Plans do exist and should be viewed as "an artifact of our *reasoning about* action, not ... the generative *mechanism* of action." (p. 39, emphasis in original).

Nevertheless, in medical work, *pre-hoc* representations of work like plans, checklists, schedules, protocols, work programmes etc. have proved extremely valuable as mechanisms giving order to work. Such plans support handling complex work situations, involving coordination and collaboration among several health professionals. For example, the patient's diagnosis and the associated treatment plan are essential coordination mechanisms, which convey information to the involved staff about the nature of the illness and how the treatment should proceed. Without this plan, extensive communication has to take place in order to inform all involved personnel about the patient, his illness and how the physician in charge intends to cure it. Thus, plans as prescriptions of activity are valuable, and indeed used, within organisations like hospitals to carry out work. This makes Schmidt and Simone (1996)[15]

raise the rhetoric question to Suchman of "What is it that makes plans such as production schedules, office procedures, classification schemes, etc. useful in the first place? What makes them 'resources'?" (p. 169).

These studies of work seem to leave us with what can be called the *planning paradox:* On the one hand, due to the contingencies of the concrete work situation work has an ad hoc nature. Plans are not the generative mechanisms of work, but are 'merely' used to reflect on work, before or after. On the other hand, we find that plans, as more or less formal representations, play a fundamental role in almost any organisation by giving order to work and thereby they effectively help getting the work done. Within a hospital context this tension between informal practice and formal procedures for work is also discussed by Symon et al. (1996)[20]:

> "[A]ny investigation of work coordination should look beyond formal procedures to consider contextual factors (i.e. factors that may give rise to informal practices), while *at the same time* taking into account the use and influence of formal procedures" (p. 3, emphasis in original).

This planning paradox is addressed in this paper. First, the theoretical understanding of human activity based on Activity Theory shows how a concept of planning does not necessarily mean total pre-handling and control of work, but can be achieved in the course of activity. The false dichotomy between plans and situated action is removed and it becomes possible to talk about, and thus support by computers, *situated planning.* This theoretical insight is then supported by empirical insight into the working of a Danish hospital by illustrating the important role, which planning plays within hospital work and how a computer system was designed to support planning without emphasising rigid matches between plans as representations of work and work itself. Finally, the paper concludes by arguing that a workflow system often exists in a tension between supporting a smooth flow of work within a work practice and the organisational needs for accounting for this work, and that this tension needs to be considered in design.

2 Activity Theory

Activity Theory originated in the former Soviet Union as part of the cultural-historical school of psychology founded by Vygotskij, Leontjev and Lurija. The theory is a philosophical framework for studying different forms of human praxis as developmental processes, with both the individual and social level interlinked. Within the HCI community, Activity Theory has recently attained increased attention (Bødker, 1991[5]; Nardi, 1996[13]) and has been proposed as a basis for CSCW research too (Kuutti, 1991[9]). Here I will focus on certain core concepts of the theory, which are fundamental in understanding the role of technology and human activity as guided by plans. The following is based on the writing of Vygotskij (1978)[22], Leontjev (1978; 1981)[10, 11], and Anokhin (1973; 1976)[2, 3].

The fundamental unit of analysis is the *human activity* which has three basic characteristics; firstly, it is directed towards a material or ideal *object* which distinguishes one activity from another; secondly, it is *mediated* by artifacts (tools, language, etc.); and thirdly, it is social within a *culture*. In this way, computer artifacts, like all other artifacts, mediate human activity within a practice. By acting in the world, human beings meet the objective world, which is experienced through the activity. Thus, human knowledge about the world is *reflection* obtained through activity, constituting the basis for expectations, and desires about activities in this world. This describes the basic dialectical relationship between the human being and the world, the subject and the object.

2.1 The Structure and Development of Human Activity

Human activity can be described as a hierarchy with three levels: *activities* realised through chains of *actions*, which are carried out through *operations*. Human activity is always directed toward a material or ideal object satisfying a need and the subject's reflection of, and expectation to, this object characterises the *motive* of the activity.

Human activity is carried out through actions, realising objective *results*. These actions are controlled by the subject's conscious *goals*, which are the

anticipation of the future results of the action. The activity exists only as one or more actions but the activity and the action are not identical and cannot be reduced to each other. For example, for a physician the activity of diagnosing a patient can be realised in several ways. He can trust the diagnosis stated by the general practitioner on the referral papers. Or he can establish his own diagnosis by obtaining the necessary clinical data, like blood sugar level, X-ray pictures, etc, using the service departments at the hospital. Or he can use a computer-based patient record system to see if such data are already available. These are different actions, mediated by different tools, which all realise the activity of diagnosing the patient. On the other hand, the same action can be a part of realising different activities: The action of requesting an X-ray examination at the radiology department can be part of the diagnosing activity or it can be part of preparing for surgery, thus realising a total different activity. Furthermore, actions are usually *polymotivated*; two or more activities can temporarily merge, motivating the same action, if the goal is part of reaching the motives of several involved activities simultaneously.

Even though the goal of the action can be represented in the human mind independently of the situation in which it has to take place, the practical process of realising the action cannot be detached from the conditions of the concrete situation. Therefore, actions are realised through a series of operations; each accommodated to the concrete physical *conditions* of the action. While the analytical level of actions describes the intention of an activity — what results should be obtained — operations describe the operational level — how the action is realised, adjusted to the actual material conditions of the action. For example, the way the phone is used to order an X-ray examination depends entirely on how the phone works, the phone number of the radiology department, the physical surroundings of the phone, etc. Operations are performed without thinking consciously but are oriented in the world by a non-conscious *orienting basis* of the operation. This orienting basis is established through experience with the concrete material conditions for the operation, and is a system of expectations about the execution of each operation controlling the operation, in the process of the activity. Again, the action and the operations realising the action are not identical and cannot be reduced to each other: an operation can be part of several actions (together with other operations) and the same action can be realised through different operations.

2.2 Planning Recurrent Actions through Anticipatory Reflection

At all three levels the human activity is guided by anticipation. This anticipation is the motive of the activity, the goal of the action and the orienting basis of the operation, respectively. The anticipation of future events is the fundamental principle of *anticipatory reflection* as developed by Anokhin. The classical example of anticipatory reflection is Anokhin's rethinking of Pavlov's discovery of the conditioned reflex: When a dog salivates in response to the ringing of a bell, it is not because saliva is needed to digest the bell but because the dog anticipates food to appear *in the future* which has to be digested. The anticipatory reflection guides the activity by making an *afferent synthesis* between a *perception* of the environmental state of the activity, and *memory* (i.e. the cumulated experience of the person). This afferent synthesis forms an anticipation of the future state as a result of the activity about to be performed. When the activity is performed there is a feedback mechanism which compares the result of the activity with the prediction, and any incongruence (i.e. a breakdown) gives rise to a learning situation (i.e. the experience of the person is expanded). This model of anticipatory reflection based on the afferent synthesis between perception and memory is a general model for all levels of the activity.

The basic principle that makes the anticipatory reflection possible is the recognition of *recurrent structures* in the world. The existing of all living beings and their reflection of recurrent structures, which repeat themselves over time, is the indispensable prerequisite for prediction. Pavlov's experiments also illustrate this because the response is mutually correlated with the amount of training sessions.

2.3 Artifacts as Mediators and Crystallisation of Work

Describing human activity as actions realised through operations helps to understand the fundamental role, which plans play in human cognition and activity. Based on prior experience the plan anticipates future results of the actions realising the activity, but these plans, or anticipations, have to be implemented through operations which are adjusted to the material conditions of the situation. The afferent synthesis explains how human activity indeed

144

is planned, i.e. anticipated, and at the same time situated, i.e. contextual.

Now one could ask what plans, as cognitive constructs have to do with material artifacts like checklists, production lists and workflow systems? However, within the cultural-historical school there is no such differentiation between ideal (i.e. cognitive) and material artifacts: plans as artifacts are used to mediate activity regardless of whether they exist on e.g. paper or are memorised. Human work is characterised by the collaborative production of artifacts; each made with the purpose of mediating a certain activity. The mediating characteristics of an activity is therefore *crystallised* (or objectified) (Bærentsen, 1989[4]) into these artifacts, and through use, the artifacts are continuously modified and shaped to meet the evolving humman needs. For example, the radiology order form used at AAS is a product of years of experience in ordering X-ray examinations, containing fields that prompt for certain important information. Therefore, the cognitive plans and their material counterpart are mere reflections of each other because they are both resources for, and products of, human activity.

3 The SAIK project: Developing Computer Support for Clinical Work

The SAIK[1] project was launched as the experimental part of redesigning a national-wide mainframe-based Hospital Information System. The aim was to investigate the coordination and planning of patient care within hospitals and based on these investigations to develop a prototype — called the PATIENT SCHEDULER — illustrating how coordination of patient care within hospitals can be supported by computer technology.

This participatory design process took a 24-bed specialised medical (endocrinological) ward as point of departure for investigating the work and collaboration among departments within the hospital for the County of Aarhus (AAS). Typical patients at the ward are diabetics or elderly patients with osteoarthritis. AAS is a middle size Danish hospital with 1700 employees and 370 beds. It has 7 medical and surgical specialised departments, each with 2 - 4 wards, several out-patients' clinics, and several service departments — e.g.

---

[1]SAIK is a Danish abbreviation for "Collaborative Informatics in Clinical Practice"

radiology, laboratory, and pathology. Historically, Danish hospitals, including AAS, have become increasingly specialised and centralised (Vallgårda, 1992[21]). This has resulted in large hospitals with a large number of specialised departments. Because of this specialised nature of medical work, collaboration across departmental and professional borders is patient treatment and care *per se*, making the hospital an excellent place for investigating issues in computer support for people cooperation closely. For example, the daily treatment of all patients admitted to the ward is based on data from e.g. blood tests and X-ray pictures, which involves frequent communication and coordination with the laboratory and radiology departments, respectively.

A fundamental statement within the participatory design tradition is that a profound understanding of the users' work practice is a pre-condition for designing computer support. This understanding of the work at AAS was done as workplace studies based on qualitative methods such as qualitative interviews; workshops; participative observations of daily work at the ward and service departments, meetings and conferences; and studies of different documents, records and other tools. Based on this understanding the PATIENT SCHEDULER was developed and used for further participatory design sessions at AAS. The PATIENT SCHEDULER aims at providing flexible support for requesting, booking and scheduling examinations, tests, etc. on different departments within the hospital.

4   Planning as a Central Activity of Clinical Work

Treatment of patients within a hospital can clearly be characterised as specialised and informal skills that have to take the contingencies of the concrete situation into account. Nevertheless, clinical work is subject to a large degree of planning and plans play a central role in guiding and recording work at a hospital. Let us consider three examples from the hospital: A central planning tool widely used within medical work is **protocols of treatment**, or Standard Operating Procedures (Strauss et al., 1985[17]), which prescribe a standard treatment for a standard disease for a standard patient. Such protocols are developed by the clinical team who uses them, and they are supported by general policies and guidelines of use. A central part of such a

protocol is often the **unravelling program**, which prescribes which initial examinations and tests should be ordered to state a precise diagnosis. Hence, the unravelling program provides a plan for obtaining the necessary clinical data for further treatment. Another planning tool applied at the ward is the **24-hour-care plan** made every afternoon by the nurses on duty. This plan describes the care of each patient within the next 24 hours and functions as a "boundary object" (Star, 1989[16]) by carrying information between three working shifts in a standardised way. This plan is made according to the overall plan of treatment (the protocol) by taking into consideration the patient's condition in the concrete situation. By analysing the use of these planning tools from an Activity Theory perspective on CSCW, the following characteristics of plans emerged:

Plans as Socially Constructed and Used Artifacts

Documents used in daily work are *socially constructed* in and through the intersubjective understanding and use of members in a community. A document is not 'just' a document, but a certain document like the medical record (Hughes and King, 1993[8]). Thus a certain document (record) is an artifact reflecting certain work activities and the socially defined purpose of these activities. For example, all departments within the hospital, like the medical, surgical and anaesthetic departments, have their own patient files and records, made to suit their special activities and needs. Similarly, plans are socially used and constructed as part of the ongoing work activities at the hospital. The production of the different unravelling plans used at the ward is an on-going activity closely connected to the treatment of patients. Thus, these plans are crystallisations of a historically developed socio-cultural knowledge of how to treat different kinds of diseases and patients. An implication of this is that plans and protocols change over time, and thus have a historicity. At the ward this is most evident in the continuous making of 24-hour-care plans by the nurses, but also unravelling plans and medical protocols for treatment of patients are changed to reflect the results of the latest research within the international medical community.

The Difference between the Plan and the Instantiation of the Plan

There is a fundamental distinction between a plan and an *instantiation* of the plan, i.e. the actual performance based on the plan. Building on prior experience, plans become resources, detached from the concrete and situated real-world activities, which later might implement and carry out the plan. The strength of the plan is the anticipation of future ways of performing activities, detached from, but still taking into account, the conditions of the real-world settings. When applying a plan to a concrete problem, the situated actions performed in the activity often mirror the plan, but are adjusted to the concrete details and conditions of the context. For example, the unravelling plan for an osteoarthritis patient might state that an X-ray image of the hip is necessary. But when applying the plan to Mr. Jones, who doesn't have any problems with his hips, this part of the plan may be skipped — and other examinations, like a blood test, might be added to Mr. Jones' unravelling plan. Thus instantiations of plans have *fuzzy boundaries*. When applying an unravelling plan at AAS, the actual use is refleeted in the patient's *examination card* that contains an overview of all examinations ordered or performed. Hence, the unravelling plan reflects the plan and the examination card reflects the instantiation of the plan.

Plans as Means of Dividing Work

Plans are used to organise the work, and when several people are involved in this work, the plan reflects the responsibility of the involved actors. Even if the plan does not contain a formal description of who is doing which part of the plan, this responsibility either refers to the wider organisational division of work or is clarified when the plan is instantiated. The nurses' 24-hour-care plan, for example, is divided into sections that reveal the care to be undertaken by each workshift, thus explicitly reflecting the responsibility of each shift. On the other hand, when a medical protocol states that the temperature of a patient has to be measured twice a day, the protocol does not explicitly state who should do this, because this is the job of the nurse in charge of the particular patient within the particular workshift.

Plans as Status Overviews

As a result of carrying a division of labour, a plan works as a *status over-view*, like a checklist, revealing the state of the work according to the prescribed plan. The characteristic of checking off items on a checklist becomes essential when several interdependent actors work together using plans to coordinate work. The 24-hour nursing plan helps coordinate the work across working shifts because the different tasks listed in it are marked done when performed. Similarly, the examination card reflects the status of the unravelling programme of a patient, containing information on the status of each test, whether they are prescribed, ordered, or carried out.

Plans as Records

Often when plans are used in work settings, like a hospital, the interesting issue is not to follow the plan but the *deviation* from the plan. Deviating from a plan is a breakdown and therefore a potential learning situation. This fact is well recognised within medical work, where the use of problem-oriented records is becoming more widespread. Problem-oriented records are based on general medical protocols for treatment of a disease, like diabetes or appendicitis, and when a patient is treated, only deviations from this protocol are recorded. This makes problem-oriented records very powerful tools, because they contain only potential learning material compared to the standard protocol and, at the same time, they are extremely effective in both production and use.

5   The Patient Scheduler

The PATIENT SCHEDULER is based on requesting, booking and scheduling services, like examinations, tests, etc. as *patient appointments* (see Figure 1). These appointments involve different *resources* within the hospital like equipment, examination rooms, physicians and patients. These resources belong to different organisational units, like the service department or the requesting ward. In principle, anything can be named a resource. In contrast to traditional booking and calendar systems supporting the task of schedul-

ing within the service department, the prototype aims to facilitate a more direct collaboration between the employees at the different wards and service departments.
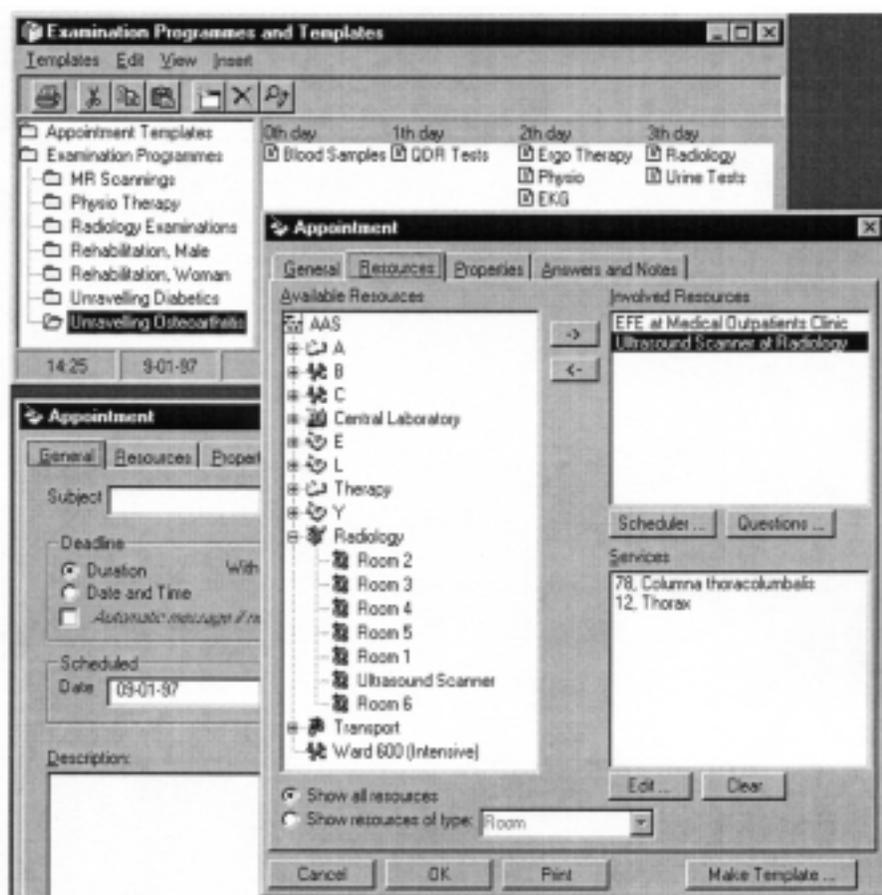
Figure 1: The Examination Programmes and an Appointment involving several resources.

Based on the analysis of the work practices at the ward and service departments, support for collaboration in the PATIENT SCHEDULER has been divided into three areas: communication, sharing and planning:

Communication: A request for a patient appointment can be sent to another department, team, or whichever organisational unit set up to

receive appointments at the hospital. When received, appointments can be sorted into different intrays (both manually and automatic) and scheduled according to different *resource calendars*. The status (requested, scheduled, performed, halted, etc.) of each appointment is generally accessible for inspection.

Planning: When requesting future examinations of a patient a *deadline* can be added to the request, indicating the latest acceptable time for examination. If the service department cannot comply with this deadline, a message can automatically be routed back to the sender on his request. Furthermore, the tool supports the creation of an *examination programme* (see Figure 1) consisting of several *templates* for patient appointments. Such a programme could be an unravelling programme and can be built up in the process of using the Patient Scheduler. A patient appointment can at any time be made into a template and added to a programme. These programmes and templates are in return available for use within the department (organisational unit) and can be instantiated on a particular patient. When instantiating a template or a programme the user can modify the resulting appointment(s) before sending it (them) to a recipient. Unnecessary appointments, e.g. the hip examination, can be skipped if desired.

Sharing: The *sharing mechanism* makes the scheduled appointments accessible within the hospital. By looking into this shared pool of appointments, the Patient Scheduler can generate different *comprehensive views* on patient appointments — e.g. a view on appointments involving a certain department, ward or physician; day calendars showing appointment 'with the CT-scanner'; and, most important, a *shared calendar for each patient* at the hospital. This shared patient calendar gives an overview of the status of the patient's trajectory and enables the users to schedule the treatment of the patient according to the patient's other appointments. The different service departments, like radiology, can share (part of) their resource calendars, hence enabling other departments to *directly book* trivial examinations that need no approval from a radiologist. This opens up for considerable timesaving in the daily routine examinations. Finally, appointment templates and examination programmes can be shared enabling e.g. the ward to use templates and programmes made at the radiology department.

6 Rethinking Workflow as Situated Planning

A typical workflow system helps to define, execute, coordinate and monitor the flow of work within an organisation. In order to do this a workflow system must contain a computerised representation of the structure of the work procedures and activities. Such a computerised representation has often been a sequential or hierarchical decomposition of an activity into tasks and are built separate to the execution of the activity. As stated by Schäl (1996)[14]:

> "Workflow management technology is composed of a workflow modelling component and a workflow execution component. The workflow modelling component enables administrators, users and organisational analysts to define working processes, so that processes and activities are defined, analysed, simulated and allocated to people (roles)" (p. 90)

These computerised representations cannot take into account unforeseen events and breakdowns. The decomposition into tasks builds on several assumptions concerning the conditions of future work and the typical problems with a workflow system arise when these assumptions break down. Hence, exception handling has attained considerable attraction within workflow management technologies, and questions on how to handle unforeseen situations and how to 'design for unanticipated use' are often raised. The central point of this paper, however, emphasises that break-down situations are *not* exceptions from work activities but are a natural and very important part of any activity which forms the basis for learning and thus for developing and enhancing plans for future action. When synthesised with the current conditions, the plan is a central resource in the realisation of any activity and is subsequently enhanced based on the experience obtained during this activity. Of course, it is important to consider exactly who is allowed to use, alter and save plans within a work practice, but this is a question of division of work and corresponding access rights within the computer system — not a separation of the planning and execution of work.

6.1 A New Understanding of Plans Based on Activity Theory

Based on Activity Theory a plan can be defined as *a cognitive or material artifact which supports the anticipatory reflection of future goals for actions, based on experience about recurrent structures in life.* As an artifact, the plan is socially constructed, is eventually crystallised into a material form, is shared among the actors in the work practice, is used to mediate work, and constitute a central part of the organisation's material conditions for work. A plan is a series of expectations to future results under certain conditions and the execution becomes an afferent synthesis between the plan and the conditions of the concrete situation. The fundamental feedback loop in the course of an activity forms the basis for a learning process embedded in the activity. This learning process creates and enhances the plan, which was originally the guiding principle for the activity.

6.2 Characteristics of Computer Tools Supporting Planning

According to the above understanding of planning as a central part of human activity, a major challenge for planning tools is to support the anticipation of recurrent events in working life and in turn to use this anticipation in the course of work. Based on this conceptualisation of human activity some characteristics of computer support for planning can be drawn from our analysis of medical work and from designing the PATIENT SCHEDULER. These characteristics can be read as guidelines for design.

Producing and Altering Plans in the Course of Work

The experience of using a plan to guide an activity under certain conditions is obtained during the activity itself. So, in order for plans to become resources for the future realisation of an activity, the plan should be made as part of this activity — *situated planning*. Thus, it is important that the planning tool allows for the ongoing creation and modification of a plan based on obtained experience in realising the plan. The PATIENT SCHEDULER supports this in

a simple way by allowing any appointment, expected to be used in the future, to be transformed into a template and added to an examination programme. These examination programmes can in turn be modified by sharing, moving and copying templates within and between programmes.

Sharing Plans Within a Work Practice

The use of the 24-hour-care plan at the ward illustrates how central the sharing of plans are, when they are used as coordination mechanisms among several actors involved in an activity. When all involved personnel has access to use the shared plan, the need for communication is considerably reduced. This enables the involved actors to act as a collective subject with a common motive. In the PATIENT SCHEDULER the underlying access mechanism controls who has access to plans enabling plans to be shared among employees and/or departments at the hospital.

Executing Plans According to the Conditions of the Work

The difference between plans as anticipated results of actions and the realisation of these actions as operations according to the conditions of the situation should be considered when designing a planning tool. Because anticipation will always be imperfect any instantiation of a plan should be malleable. For example, in the PATIENT SCHEDULER every appointment made on the basis of an examination programme can be altered or skipped according to the need of the user.

Inspecting Plans and their Potential Outcome

First of all, an overview of the available planning artifacts within a work practice is clearly a prerequisite for using plans in the first place. The PATIENT SCHEDULER supports this in the 'examination programme window' (Figure 1). Secondly, to avoid pure trial-and-error use of plans, the tool must reveal the *potential outcome* from applying a particular plan. This can be accomplished in many ways. In the PATIENT SCHEDULER, the appointment templates within a programme are listed according to a time axis, revealing,

in a rudimentary fashion, the temporal order of the resulting appointments from applying the plan. As discussed at AAS, another way of revealing the result of instantiating a plan, is a simulation mechanism: being able to simulate the plan and alter the resulting scheduling of patient appointment, before 'letting them loose' within the hospital. This simulation part of the prototype has not yet been implemented. Finally, the overview of plans should reveal the condition under which the plan is useful and helps establish whether some concrete conditions match the conditions of the plan. This is supported in a very rudimentary way in the PATIENT SCHEDULER, where an examination programme contains a textual description of the premises of the plan, leaving it to the user to establish the connection between this description and his current conditions.

Monitoring the Execution of Plans

Having an overview of the unfolding of activities is essential to all work. However, when the work is initiated on the basis of a plan, it becomes important to monitor the progress in work *according to the plan*. Thus, recognising any deviation from the plan is particularly important and should be supported by the planning tool. This monitoring of any deviation from a plan also encompasses any initial deviation when instantiating the plan, as emphasised in the above guideline. This part has not yet been implemented in the PATIENT SCHEDULER. When the user has instantiated an examination programme the resulting appointments cannot be traced back-ward to the original programme. This functionality, however, was raised and discussed as a central requirement during several prototyping sessions.

7 Conclusion: Plans as Situated Actions or Technologies of Accountability

This paper has re-entered into the discussion on how to support ways of planning and prescribing work by providing a new conceptualisation of the role of plans and prescriptions in work activities. By analysing the work within a hospital and designing computer support for planning work, it was illustrated that planning is not to be viewed as opposed to work *in situ*.

Plans as chains of anticipated goals, are a central part of human activity, but are realised accommodated to the contextual conditions. The core point is to recognise the function of plans as ways of anticipating and pre-handling events in (working) life based on their recurrent nature, and be able to save and later reuse the experience obtained in handling these events. Winograd and Flores (1986)[24] make the same argument by showing how many patterns of action within organisations are designed to anticipate and cope with such recurrent structures. This is especially evident within a hospital; plans for handling all kinds of recurrent events, from receiving injured people involved in car accidents to ordering food for patients at the ward daily, have been made and constitute the operational backbone of the hospital. This understanding of plans as central assets in work has some implication for the issue of workflow systems: instead of supporting routing information around in organisations according to a workflow process model, the computer should be a tool mediating the anticipatory reflection of recurrent events in working life. Hence, such a planning tool should support *situated planning* — building, altering, sharing, executing, and monitoring plans within the cooperative work activities.

Based on this conceptualisation it becomes possible to make a planning tool that does not emphasise a rigid match between process models and work. However, it is central to understand why such formal process models are made and embedded in workflow systems in the first place. Often — e.g. in the area of Business Process Reengineering — workflow systems are viewed as the 'enabling technologies' for turning the modern firm into a process organisation with greater opportunities for efficiency and cost reduction (see e.g. Abbott and Sarin, 1994[1]). Thus, workflow systems are conceived as organisational infrastructure used and designed for meeting organisational goals (e.g. customer satisfaction) (Schäl, 1996[14]). When viewed from this overall organisational perspective, workflow systems are often used to keep track of the work according to these organisational goals. This means that a workflow system is not just mediating the workflow (which has been the premise for this paper so far), but is used for additional managerial purposes. Hence, the workflow system becomes a 'technology of accountability' as defined by Suchman (1994)[18]:

> "By technologies of accountability I mean systems aimed at the inscription and documentation of actions to which parties are

account able [. . .] in the sense represented by the bookkeeper's ledger, the record of accounts paid and those still outstanding" (p. 188).

In this sense the actions realised by the workflow system are *polymotivated*. On the one hand, the system is used to give order to the unfolding of work within the organisation by making some top-down decomposition of the organisational goals into work processes. On the other hand, the system is a 'technology of accountability' by recording the progress of work according to such process models.

The idea of many workflow systems is to consider this polymotivated nature of organisational work and try to integrate (at least) these two motives within the organisation in one system. Unfortunately, this often ends up in having the organisational and administrative activities setting the agenda for the work activities. For example, Bowers et al., (1995)[6] describe a workflow system that embeds the motive of management of keeping track of print-work at the expense of the motive of the employees at the shopfloor of 'maintaining a smooth flow of work'. Similarly, Heath and Luff (1996)[7], reporting from a case study in the Healthcare sector in the UK, illustrate how a workflow system is designed to satisfy the motive of the pharmaceutical firms to record the amount of used medication, at the expense of the motive of the medical practitioners to structure their medical record according to 'descriptive economies'.

The point to be emphasised here is that such problems with existing workflow systems should not be understood merely as conflicting motives and goals within the organisation which could easily end up in a conclusion saying that either you design for accountability or you design for work support. It is important to recognise that an organisation, like a hospital, is not merely 'getting the work done', e.g. curing patients, but is doing this work in a visible, inspectable, documentable and accountable way (Bowers et al., 1995[6]). An organisation is not only engaged in the activity of producing a product, or curing patients. An organisation has to be viewed as a collection of multiple activities, each realising different needs. Some of these activities are directed toward the 'object' of the organisation, like curing patients, and others are directed toward an organisational accountability of work. From an Activity Theory perspective this means that the polymotivated nature of actions involved in a plan should be considered so that motives of all involved

actors, responsible for different areas of the work within the organisation, are recognised — and satisfied if possible.

8 Acknowledgements

References

[1] Abbott, K., and Sarin, S. (1994): "Experiences with workflow management: Issues for the next generation", In *Proceedings of the Conference on CSCW, Chapel Hill, USA.* ACM, p. 113-120.

[2] Anokhin, P. K. (1973): "The forming of natural and artificial intelligence", *Impact of Science on Society* XXIII (3).

[3] Anokhin, P. K (1976): "The Philosophical Importance of the Problem of Natural and Artificial Intellects", *Soviet Studies in Philosophy* XIV (4), p. 3-27.

[4] Bærentsen, K. (1989): "Mennesker og Maskine [Man and Machine]", In Hedegaard, Hansen, and Thyssen (eds): *Et virksomt liv [An active life].* Aarhus: Aarhus Universitets Forlag, p. 142-187.

[5] Bødker, S. (1991): *Through the Interface: A Human Activity Approach to User Interface Design.* Hillsdale, NJ: LEA.

[6] Bowers, J., Button, G., and Sharrock, W. (1995): "Workflow from within and without: Technology and Cooperative Work on the Print Industry Shopfloor", In *Proceedings of the Fourth European Conference on CSCW, Stockholm, Sweden.* Kluwer Academic Publishers, p. 51-66.

[7] Heath, C. and Luff, P. (1996): "Documents and Professional Practice: 'bad' organisational reasons for 'good' clinical records", In *Proceedings of the Conference on CSCW, Boston, Massachusetts USA.* ACM, p. 354-363.

[8] Hughes, J. and King, V. (1993): "Paperwork", In S. Benford and J. Mariani (Eds.): COMIC D4.1: *Requirements and Metaphors of Shared Interaction,* Lancaster: Lancaster University.

[9] Kuutti, K. (1991): "The concept of activity as a basic unit of analysis for CSCW research", In *Proceedings of the Second European Conference on CSCW, Amsterdam.* Kluwer Academic Publisher, p. 249-264.

[10] Leontjev, A. (1978): *Activity, Consciousness, and Personality,* Englewood Cliffs NJ: Prentice-Hall.

[11] Leontjev, A. (1981): *Problems of the Development of Mind.* Moscow: Progress Publishers.

[12] Medina-Mora, R., Winograd, T., Flores, R. and Flores, F. (1992): "The action workflow approach to workflow management", In *Proceedings of the Conference on CSCW, Toronto, Canada.* ACM, p. 281-288.

[13] Nardi, B. A., (ed.) (1996): *Context and Consciousness: Activity Theory and Human-Computer Interaction.* Cambrigde, MA: MIT Press.

[14] Schäl, T. (1996): *Workflow Management Systems for Process Organisations.* Berlin: Springer Verlag.

[15] Schmidt, K. and Simone, C. (1996): "Coordination mechanisms: Towards a Conceptual Foundation of CSCW Systems Design", *Computer Supported Cooperative Work 5*, p. 155-200.

[16] Star, S. L. (1989): "The Structure of Ill-Structured Solutions: Boundary Objects and Heterogeneous Distributed Problem Solving", In L. Gasser and M. Huhns (Eds.): *Distributed Artificial Intelligence*, London: Pitman, p. 37-54.

[17] Strauss, A., Fagerhaugh, S., Suczek, B. and Wiener, C. (1985): *Social Organization of Medical Work.* Chicago and London: University of Chicago Press.

[18] Suchman, L. (1987): *Plans and situated actions. The problem of human-machine communication.* Cambridge: Cambridge University Press.

159

[19] Suchman, L. (1994): "Do categories have politics? The language/action perspective reconsidered", *Computer Supported Cooperative Work 2* (3), p. 177-190.

[20] Symon, G., Long, K., and Ellis, J. (1996): "The Coordination of Work Activities: Cooperation and Conflict in a Hospital Context", *Computer Supported Cooperative Work 5,* p. 1-31.

[21] Vallgårda, S. (1992): *Sygehuse og sygehuspolitik i Danmark: Et bidrag til det specialiserede sygehusvæsens historie 1930-1987. [Hospitals and hospital politics in Denmark: A contribution to the history of the specialised hospital sector 1930-1987].* København: Jurist- og Økonomforbundets Forlag.

[22] Vygotskij, L. S. (1978): *Mind and Society.* Cambrigde, MA: Harvard University Press.

[23] Winograd, T. (1994): "Categories, diciplines and social coordination", *Computer Supported Cooperative Work 2* (3), p. 177-190.

[24] Winograd, T. and Flores, F. (1986): *Understanding Computers and Cognition: A New Foundation for Design.* Norwood, New Jersey: Ablex Publishing Corp.

I Love the System - I just don't use it!

Jakob E. Bardram

Computer Science Department,
University of Aarhus, and
Kommunedata, DK-8000 Aarhus C, Denmark

Abstract

This paper addresses how studies of work can provide the basis for redesigning existing information technology (IT). The paper reports on a field study of the differences in work practices of hospitals using a computer system and hospitals not using the system. We shall present the variety of strategies healthcare workers have adopted to coordinate their widely distributed activities, and discuss the consequences for these strategies when using the computer system. The paper concludes that the design of groupware should recognize the multiplicity of artifacts in the workplace (both manual and computational) and the need for interconnecting groupware with Information Systems.

1   Introduction

This paper reports a field study of coordination of work by information technology (IT) within hospitals in Denmark. The title originated from an interview with a secretary using the system in question, and reflects the fact that she was absolutely thrilled about it, but agreed that she actually did not use it for the intended purpose. We shall return to this paradox later.

Within CSCW, several investigations into work practices in different settings have revealed the inherent contingencies and complexities characterizing co-

operative work. These investigations stress how organization of collaborative work is socially organized and distributed within a certain work-practice [4,14,15]. Similar studies have revealed how systems designed and implemented for organizational or managerial purposes fail when introduced to the work, because they do not take into account the socially organized practices of a work setting [2,3]. In the UK general practitioners are committed to use a computer-based record system for bureaucratic reasons, but keep using the old paper-based records in parallel because the system does not fit their work-practice [8]. A common theme in many of these investigations is how people invent ways of 'working around' the system or how people do 'double-work' by maintaining both a paper-based and a computer-based system.

The present study of work and time coordination within Danish hospitals confirms these observations. The case details the indigenous aspects involved in a seemly trivial task of ordering an examination from one department to another, and shows how the present Hospital Information System (HIS) only supports a fragment of this task — and even works counter-productive in certain instances. However, the study also points to the strengths of the system and thus to additional issues to address when designing groupware technology. Previous studies of work coordination are limited in their focus on small, self-contained work groups [19]. Therefore, design of groupware has primarily looked into the support of coordination and information sharing on a small scale. This is a too narrow focus when designing Hospital Information Systems. The overall design of an HIS has to adopt a broader perspective on cooperation across time, location and actors, and has to acknowledge the organizational status of coordination support.

There are several lessons to be learned from this study. First, when designing groupware the multiplicity of the different artifact being modeled has to be recognized. Second, development of IT today has shifted from design of new systems to redesign of already existing systems. Studies of work performed both with and without the system in question are valuable resources in this process. Third, the construction of groupware systems needs to be integrated with any existing Information System.

2 Background

2.1 Hospitals in Denmark Today

Resembling the development in other western countries the hospitals in Denmark have within the last 30 years tended to become bigger, more specialized and capable of treating more diseases and disorders [20]. This centralization and specialization is a result of an urge to concentrate the knowledge and research within the different areas of medicine, to make the treatment and care more effective, and to utilize the increasingly expensive equipment (e.g. radiology equipment) necessary for making new treatments. The specialization is reflected in the organizational structure of the hospital, which consists of departments functionally divided according to the specialities, which again often is divided according to the human anatomy.

Because the hospitals in Denmark are 100% publicly funded they are subject to strong political government. In order to control the increasing expenses in the healthcare sector, a tight budget control was established during the 1980's. Based on registration of activities in terms of officially standardized 'services' (e.g. removing an appendix or an out-patient consultation) fixed annual budgets are made for each hospital and each department. The budgets cannot be exceeded, which has lead to considerable waiting lists for certain treatments. From a political point of view, however, the expenses to the healthcare sector and the hospitals in Denmark are under firm control.

The functionally divided structure of the hospitals according to the medical specialities has resulted in certain organizational, work-oriented and qualitative problems in the treatment and care of patients. First of all problems of coordinating the treatment made in the different departments arises. Secondly, it results in an enormous management overhead in figuring out the cost and efficiency of the different treatments.

2.2 The SAIK Project: Developing Computer Support for Healthcare Work

The SAIK project[1] was launched as an experimental pilot project at Kommunedata in our attempt to redesign a national-wide Hospital Information System called the Green System (GS). Currently GS is a large mainframe-based information system used by most hospitals in Denmark. The aim is to redesign GS into a client-server architecture, preserving the mainframe technology as a database server but building PC-based client applications dedicated to support the work at different departments within a hospital — e.g. at the emergency and casualty department, at a medical ward, and at a surgical planning office.

As described above, one of the main problems within Danish hospitals today is coordinating the treatment made in the different departments. The purpose of the SAIK project is to investigate how coordination and planning of patient care happens today — both with and without computer support — and based on these investigations to reveal how this coordination can be supported by computer technology. Even though the Green System is designed to support such coordination and cooperation among departments, there has been a very low adoption of this functionality at the hospitals using GS. Thus, from Kommunedata's perspective there is an interest in investigating the possibilities of supporting this coordination of work, due to the difficulties in supporting it with the existing system.

3   An Outline of the Methods Used

Ethnographic inspired workplace studies were conducted at 3 hospitals, which have been using GS for requesting and booking examinations for at least 5 years, and at 2 hospitals, which have never used GS for this task. These workplace studies and preliminary data analysis were based on qualitative methods such as qualitative interviews; participative observations of daily work at the ward, meetings and conferences (cf. [13]); and studies of different documents, records and other tools [9]. Furthermore, future workshops [10] with participants from the ward was conducted. The data analysis was

---

[1]SAIK is a Danish abbreviation for "Collaborative Informatics in Clinical Practice."

done by transcribing the interviews and parts of the workshops, by drawing different rich pictures of the flow of documents within the hospital and by writing detailed scenarios describing the current work practice. As opposed to the 'traditional' way using grounded theory [17] within CSCW, our qualitative data were subsequently interpreted by applying Activity Theory.

4 Activity Theory

Activity Theory originated in the former Soviet Union as part of the cultural-historical school of psychology founded by Vygotskij, Leontjev and Lurija. The following presentation is based on the writings of Vygotskij [21] and Leontjev [11,12], and focus on certain core concepts of the theory, which are fundamental in understanding the role of cooperative work and the use of technology in human activity.

The fundamental unit of analysis is the *human activity*, which has four basic characteristics: Firstly, an activity is directed towards a material or ideal object satisfying a need, which constitutes the overall motive of the activity. For example, the physician's medical treatment of a patient is directed toward curing this patient. Secondly, human activity is always *mediated by artifacts*, either external (e.g. the physician using his stethoscope) or internal (cognitive — the physician using medical concepts and heuristics). Thirdly, individual activity is practically always part of *collective activities*, structured according to the work practice in which they take place (i.e. the *context* of the activity). For example, the diagnosis of a (medically ill) patient can seldomly be established without a diversity of medical in formation, which are obtained by cooperating with the specialized personnel at different service departments — e.g. radiology, laboratory, and pathology. The collective activities is thus organized according to a *division of labor*.

Finally, human activity can be described as a hierarchy with three levels: *activities* realized through chains of *actions*, which are carried out through operations. Actions are controlled by the subject's conscious *goals*, which are expectations of future results achieved by the action. The activity exists only as one or more actions but the activity and the action are not identical and cannot be reduced to each other. Actions are realized through operations that are determined by the actual *conditions* in the context of the activity.

The level of activity describes *why* a person is carrying out an activity (objective), the level of action explains *what* (s)he is doing (results), and the level of operations describes *how* the activity is realized (conditions). For example, the physician's activity of treating a medical ill patient can roughly be characterized as a cyclic process consisting of five actions: (i) examination, (ii) requesting and interpreting a diversity of medical information, (iii) decision making concerning the conditions and illness of the patient, (iv) further medical treatment and (v) monitoring the effect of the treatment. Exactly how the action of examination is performed depends clearly on the concrete conditions, e.g. the type of decease in question, the state of the patient, available medical instruments, knowledge and experience of the physician, etc.

5   Coordinating Activities without Computer support

The above example illustrates how examinations and tests are requested both for the reason of unraveling the state of the patient and for monitoring progress in medical treatment. This implies a considerable collaboration with other departments in every cycle of treatment. A common theme in all the hospitals observed was a close cooperation between the ward in charge of a particular medical treatment and the radiology department, and shall thus be the primal example discussed here. However, the insights discussed here applied equally for the cooperation between other departments within a hospital. In our observations and in our subsequent analysis, we have identified five major *strategies for coordination collective activities* distributed across space, time, and employees:

    i.
    i.   Minimizing articulation among collaborators.
    ii.   Prioritizing and scheduling work, and ensuring commitment to the schedule.
    iii.   Sharing information and maintaining an overview.
    iv.   Ensuring fair and optimal workloads.
    v.   Anticipating, planning and pre-handling work.

5.1 Minimizing Articulation among Collaborators

The treatment of a patient is a collective activity. It involves multiple health-care professionals that are mutually dependent in their work and therefore are required to cooperate in their work. This means that the physician at the ward relies on the quality and timeliness of e.g. the radiologist and vice versa. Compared to individual work, this means that these collective activities incurs an overhead cost in terms of articulating (divide, allocate, coordinate, schedule, etc.) the healthcare workers' distributed activities [16].

In our observations we noticed that the work practices are constantly evolving towards minimizing such mutual articulation among people involved in collective activities, without jeopardizing the motive of treating the patient. In Activity Theory terms this is done through a strict division of labor, enabling the healthcare workers to specialize in certain activities, and by designing certain *structured* artifacts that mediate the activity in an efficient way.

An important type of artifact within hospitals is the *paper-based order forms* for different service departments. These semi-structured forms prompt for information, which is necessary in order for the service department to perform the requested examination or test. At a medical ward, these forms are used at the daily ward round. The physician prescribes the examinations and treatment, and the nurse(s) fill in these paper-based order forms for the different kind of examinations, tests and treatments. Patients at a medical ward typically need to be X-ray examined in the radiology department of the region thorax and colon, to have different types of blood tests analyzed by the central laboratory, and to attend a rehabilitation program in physio-and occupational therapy.

When requesting a service the physician and/or nurse need to state *what* the patient is to be examined for (e.g. an X-ray picture of the colon region), and *why* the patient needs to be examined (the diagnosis). This means, in Activity Theory terms, that the action is requested from the ward, but the motivation for the activity, which the action is part of, is also stated on the form. Hereby the responsibility is handed over to the radiologist, which means that (s)he — in principle — can change the request if (s)he finds it unnecessary or if the requested examination is insufficient to address the stated problem. Hence, the radiologist can consider exactly how the

action should be realized according to his conditions and knowledge. Another important part of realizing this action of requesting an X-ray examination is to make sure that the radiology department actually receives it. This operation is the responsibility of the secretary at the ward, who collects the order forms, and walks around to the different departments and delivers them there.

At the radiology department an important type of artifact is the different in- and out-trays containing all incoming order forms and outgoing answers. The in-tray enables the secretary from the ward to hand in her forms without contacting anyone at the radiology department, thus reducing their mutual articulation. A secretary at the radiology department takes all the incoming order forms and sorts them into different categories according to the type of examination, its urgency, the ward who send it, etc. There are different trays resembling these categories and for each of the radiologists. Putting an order form into one of these trays is a sign from the secretary to the other staff to handle the form from there.

When the picture has been taken and developed, the new and the old pictures along with the description on the order form forms the basis for the radiologist's answer on the request. The answer is put into the out-tray of the ward that ordered the examination. Every morning, just before the ward round, the ward's staff of physicians enters the radiology department for the radiology conference. At this conference the radiologist describes the result of each examination as also stated in the written answer in a highly structured and efficient way. Meanwhile, the ward's secretary collects the written answers in the out-tray, and puts them into the medical record in order to have the answer ready-at-hand in the future treatment of the patient.

5.2 Prioritizing and Scheduling Work, and Ensuring Commitment to the Schedule

The above description reveals how the order form works as a coordination mechanism mediating the articulation of the physician's need for an X-ray examination in order to continue his treatment of the patient. The order-form is, however, insufficient in many cases. The analysis of human activity as a hierarchical three-level structure emphasizes that the same activity can

be realized through different actions and the same action can be realized through different operations. The other way around, the same action can be a part of realizing different activities: The action of requesting an X-ray examination at the radiology department can be part of the diagnosing activity or it can be part of preparing for surgery, thus realizing a total different activity. Similarly, an operation can be part of several actions (together with other operations). The choice of operations depends on the conditions of the context in which the action is taking place. Thus, realizing an activity in a contingent environment is aided considerably by having a *repertoire of actions and operations* to choose from.

One particular crucial constraint to consider in the activity of patient treatment is the temporal characteristics of medical work. First of all *speed* is crucial, because it can mean the difference between life and death, between chronic illness and total recovery, between simple treatment or complex and lengthy hospitalization. Secondly, *temporal sequence* is important, because some examinations and tests need to be made before a treatment can be initiated or a diagnosis can be established. Finally, the *synchronization* of medical work is important and has several implications. If for instance, a patient needs an examination at another hospital, it would be preferable that all the examinations needed at that hospital are done within the same visit. Therefore, the different examinations have to be prioritized and scheduled according to such temporal characteristics and constraints.

One of the primary responsibilities of the secretary at the ward is to ensure that such more or less critical timing constraints are fulfilled and balanced. This cannot be achieved by just turning in an order form and the secretary therefore uses the phone as another way of mediating the 'request-an-examination' action. The secretary described this task as putting together a *jigsaw puzzle*. By gathering the order form from the physicians the secretary figures out how they should be scheduled according to different constraints and she then phones the service departments negotiating for specific timeslots that fit into her overall picture. Because of the scarce resources in Danish hospitals and because she is not the only one, who is trying to put together such jigsaw puzzles within the hospital, the requests for specific timeslots can seldomly be met. Therefore, a regular barter-economy has evolved at the hospital: if the secretary really needs a special request she most often has some other examination to trade with, for example another 'of her own'

patients who can be postponed. Alternatively, she can call another ward, make a deal with them in order to get one of their timeslots, and then negotiate the switch between patients with the radiology department. The use of the telephone for this task is obvious. If the timing request were written on the order form — as it sometimes is — the secretary (and thus the physician) would not know whether the request was met. The telephone provides the opportunity to get a commitment or rejection immediately and to convey the information to the medical staff involved.

At the radiology department another jigsaw puzzle has to be put together when the many requests for examinations has to be scheduled. To ensure a smooth flow of work within some tight resource constraints, the request are prioritized and scheduled according to the type of examination, the urgency, the diagnosis and state of the patient, which radiologist needs to approve the request, etc. For example, when a request of an urgent examination is received, a radiologist needs to approve that this really is urgent enough to reschedule the whole program for the day. The radiology department maintains a commitment to perform examinations according to their priority: to ensure that a acute examination is made immediately on request, the schedule for the standard examinations are kept flexible loose. Standard examinations are not scheduled at a specific time, just at a specific day. The employees in each of the examination rooms continuously check their schedule for the day and decide which of the patients to examine next. This gives the radiology department the freedom of re-scheduling all day, because nobody knows the exact time, and hence compensates for lack of idle resources to handle acute cases. The radiologist calls the ward a half hour in advance asking them to prepare the patient for the radiology examination. However, because the ward does not know the exact time of examination, the patient is sometimes away for other examinations or some rehabilitation program when the radiology department calls. This forces the radiology department to pick another patient from the list.

5.3 Sharing Information and Maintaining an Overview

Until now we have seen how the order form and the telephone are the central artifacts mediating the coordination of examinations. The use of telephones is, nevertheless, associated with considerable overhead in the coordination of

work. The whole task of calling different departments is time consuming, because telephones are typically busy. Furthermore, the use of phones leaves no traces for the other involved actors in the task of examination. The message received in a telephone call has to be communicated in one way or another. This problem grows when appointments are changed or cancelled, leaving the person who answered the phone with a serious job of communicating this change to all involved staff. Ideally, therefore, the artifacts mediating the collective activities involved in medical work need to be *shared* as a way of maintaining an overview of the total activity. However, sharing artifacts when work is distributed is not always easy. Let us consider some of the strategies applied by the healthcare professionals to cope with this dilemma.

Because each of the involved actors needs the information about the examination, in this case presented via the order form, they are *making copies* of it. At the ward the physician records a prescribed examination in the *medical record* via the dictation made during every ward round. The nurse records the examination in an *examination program* in the kardex (nursing record). The secretary copies the information into her *day-plan* in order to keep an overview of the whereabouts of patients on a particular day. These are three different overviews, made for three different purposes and with three different time-span: (i) an overview of the overall medical treatment of the patient, (ii) an overview of the examinations of the patient during this hospitalization, and (iii) an overview of the different examinations (and other activities) for the patients at the ward on a particular day.

At the radiology department the secretary schedules the request in the radiology department's *booing calendar*, which is their central coordination mechanism. For each type of radiology equipment available at the department the booking calendar contains a schedule of all examinations, their starting time and duration, the patient, the diagnosis, the referring ward, and a description of the examination to be performed. This shared artifact mediates the coordination of the collective activities of all involved personnel — secretaries, nurses, radiologists, porters, etc. — just by being publicly accessible. However, this shared artifact is not enough. According to Danish law, the patient's medical record has to be present when an examination is to be performed. This is to ensure that the doctor is familiar with the patient's history of illness and the overall medical context of the current examination. Thus, one of the prime shared artifacts within a hospital is the

medical record. However, the record is seldomly available because it is used at the ward. So for practical reasons, the radiology department has its own records of previous radiology examinations. By having this old information ready-at-hand, the radiology department reduces its dependency on other medical staff involved in the treatment. Again we see how the difficulties in sharing information (artifacts) is overcomed by making copies.

This strategy of duplicating information serves several purposes. (1) Each group of persons involved needs an overview tailored according to their *specific role* in the overall collective activity. (2) The information about the examinations needs to be accessed and shared simultaneously at *different places physically apart.* (3) The *colleagues* of the nurse, the physician or the radiologist need to know what examination has been ordered and performed e.g. during other shifts. These three purposes can be described as the need for keeping a relevant overview of the cooperation across space, time and actors.

5.4 Ensuring Fair and Optimal Workloads

Work is not only scheduled and prioritized according to the constraints concerning the examination of the patient but also according to the constraints within the work practice and division of labor of the collective activities. The distribution of workload among the people within the practice needs to be considered and some effort is put into ensuring both a fair and optimal workload.

At the ward, for example, the workload during a dayshift is by far the largest. Therefore, all work that can be postponed (mostly administrative work) is handed over to the evening- and nightshifts. When scheduling examinations at the radiology department the complexity of the examination has to be considered in order to ensure an optimal allocation of resources — e.g. taking into account that some radiologists are specialized in different examination. However, when the different examinations are scheduled in the booking calendar it is important to ensure that there is an even workload among the different radiology-rooms and thus between the different employees. For example, at a radiology department a secretary told us that the personnel at 'Room 1' had complained that they always had the largest workload just be-

cause they were listed first in the booking calendar. Today this was avoided by maintaining an overview sheet in front of the booking calendar showing the workload. This illustrates that an effort is often put into ensuring a fair distribution of examinations when scheduling examination.

Another important aspect of human activity is that actions are usually *polymotivated*; two or more activities can temporarily merge, motivating the same action, if the goal is part of reaching the motives of several involved activities simultaneously. For example, the radiology department, and the hospital in general, has the responsibility of educating younger radiologists. Therefore, the action of making an X-ray examination serves the purpose of both providing some medical information to the requesting ward as well as educating younger radiologists. They cannot, therefore, be assigned to trivial and standard examinations only, but need to be trained in all kinds of examinations — another constraint to consider when scheduling examinations.

5.5   Anticipating, Planning and Pre-handling Work

According to Activity Theory, all human activity is guided by anticipation. The basic principle that makes this anticipation possible is the recognition of *recurrent structures* in the world, which repeat themselves over time. Based on the experience of handling such recurrent structures they can be planned for and artifacts can be designed in an attempt to be prepared for them. This anticipation of work and attempts to pre-handle it was confirmed by our observations, which revealed that clinical work is subject to a large degree of planning. Plans play a central role in guiding and recording work at a hospital [1].

When a new patient enters the ward, the physician needs to have several tests and examinations performed at once in order to make the correct diagnosis and to prescribe a correct plan of treatment. Because these tests are mainly the same within different categories of diseases, the ward has pre-made examination programs for unraveling the condition of the patient. These *unraveling programs* prescribe which initial examinations and tests should be ordered to state a precise diagnosis. Hence, the unraveling program provides a plan for obtaining the necessary clinical data for further treatment. The unraveling program is a pre-printed examination program,

which is directly inserted, in the new kardex for the patient and the different examinations are ordered on the basis of this examination program.

In principle all requests to the radiology department need to be looked at and approved by a radiologist in order to ensure correct treatment and a correct prioritizing. However, a majority (ca. 75%) of the requests for radiology examinations is standard bone examinations, which are fairly trivial and do not need any approval. This division of examinations into standard and non-standard examinations is a way of pre-handling a certain set of recurrent examinations in order to save time in the daily work. Thus standard examinations (e.g. bone X-ray pictures) need no approval — or rather has been *pre-approved* by the radiologist. Anticipation and pre-handling of breakdowns are also evident in the way that the machinery is subject to service checks at a regular basis (ca. once a month). Also at a day-to-day basis, the workload is anticipated and sought to be pre-handled. One day, for example, the local radio station reported from a multiple car-crash on the highway — a 'pile up'. This immediately made the radiology department re-schedule the whole day in order to be ready for incoming patients with broken arms, legs, etc. anticipated to arrive in the near future.

6   IT in the Danish Healthcare Sector

Approximately 50% of the Danish healthcare sector uses the Green System from Kommunedata, which makes it the most widely used Hospital Information System in Denmark. It consists of 5 overall functional modules:

Patient administration: Provides the basis for handling the large amount of patients and supports registration of services extended to these patients, thus providing a basis for the budget planning and control in the Danish healthcare sector. Specialized modules for handling patients hospitalized and treated at wards, outpatient clinics, emergency and casualty departments, and in psychiatric hospitals have been made.

Booking, Internal Communication & Electronic Data Werchange (EDI): Supports requesting services from one department to another, like a surgical ward requesting an X-ray examination from the radiology department, and booking a hospital porter for transportation of the patient. The EDI module

supports communication between the general practitioners and the hospital, like referral forms, discharge letters, laboratory service requests and reports.

Management: Supports charging and billing internally in the healthcare sector, and supports internal management information to the management of the different departments and hospitals.

Data warehouse: A national-wide shared database containing information on patients who have been treated at different hospitals. This database is accessible from all hospitals using the Green System in Denmark giving valuable information on a patient's history of treatment.

Classification: Used to register and statistically process all the different services provided within the Danish healthcare sector according to the official classification from the Ministry of Health.

The Green System was primarily developed for organizational reasons in order to support the handling of the large number of patients entering a hospital, to provide a technological basis for budget control and to support the coordination and collaboration between the highly specialized departments and hospitals. Therefore, the system has been used by trained secretaries and other administrative personnel and has generally received little attention from healthcare professionals such as physicians, consultants and nurses. The system is oriented towards the central needs of the organization (e.g. patient administration) and thus becomes an extension of the organizational infrastructure of a hospital. Although one goal is to assist patient care and treatment (e.g. by supporting booking and requesting services), support to the work-practices in the clinic is made according to the overall organizational needs.

7 Coordinating Work through the Green System

Even though the use of the Green System within Danish hospitals is rather extensive, it has mainly been used as a patient administration system. The module supporting booking and requesting examinations has had a low adoption rate, even though the design of the system was made to support this

task from the very beginning, in order to "collect data on services where they were requested." Contrasting the previous study of work associated with coordinating examinations using the Green System, it becomes evident that GS only supports part of the multiplicity of coordinating and requesting examinations within a hospital. Let us give some details.

7.1 Minimizing Articulation among Collaborators

The order form, as we find it in many hospitals, has been modeled as a semi-structured form called the *requisition* in GS. The requisition contains fields for identifying the patient, the diagnosis, for requesting certain services from the classification of services, for free text description, for stating a proposed time for the examination, and for the signature (initials) of the referring physician. At a service department, like the radiology department, all incoming requisitions are received and can be scheduled on different *resource calendars*. A resource in GS can, for example, represent a piece of radiology equipment, a consultant, a scanner, etc. The answer to the examination can be typed into the system and send back to the department that requested it. At the radiology department the answer is electronically filed. Hence, the Green System supports the requesting, transportation and answering to an examinations internal at a hospital, saving the secretaries a lot of phone calls and walking around the hospital. This has also been the main design rationale for the 'Booking & Internal Communication' module of the system.

GS does not, however, support the action of prioritizing and sorting incoming order forms at the radiology department. All incoming requisitions are listed in one view with no support for sorting them into different categories (e.g. like folders in a typical email system). At the radiology department all incoming requisitions are typically printed out and dealt with in the same way as the paper-based ones. There are several reasons for printing the requisition: (i) it has to be dealt with in connection with the other paper-based requisitions, (ii) the radiologist who approves the requests needs them in paper because (s)he does not bother to find them in the system, (iii) the requisition is needed during the examination, where the system is cumbersome to use, and (iv) the requisition needs to be filed together with the pictures in the central archive. Thus, GS is often recognized as just another in-tray to the radiology department.

7.2 Prioritizing and Scheduling Work, and Ensuring Commitment to the Schedule

We noted that many examinations were not ordered purely by using the order form, but was realized as a jigsaw puzzle in order to coordinate the temporal order of examinations, tests, and treatments. GS provides a field for proposing a time for examination at the requisition form. However, when looking into the use of GS in the hospitals, this field was seldomly used for the same reason that the field was not used in the paper-based forms: there was no immediate confirmation or rejection to the request. Thus, the telephone was still used for this time negotiation and when an agreement was accomplished the proposed time was filled into the requisition and sent to the radiology department. Furthermore, it is the ward, and thus the secretary at the ward, who has the overall responsibility and overview of the treatment of the patient. Therefore it is obvious that the ward calls the radiology department in order to engage in a negotiation, in which the ward can say which timeslots confirm to the other examinations and activities of the patient and which do not. Hence, just one field for a proposed time is not enough, because several time intervals might do.

When the radiology department is scheduling the incoming requisitions on a resource calendar, a specific examination time need to be stated. Hence, the way of just having patients scheduled for a particular day, with no time allocation, is not supported. This is, however, worked around by allocating the time '00:00' to all standard examination for that day.

7.3 Sharing Information and Maintaining an Overview

We noted that the work of coordinating the examinations and tests at the hospital involved keeping a relevant overview of the cooperation across space, time and actors. Different overview charts for different purposes were made according to the need for re-representing the information stated at the order form. Looking at GS from this perspective there is little, if no, support for either having or producing such overviews. The examination program, which was one of the central overviews used at the ward, cannot be made from GS, nor can the secretary's list of examinations for all patients at the ward at a particular day. Even though the system can provide a list of

examinations performed on a particular patient, this list is statistical and historically oriented, and does not reveal the status of future examinations, their time schedule, and the subject of the examination.

At the radiology department the overview of activities during one day can be made as a printout of the resource calendars. Such a printout contains a list of patients scheduled during the day. However the list does not reveal the kind of examination that has to be performed, only the time, the patient and the diagnosis, and provides thus little help as a guide to the examination itself. Furthermore, more overall overviews of more than one day or more than one resource at a time cannot be made. These kinds of overviews are extremely important and were therefore often made manually. For example at one hospital, visiting the radiation department for cancer treatment they used both a manually *planning board* and GS. The main resource and thus temporal bottleneck is the radiation machine. A cancer patient needs from 20 to 30 rounds of radiation treatment and thus the whole treatment was often spread out on 6 to 10 weeks (with a maximum of 5 treatments a week). Consequently, an overview of at least 10 weeks was necessary in order to schedule a treatment consisting of a whole series of radiation treatments. GS could not provide this overview so a planning board consisting of a large board of Lego bricks representing 13 weeks was used. The planning and scheduling was done on the planning board and later the radiation treatments were entered into GS. Hence, the secretary maintained the schedule both at the planning board and in GS. Why this double work?

The use of the planning board was used because it offered 3 important benefits compared to GS. (i) The board provided a temporal overview of all examinations on a 13-week time span. Furthermore the board supported adding small post-it notes for additional and detailed information. (ii) Rescheduling was easy — the Lego brick representing a treatment was just moved to a new timeslot. (iii) The board was highly visible for all persons involved in scheduling examinations, like the radiologist, the physicians, the nurses, and especially the patients who could see when a timeslot was available and compare it with their own calendars. Furthermore the visibility of the board revealed also how busy thing were at different periods, and thus provided the overview necessary to even out the workload. On these terms, GS failed to support these important aspects of providing a highly visible, malleable, and sharable representation of the scheduled treatments.

7.4 Ensuring Fair and Optimal Workloads

We noted that an even distribution of the workload and the examinations across resources at the radiology department were of central importance. Regardless of this, there is no way in GS to see the overall workload on the different resources. This makes the task of scheduling an examination rather cumbersome, because every resource calendar needs to be looked at before the most optimal one can be chosen. Thus, many trained booking secretaries at the different service department reported that it was of crucial importance to maintain a mental image of the overall workload on the different resources in the weeks to come. This mental image was developed and maintained during scheduling each day, thus making it hard to reenter the scheduling activity after periods of vacation or illness. At the radiation clinic the planning board was used for maintaining this overview.

Often a standard paper-based calendar was used in connection with the system, which was used both as a normal calendar — showing the connection between dates, weekdays, and weeknumbers — and as a representation of different aspects to consider on particular days. This could be working shifts, particular types of patients, education, etc. Even though GS provided a free text entry for each day within a year, for each resource, this functionality was seldom used, because the text could only be read by looking at every single resource calendar.

7.5 Anticipating, Planning and Pre-handling Work

We saw how the work of unraveling the precise diagnosis of a patient often involved requesting several examinations and tests as a part of a pre-made examination program. This idea of collecting examinations into a series of requests is not supported in GS. At the radiology department GS supports blocking certain days or time periods in the resource calendars for maintenance and service of equipment. This functionality was occasionally used, but the value was restricted caused by the limited overview.

8 Organizational Accountability

Returning to the opening story of the paper, the title emerged during an interview with the secretary at the radiation clinic. How can she state that she loves the system, and then agrees with our observations, showing that she does not use it for scheduling the treatments, but instead uses the planning board? We have already seen why she uses the planning board, but why does she do the extra work of entering all the information once again into GS? Looking at her use of the system it was rather obvious that she actually had considerable benefit from using it.

Firstly, there was some minor functionality within the system that was of great benefit to her. For example, instead of handwriting the patient's name and social security number on all material involved in a treatment, GS could print out labels with this information. This small functionality saved her a lot of time. Also the ability to print out work schedules based on the resource calendars were considered valuable. Secondly, as an organizational-wide system, GS provides access to different information on patients. This was widely used as ways of locating patients, to look into the historical trajectory of illness, and to find telephone numbers and addresses on patients. However, the most important aspect was, that every afternoon when the treatments for the day has ended, the secretary could register the activity of the whole day just by approving the requisitions listed in the resource calendar for that day. By approving a requisition, the services attached to it were registered automatically. Before GS was installed the secretary spend 3 hours of manually counting treatments each day which often resulted in considerable overtime. The system had actually replaced these 3 hours of trivial counting work with 5 minutes of checking off items on a list. No wonder she loved the system!

This small episode might also help explain why Danish hospitals have spent several million Danish Kroner on this system when it has so many obvious flaws in supporting the work practices at the wards and service departments. If the system is used only as a delivery system for order forms replacing the walking of the secretary, the money could be used to hire some additional personnel to do that job. In order to understand these questions and apparent paradoxes it is important to understand that a 6th aspect of cooperative work at hospitals exists: *keeping account* of the activities done. In this sense, GS

is a technology of accountability as defined by Suchman [18]:

> *"By technologies of accountability, I mean systems aimed at the inscription and documentation of actions to which parties are accountable [. . .] in the sense represented by the bookkeeper's ledger, the record of accounts paid and those still outstanding."(p. 188)*

In order to maintain the tight budget control and to estimate and document the activity in the different departments, each department is held accountable for its work. Registering the activity in terms of performed services and reporting to the health authorities in Denmark is mandatory for all departments and hospitals. This task of accounting for work is extremely well-supported by GS, and is one of the raison d'être for its design.

9 Conclusions: Time Coordination, Groupware, and Information Technology

The fieldwork reported here seeks to reveal and illustrate some of the aspects to consider if GS should be more integrated in the clinical work practices, and not remain external to this work, acting merely as a system for registry and accounting for work. However, the study also points to difficulties of designing groupware within an organizational context. Let us elaborate on these concluding remarks.

9.1 Time Coordination of Hospital Work

The study revealed the many aspects of coordinating the treatment of patients within hospitals. One lesson was that coordination of work often involved temporal dependencies, regarded as a jigsaw puzzle solved through swapping timeslots. The main problem of scheduling patient examination were that the ward had the responsibility and overview necessary to synchronize the patient's trajectory, but did not have access to scheduling the examination. This was done by the service department, owning the resource, on request (either paper-based or using GS). However, solutions to this problem exist. One solution is to allocate separate timeslots to the different wards

allowing them to schedule the examination on their own. Another solution is to allow the radiology department to look into the other activities of the patient and then schedule the examination according to certain time constraints described in the requisition. A main stumbling block against implementing such cooperative procedures are the degree of transparency which this would require [6]. The close coordination through sharing resource calendars works counter to a longstanding tradition of autonomy of service departments and ownership of resources. Hence, computer support for sharing resources needs to ensure that the service department, responsible for the resources, can maintain control over the allocation of resources and the visibility of work.

9.2   Designing Groupware

The redesign of the Green System to incorporate groupware technology has indeed prospered from these workplace studies. Yet there are some more general lessons to be learned from this analysis.

Activity Theory helps us to understand, that it does not make sense to analyze the action of e.g. sending a request to a service department without taking into account the overall collective activity (or activities) which it realizes. The problem that GS only supports a fragment of this web of actions involved in coordination can be traced back to a too narrow analysis looking only at the action of 'sending a requisition'. The action needs to be analyzed as a part of a turbulent context consisting of other actions within the same activity, other activities and the artifacts mediating these activities, and the conditions of the work practice itself.

More specifically, this means that understanding the way in which work coordination is achieved in practice is essential to the development of effective groupware technology. The design of groupware needs a persistent focus on the work practices in order to achieve the intended support for the work, and in order to ensure that the system at least does not contradict the employees' own work practices [8]. Secondly, paying attention to the minor but useful functionality of the system, like production of labels and other printouts, can assist the diffusion of groupware technology into an organization [7]. Thirdly, the multiplicity of roles that an artifact plays must be recognized. In GS the requisition is designed to resemble the paper-based order form evident in

many hospitals. However, only the role of the form as a conveyer of information from a requester to a receiver is recognized, leaving out all the other roles that the form play in the coordination of work. The different actors involved in realizing the task of an X-ray examination cooperate without having a precise knowledge of each other's work, has different goals, time horizons and responsibility and employ different units of analysis, methods and abstraction of the involved information. They do this by creating different overview of their own, like the medical record, the examination program, and booking calendars based on information present at the order form.

Furthermore, the design of computer systems today is not initiated on bare ground, but is often a redesign of existing technology. Thus, it would be obvious to analyze the work practices surrounding the existing system in order to reveal constraints and problems, but also strengths and potentials of the system. However, studying the same work practices not using the system are equally important resources for redesign. By looking into work not 'soiled' by the system, new and exciting aspects for redesign might occur. This provides the opportunity of not just solving problems with the existing system, but to leverage the whole design to encompass and support a greater variety of work.

9.3 Organizational Constrains, Accountability and Information Systems

As we have seen, the specialized organization of hospitals implies certain problems of coordinating the different activities necessary in the treatment and care of patients. The work and problems associated with the coordination of the collective activities involved in treatment of patients, is a direct consequence of the organization of the hospital. This organizational structure, however, is one of the conditions that we need to take into account when designing groupware. Furthermore, organizations invest in computer technology for different organizational, bureaucratic and managerial reasons, and the design of computer support has to reflect these purposes *as well as* the work done within the organization. The possibilities of the computer to explicit structure and to handle large amounts of otherwise heterogeneous and contingent material into 'structured domains' can potentially enable an organization to pursue its goals in a more efficient way [22]. Computer sys-

tems need to be technologies for accountability in order to help organizations overcome the problems and tasks they face. So, the need for taking into consideration the work-practices of an organization in the design of a computer system is certainly important. Nonetheless, what is needed is not a shift from one perspective to another, but rather a consistent emphasis on both at the same time.

In the redesign of GS, the problems of supporting the existing work practices surrounding the ordering of examinations should not be understood merely as conflicting motives and goals within the organization. This could easily end up in a conclusion saying that either you design for accountability (i.e. large Information Systems) or you design for work support (i.e. Groupware Technology). It is important to recognize that an organization, like a hospital, is not merely 'getting the work done', e.g. curing patients, but is doing this work in a visible, inspectable, documentable and accountable way [2]. An organization is not only engaged in the activity of producing a product, or curing a patient. An organization has to be viewed as a collection of multiple activities, each realizing different needs. Some of these activities are directed toward the 'object' of the organization, like curing patients, and others are directed toward an organizational accountability of work. From an Activity Theory perspective, this means that the poly-motivated nature of actions involved in the same work should be considered so that motives of all involved actors, responsible for different areas of the work within the organization, are recognized and designed for.

The conclusion of our study is that the redesign of information technology to incorporate groupware support is a complex process. The need for studying work practices of coordination is clearly important, but a naïve view of cooperative work as the only issue to be addressed has no plate within hospitals. This conclusion is consistent with the growing interest in the design of Cooperative Information Systems which views information technology as composed of three interrelated facets: (i) the system facet, (ii) the group collaboration facet, and (iii) the organizational facet [5].

10   Acknowledgments

References

[1]   Bardram, J.E. Plans as Situated Action: An Activity Theory Approach to Workflow Systems. In *Proceedings of the 5th European Conference on CSCW,* Klüwer Academic Publishers, 1997.

[2]   Bowers, J., Button, G., & Sharrock, W. Workflow from within and without: Technology and Cooperative Work on the Print Industry Shopfloor. In *Poceedings of the 4th European Conference on CSCW,* Klüwer, 1995, 51-66.

[3]   Button, G. & Harper, R. The Relevance of 'Work-Practice' for Design. *Computer Supported Cooperative Work, 4, 4,* 199511996, 263-280.

[4]   Cicourel, A.V. The Integration of Distributed Knowledge in Collaborative Medical Diagnosis. In Galegher, J., Kraut, R. & Egido, C. (Eds.) *Intellectual Teamwork: Social and Technological Foundations of Cooperative Work.* LEA, Hillsdale NJ, 1990, 221-242.

[5]   De Michelis, G. et al. Cooperative Information Systems: A Manifesto. In Papazoglou, M.P. & Schlageter, G. (Eds.) *Cooperative Information Systems: Trends and Directions.* Academic-Press, 1997

[6]   Egger, E. & Wagner, I. Negotiating Temporal Orders. The Case of Collaborative Time Management in a Surgery Clinic. *Computer Supported Cooperative Work, 1,* 1992. 255-275.

[7]   Grudin, G. & Palen, L. Why Groupware Succeeds: Discretion or Mandate? In *Poceedings of the 4th European Conference on CSCW.* Klüwer, 1995, 263-278.

[8] Heath, C. & Luff, P. Documents and Professional Practice: 'bad' organizational reasons for 'good' clinical records. In *Proceedings of CSCW'96.* 1996, ACM.

[9] Jordan, B. Ethnographic Workplace Studies and CSCW. In Shapiro, D., Tauber, M. & Traunmtüller, R. (Eds.) *The Design of Computer Supported Cooperative Work and Groupware Systems.* Elsevier, Amsterdam, 1996.

[10] Kensing, F. & Madsen, K.H. Generating Visions: Future Workshops and Metaphorical Design. In Greenbaum, J. & Kyng, M. (Eds.) *Design at Work: Cooperative Design of Computer Systems,* LEA, Hillsdale NJ, 1991.

[11] Leontjev, A. *Activity, Consciousness, and Personality,* Prentice-Hall, Englewood Cliffs NJ, 1978.

[12] Leontjev, A. *Problems of the Development of Mind.* Progress Publishers, Moscow, 1981.

[13] Patton, M.Q. *Qualitative Evaluation and Research Methods, 2nd edition,* SAGE, Newbury Park, 1990.

[14] Rogers, Y. 1993. Coordinating Computer-Mediated Work. *Computer Supported Cooperative Work, 1,* 1993, 295-315.

[15] Rogers, Y. & Ellis, J. Distributed cognition: an alternative framework for analysing and explaining collaborative working. *Journal of Information Technology, 9,* 1994 119-128.

[16] Schmidt, K. & Simone, C. Coordination mechanisms: Towards a Conceptual Foundation of CSCW Systems Design, *Computer Supported Cooperative Work, 5,* 1996, 155-200.

[17] Strauss, A. & Corbin, J. Grounded Theory Methodology: An Overview. In Denzin, N. & Lincoln, Y. (Eds.) *Handbook of Qualitative Research.* SAGE, 1994.

[18] Suchman, L. Do categories have politics? The language/action perspective reconsidered. *Computer Supported Cooperative Work, 2,* 1994, 177-190.

[19] Symon, G., Long, K., & Ellis, J. The Coordination of Work Activities: Cooperation and Conflict in a Hospital Context, *Computer Supported Cooperative Work, 5,* 1996, 1-31.

[20] Vallgårda, S. Sygehuse og sygehuspolitik i Danmark: Et bidrag til det specialiserede sygehusvæsens historie 1930-1987. [Hospitals and hospital politics in Denmark: A contribution to the history of the specialized hospital sector 1930-1987], Jurist- og Økonomforbundets Forlag, København, 1992

[21] Vygotskij, L. S. *Mind and Society.* Harvard University Press, Cambridge MA, 1978.

[22] Winograd, T. Categories, Discipline, and Social Coordination. *Computer Supported Cooperative Work, 2,* 1994, 191-197.

Scenario-Based Design of Cooperative Systems

Jakob E. Bardram

Department of Computer Science, Aarhus University, Denmark

bardram@daimi.aau.dk

Abstract

Over the past few years, scenario-based design has attained a growing interest as a way to incorporate a focus on the future use of an application into the construction of software. Scenarios have, however, mostly been used in the design of user-interfaces and hence focused on single-user situations. Based on experiences from applying scenarios in the re-design of a Hospital Information System in the Danish healthcare sector, this paper describes how collaborative scenarios can be used in the design of cooperative computer systems and what such collaborative scenarios should contain. The paper concludes that such scenarios were useful in bridging the gab between understanding collaborative work practices and designing collaborative computer systems.

1 Introduction

According to Friedman (1989)[11] the biggest challenge in software development since the 1980s has been to fulfill the needs of the users. According to Winograd (1996)[26] this challenge has in the 1990s been extended to bring *design* to software development in order to ensure that software really *works* — not in the traditional software engineering sense of reliability and efficiency, but in the sense that the *software works for people in a context*. Hence, we would like to work with design requirements for a piece of software that addresses the human activity of using computers for a specific purpose

— requirements like easy to learn and use, argument human activities, meet peoples expectations, and become cultural meaningful artifacts. As argued by Carroll (1995)[9] these later requirements are far more difficult to specify and to satisfy. We have little prospect of developing final answers to questions about human activity — and certainly not at the level of detail that would provide specific guidance to designers. Our best course is, therefore, to develop rich and flexible methods and concepts that can incorporate descriptions of users and their current and potential use of a computer system into the very design reasoning about such a system. As a narrative description of what users do and experience when using a computer system, scenarios are such rich description of the human activities that can augment the design of computer systems.

The use of scenarios within Human-Computer Interaction has typically been addressing individual users. Jacobsen's use-cases are, for example, "a sequence of transactions in a system whose task is to yield a result of measurable value to an *indiuidual* actor of the system" (Jacobson 1992[17], my emphasis). A focus solely on the individual use of a computer system is however too narrow to reveal the conditions for developing and using computer systems, and might even contradict the purpose of contextualizing the design process by applying scenarios. When designing computer support for cooperative work (CSCW) it certainly becomes important to address the collaborative activities at a workplace. The aim of the present paper is to outline such collaborative scenarios. These scenarios were designed and used as a part of redesigning a Hospital Information System in Denmark. The outset for using scenarios in this project originated in the work done in the Euro-CoOp and EuroCODE projects at Aarhus University (Bødker et al. 1993[7]; Kyng, 1995[22]; Grønbæk et al., 1995[14]).

2   Scenario-Based Design

Scenario-based design is useful in situations where the design of the system is fragile in the sense that there is no detailed conception of exactly which work activities should be supported and in which way. Such projects are characterized by high uncertainty and risk, and therefore have to adapt an experimental and iterative way of design (Boehm, 1988[4]). For the purpose

of the discussion in this paper there are two central characteristics of such a design process. First, a design process is characterized by *re-designing* existing ways of doing things, which forms the basis for an understanding of how it can be done differently using a computer system. Today, the existing way of doing things already often involves some kind of computer support, which has limitation in its capability of supporting the ever changing work practices. A re-design necessarily has to start by investigating the problems and benefits of the existing system. Second, design is a creative activity that cannot be fully reduced to standard steps. However, a creative process is aided by inspiration, which to a large part comes from looking at the context of future use. Hence, creative design ideas emerge in the *meeting* between the computer professional, drawing on his technological knowledge, and the user, drawing on his or hers knowledge about the work-practices and the organizational setting (see e.g. Bødker & Christiansen, 1994[8]). However, relying on creative ideas to emerge in the juxtaposition of the designers' and users' knowledge in a diffuse high risk design process creates problems of on the one hand to guide the creativity in 'the right direction', and on the other hand to decide whether the emerging ideas are so good and creative after all. Hence, in a design process we want to be able to answer questions like; are these design ideas useful, i.e. what kind of work activities do they support and which one do they disturb? How will these design ideas and the system in general fit into the existing organizational context, and how will this context be changed by the system — for good or for worse? How will the system integrate with work practices and instruments that remain unchanged? In these kind of design situations, the benefits of using scenarios are twofold: on the one hand they are vehicles for supporting the creative meeting between designers and users, and on the other hand they help answer the questions on the usefulness of a system compared to the work practices within an organization. Let us consider what scenarios aimed at describing collaborative work activities should entail.

2.1 Collaborative Scenarios

The purpose of collaborative scenarios is to provide support for the overall design of a computer system by describing collaborative work activities that are to be supported and/or affected by the future computer system. Such scenarios are work-driven, open-ended and informal narratives of what people

do and experience as they try to perform different activities with or without making use of a computer application. Despite their popularity, there is no general accepted definition of what a scenario is, what it should entail, or how it should be used — even the inclusion of the 'computer' in scenarios is not always taken for granted (see e.g. the definition in Karat (1995[20])). However, the definition provided by Carroll (1995[9]) makes a good starting point for discussing what a collaborative scenario should cover:

> "The defining property of a scenario is that it projects a concrete description of activities that the user engages in when performing a specific task, a description sufficiently detailed so that design implications can be inferred and reasoned about. Using scenarios in system development helps keep the future use of the envisioned system in view as the system is designed and implemented; it makes use concrete — which makes it easier to discuss use and to design use." (p. 4).

This broad definition of a scenario however raises both interesting and difficult questions: First, system development has always been sided by descriptions of potential new ways of supporting and enhancing work by computer technology. So what is new in using scenarios and how does they differ from traditional requirement specifications? Second, what is meant by 'a concrete description of activities'? What is meant by an activity? How concrete should the description be? What should this description contain? Third, what is important to write down in a scenario so that 'design implications can be inferred and reasoned about'? What kind of implications are we talking about? The kind of implications that we would like the system to have or the unwanted kind of implications that just seems to come anyway? What is the role of the computer system in the scenarios describing activities? Finally, how can a scenario, as a narrative description on a piece of paper, 'envision' a future use situation that is not even quite envisioned by the designer, let alone the user? And what is meant by 'discuss use' and 'design use' — with whom should we discuss and design use?

Now these are general and far-reaching questions and the scope of this paper clearly do not allow a detailed discussion of all of them. Therefore, I shall concentrate on the second and third question and shortly comment on the last one. Answers to the first question has been discussed extensively by

the different authors in the book edited by Carroll (1995[9]) and in different paper in the Journal on Human-Computer Interaction (e.g. Bürkle et al. 1995[5]).

3 The SAIK Project: Computer Support for Coordinating Medical Work

The SAIK project[1] was launched as an experimental pilot project at Kommunedata in an attempt to redesign a national-wide Hospital Infiormation System called the Green System (GS). Currently GS is a large mainframe-based information system used by most hospitals in Denmark. The aim was to redesign GS into a client-server architecture, preserving the mainframe technology as a database server but building PC-based client applications dedicated to support the work at different departments within a hospital — e.g. at the emergency and casualty department, at a medical ward, and at a surgical planning office. One of the main problems within Danish hospitals today is coordinating the treatment made in the different departments. The purpose of the SAIK project was to investigate how coordination and planning of patient care happens today — both with and without computer support — and based on these investigations to reveal how this coordination can be supported by computer technology. The PATIENT SCHEDULER is a prototype that illustrates how the coordination of healthcare work can be coordinated by computers.

3.1 Methods and Scope of the Investigations

The SAIK project took place over a period of two years, involving 5 different hospitals in Denmark. The project had two main strands: ethnographic inspired workplace studies of the cooperative nature of work within hospitals, and a participatory design process developing the PATIENT SCHEDULER. The workplace studies and preliminary data analysis were based on qualitative methods such as qualitative interviews; participative observations of daily work at the ward, meetings and conferences (cf. Patton, 1990[24]); and

---

[1]SAIK is a Danish abbreviation for "Collaborative Informatics in Clinical Practice."

A detailed analysis of one collaborative work activity entails asking:

- *what is done and why* – analyzing the product and purpose of the activity from the point of view of the organization and the from the point of view of the different groups of involved actors
- *what sub-actions* are part of the activity – analyzing the detailed flow of distributed tasks of all participants
- *how* are these sub-actions realized using different tools and artifacts – analyzing the role of artifacts and their mediating and coordinating role, and how these artifacts interrelate
- *who* are responsible for these sub-actions – analyzing the division of work
- *where* and *when* are these sub-actions done – analyzing the spatial and temporal arrangement of the activity, crossing departmental, organizational or geographical boundaries to encompass all the actors involved

A detailed analysis of *several interdependent* collaborative activities involves asking:

- how is the routinely flow of work continuously coordinated in terms of the three basic types of coordination: (i) *communicative coordination*, where the actors coordinate through signs and language, (ii) *instrumental coordination*, where each actors coordinate his activity according to the activities of others, and (iii) *scripted coordination*, where each actor coordinates his activity according to a script for action, e.g. a checklist, a plan or a schedule.
- what kind of *collaborative breakdowns* happens in the daily flow of work, looking at:
  - when and how the routinely *coordinated* work collapses caused by necessary accommodation to unforeseen constraints in the working situation and how the coordinated flow of work is reestablished through a mutual cooperative effort.
  - when and how *cooperative* work breaks down caused by conflicting motives and goals and how this situation is handled through re-thinking and co-constructing of the activity system.
- how are the different activities *interdependent* in terms of the three general types of interdependencies: the need for (i) simultaneous activities, (ii) sequential activities, and (iii) shared resources in activities.
- what are the contradictions and conflict within and between existing work activities and between existing work activities and potential new ones supported by the computer technology

Figure 1: A checklist for creating collaborative scenarios.

studies of different documents, records and other tools (Jordan, 1996[19]). Field studies were made in 5 hospitals. Two of these hospitals were incorporated in the participatory design process of the Patient Scheduler applying methods such as future workshops (Kensing & Madsen, 1991[21]), cooperative prototyping session (Bødker & Grønbæk, 1991[6]) and organizational prototyping (Bardram, 1996[2]).

4   Design Documentation

Now let us turn to a description of the different design documents used to sustain the experiences obtained during all these activities. Figure 1 contains a summary of the documents. Please note that when using the word 'document' we do not solely mean written documents; documentation in the form

of photographs, video, rich pictures, process flow-charts, and photocopies of different paper-based forms, documents, work protocols, etc. were central parts of the documentation. The documentation can be divided into two broad categories: (i) organizational overviews, providing a description of the organizational context of the collaborative work-processes; and (ii) work activity scenarios, which are scenarios trying to capture the collaborative work, which we are designing for.

4.1   Organizational Overviews

An insight into the organization where the future computer system has to be implemented and where the system development process has to take place is clearly indispensable. Thus several authors stress the need for 'getting to know the domain, people and tasks' (Johnson et al., 1995 p. 214[18]) and the need for general 'work situation overviews' (Kyng, 1995[22]). These kinds of descriptions are essential because a specific work-task scenario is only given meaning from the situation in which it is used. In our project we used four different kind of representation of the hospitals as organizations:

Organizational overview (OO):

The OO is intended to provide a sufficiently detailed description of the tasks, goals, purposes, and strategies of the organization, the types of jobs and the roles within the organization, how the employee are organized (structure), and the different kind of technology used there. The environment of the organization in terms of cormpetitors, society, labor unions, etc. is part of such an organizational overview as well as necessary descriptions on cultural systems of status, prestige, etc.

Person-oriented record (POR):

The POR is intended to capture the work practices of a person — both a particular person and a generic job description: the sequence of actions and tasks in the daily round, who they collaborate with, their responsibilities and

job descriptions, what they perceived as routine and exceptional work, how they handle exceptions and problems, and so on.

Object-oriented record (OOR):

The OOR is intended to describe the construction and career of an object, artifact, or document through the system: how is the object created, what does it consists of, what locations does it 'visit', who owns it, what other objects is it depending on and in contact with, who has the right to manipulate it, change it, remove it, and so on.

Setting-oriented record (SOR):

The SOR chronicles what happens in a particular location through time — throughout a shift, a day, a week, or other relevant temporal cycle to the workplace in question. Many kinds of work activities are spatially distributed and the SOR is intended to capture the work taking place in these separate locations.

4.2 Work Activity Scenarios

In a system development project the organizational overviews are typically made once and for all. In contrast hereto the Work Activity Scenarios (WAS) are alive during the whole system development process. They are constantly modified and rewritten according to new understandings of the work practice and according to the evolving design of the computer system. Hence, we maintain two sets of activity scenarios: one set of scenarios of current work activities and one set of scenarios of the envisioned future work activities. This might sound as a lot, but often the introduction of a computer system might not change much in the overall activity system, and if it does, such changes has to be considered and described anyway. WASs are scenarios that detail the activities necessary to get a particular task or process within the total scope of work done. The WAS has a unique name in order to facilitate communication among designers, users, stakeholders, etc. A WAS describe the recurring, regular features of typical tasks and how they relate to the or-

ganizational context and to the physical setting, facilities and persons at the workplace. The scenarios are non-technical and encompass both individual as well as collaborative work tasks. They have the purpose of requirement analysis, environment for the overall design decisions, and provide the basis for all further scenarios. The future WASs are also used for implementation and training.

A WAS is produced by workplace studies and participatory design techniques. Figure 1 shows a checklist of aspects of collaborative work that a collaborative work scenario should address. This checklist has been compiled from Activity Theory as a framework for design of CSCW systems (see Bardram, in prep.[3]), and the insights from our workplace studies and from numerous other workplace studies done within CSCW (for an overview of some of the findings see Plowman et al., (1995)[25] and Grinter (1997)[13]).

Some work activities are central to the (re-)design of a computer system and hence need to be analyzed in greater detail. For this purpose *Analytical Scenarios* (AS) can be made. An example of an analytical scenario is illustrated in figure 2. The analytical scenario describes in detail what is happening, where and when, by who and why, and how both today and potentially in the future supported by a computer system. Relevant information from the organizational overviews are included (e.g. the description of the responsibility of the head radiologist) and the underlining are reference[2] to other description (e.g. the SOR describing the offices). The last column (the 'HOW — PATIENT SCHEDULER') is added later when the design is evolving and illustrated partly by prototypes or mock-ups. Even if the design obliterates some subtasks, these are kept in the analytical scenario as a reminder of how the future system will change and potentially ennance work. The sentences in italic are used to comments for further action in the design of the computer system — e.g. there might be a serious problem in not supporting the central task of prioritizing incoming requisitions. In this case we have a *contradiction* between the current and the future scenario as supported with the current design of the prototype.

---

[2]These scenarios were written in Microsoft Word® with the Devise Hypermedia extension. Therefore these references were hyperlinks across the different documents including photographs and scanned documents. Thus a central part of writing a scenario was to establish the particular scenario's relations to other design representation.

Scheduling examination at the Radiology Department

What	Where & When	Who & Why	How – Today	How – PATIENT SCHEDULER
Receiving paper requisitions	In the office of the radiology department. All day		The ward requesting the examination places it into an inbox at the counter at the office. There are 4 kind of in-boxes ...	Paper-based requisitions have to be entered manually into the system. NOTE: We need to consider connection to EDIFACT messages!
Printing out electronic requisitions	Using the Green System at the main desk in the office.	A paper copy is printed because: (i) the head radiologist need a paper copy, (ii) it needs to be present during the examination, (iii) it has to be achieved in the big filing cabinet.	Entering the 'Receiving requisitions' form in the Green System. Typing 'pr' outside each req. that should be printed. ...	Select (multiple select) requisition in folder. Press Menu|Print or Press Crtl+P or press the print icon in the tool bar.
Sorting requisitions			The secretaries department sorts the requisitions according to several criteria, like what kind of examination ordered, levels of urgency, the type of illness of the patient, etc.	Sort the list of requisitions according to sender, type of examinations, etc. Creating new folders in a hierarchy of folders. Sharing folders among users.
Prioritizing examinations	At the head radiologist's office.	The head radiologist, the head nurse, and a secretary. The priority, and thereby the order that patients are being examined are solely the responsibility of the head radiologist.	AKH: the secretary has made a pre-priority because she knows how typical patients are prioritized by the head radiologist. This saves some time, because the head radiologist only has to concentrate on the special cases.	To each requisition a dispersal note can be attached telling how this case should be handled. NOTE: We cannot explicitly support the prioritizing of requisitions!

Figure 2: An example of an Analytical Scenario

4.3 Activity Maps

As a way of providing an overview of all interdependent and contradicting activities activity maps were drawn. These maps were merely a graph with activities as nodes and relations in term of interdependencies and/or contradiction as arcs. Activity maps were drawn both of the current work situation and of the envisioned future work situation.

5 Applying Scenarios in the SAIK Software Design Process

In the SAIK project an evolving set of scenarios constituted a backbone, tying together the many activities in the system development lifecycle. This is in contrast to authors advocating the use of scenarios only for workplace descriptions and initial requirement specification (Anderson & Durney, 1992[1]; Hsia et al., 1994[15]) or for evaluation (Nielsen, 1995[23]). Central to our approach is to use scenarios for describing existing work situations and then use these to help generate a system solution and for continuous verification of the design through experimentation. In the SAIK project collaborative scenarios played three overall purposes: (i) continuous analysis and design documentation, (ii) validation of design solutions and experimentation with prototypes, and (iii) generalization of experiences in order to reuse design insights and solutions in other design projects.

5.1 Senarios as the Fulcrum in the Design Process

In the SAIK project we operated with a design process consisting of three activities: (i) exploration, (ii) design, and (iii) experimentation. We alternated between these activities in an iterative way, trying to use the experience obtained in one activity as an input for the other activities.

In the *exporation* activity the necessary insight into the overall socio-economical and organizational context was initiated. Understanding the Danish hospital sector and its political and economical nature was of central importance to the SAIK project and this exploration was hence never terminated, but continued throughout the whole project. This organizational insight was documented in the organizational overviews.

The work activity scenarios of existing ways of doing work was also created in this activity. In the SAIK project central work processes for collaboration and communication at the hospital was described. Because the PATIENT SCHEDULER was aiming at supporting the cooperation across departmental boundaries, we wrote scenarios concerning the requisition of radiology examinations, the collaboration among physicians at different conferences, the planning and booking of examinations at the radiology department, etc.

Subsequently, analytical scenarios were made for these central work processes (see e.g. figure 2). However, scenarios 'at the border' of such central activities for the PATIENT SCHEDULER were made as well, e.g. the way medication was given at the ward, and how the physician was using the medical record. The organizational overviews and the work activity scenarios were compiled into the activity maps. These maps were in practice the walls of our offices. Scenarios, pictures, screen-dumps, and description of different artifacts (mostly documents and forms) used at the workplace were put on large bulletin boards, and the connections between all this were maintained by red yarn and post-its notes.

At some point concurrent with the exploration activity, the *design* activity is initiated. This is a creative process of generating ideas for computer support, which is guided by the obtained insight in the exploration activity. Design decisions are facilitated by the different work activity scenarios, which point to issues in the current way of working that need to be considered. For example, the scenario describing the activity of scheduling examinations at the radiology department shown in figure 2 pointed to the need of supporting the sorting of incoming requisitions. This design decision was subsequently evolving into support for setting up some kind of automatic filtering according to sender, type of request, etc. For each of the work processes, that we were trying to support, future scenarios were used to document how the computer system might enhance, change, or obliterate existing work activities. These future scenarios are changed, up-dated and used throughout the whole design and construction phase of the computer system. For example, in the SAIK-project it was decided that the PATIENT SCHEDULER should support 'both ends of the collaboration' — i.e. that it should support both receiving and sending requests for work at other departments. Hence, future scenarios for both the work at wards and at radiology and other service departments were written. Furthermore, a design solution allowing the physician at the ward to book examinations at radiology on his own was made. This would save both the physician and the secretaries at radiology a lot of work. However, this was a radical new solution to the communication between wards and radiology, and several future scenarios were made to envision how this would be possible.

5.2   Design Experimentation and Confrontation

A central part of an iterative design process is to make *experiments* in order to clarify the overall design of the system and to investigates the qualitative aspect of usability, acceptability, and suitability within the target domain(s). For this purpose we operated with four kind of *design confrontations*: (i) validation, (ii) logical confrontation, (iii) use confrontation, and (iv) organizational confrontation.

Validation is a confrontation between the understanding obtained during the exploration activity as documented in the organizational and work-oriented descriptions and scenarios. In other words, it is a validation of the correctness of the obtained descriptions by discussing the scenarios with the users. This validation is of crucial importance when the scenarios are to be used for further development and design. In the SAIK project this validation was achieved by reviews of documents and video analysis, and in workshops with different employees who has participated in the exploration phase.

A *logical confrontation* happens between a proposed design and the analytical scenarios. The confrontation aims at pinpointing the potential opportunities and risks of the future system according to the way work is done today. The confrontation is called logical because it is a systematic comparison of a proposed design with the knowledge about the work practice of today. Two examples of logical confrontations are illustrated in the analytical scenario in figure 2 (shown in italic). These reveals problems of connecting the PATIENT SCHEDULER to EDIFACT messages coming from outside the hospital, and problems of supporting the prioritizing of requisitions. Thus, these confrontations pointed to potential risks in the overall design.

A *use confrontation* happens between a proposed design as documented by the future scenarios and the future users of the computer system. In the SAIK project we enacted the future scenarios together with the users, using different prototypes illustrating the future system. This confrontation aims at revealing the use-characteristics of the system, potential problems and opportunities for father design. The future scenarios were changed and enriched together with suggested changes to the prototypes.

An *organizational confrontation* happens between a proposed design — either illustrated by a prototype or by the final system — and the organizational

context of the new system. The aim is to reveal how the computer system supports, enhances and changes the working of the organization as a whole. Thus the system has to be evaluated and confronted with work practices, the organizational structure and culture, related technology, resource constrains, spatial arrangements in the workplace, etc. In the SAIK-project this kind of confrontation was made in different workshops with managerial representatives. In one of these workshops the design solution of having physicians directly book radiology examinations on their own was discussed and found highly problematic from the radiology departments point of view. Several problems with the solution were revealed, ranging from the fact that a physician cannot book all radiology examinations without advice from a radiologist, to more economical issues of how the radiology department can control their expenses if everybody were granted access to book on their own. Hence, there was a need for designing a solution for keeping radiology in control. This involved creating an access mechanism, so that radiology could decide exactly what kind of examinations could be booked by who, when, how, etc.

5.3 Analysis Patterns - Generalizing Design Knowledge

In the SAIK project, the analytical scenario has two distinct purposes in the system development lifecycle: (a) as detailed task analysis of work practices of central importance to the design, and (b) as generalizations of experiences from the different hospitals involved in the project. The last purpose must be viewed in light of the overall aim of the SAIK project to design a system that not only should be used at the hospitals involved in the design process, but potentially at all hospitals in Denmark. When deviations were discovered they were kept in the scenario — for example the sentence in figure 2 marked with 'ÅKH:' is an observation made only at this hospital. The scenarios made during our investigations helped us on the one hand to identify and sustain the differences in work practices across different departments and hospitals. On the other hand the scenarios captured aspects of collaborative work that were stable and similar across different work settings, and they could be generalized into generic scenarios for different types of activities within a hospital. Examples of such generic types of activities

are the paper-based requisition of radiology examinations and the scheduling and sorting of incoming requisitions. These generic scenarios provided the background for extracting the general design knowledge embedded in the PATIENT SCHEDULER as *Analysis Patterns*, which could be reused in other projects at Kommunedata. In contrast to Design Patterns (Gamma et al. 1995[12]), an analysis pattern is a solution to a recurrent problem within an *organizational* context, not within construction of software. An analysis pattern is an object-oriented solution that represents a common construction in some business modeling — in this case within hospitals as an organization (see also Fowler, 1997[10]). The real-world problem, that each analysis pattern is attempting to solve, is represented as a generic scenario, which work as an inspiration for the analyst in the future.

6   Conclusions

The collaborative scenarios, as discussed in this paper, are summarized in figure 3. In conclusion, using collaborative scenarios as the backbone in the design of a cooperative system in the SAIK-project, has been very successful. They provided a necessary tool for analyzing and documenting existing work practices and hence paved the way for generating ideas for new or re-designed computer support for these work practices. But most important, collaborative scenarios worked as important thinking tools for grounding the creative envisioning of how work could be organized using new computer technology. As such imaginary thinking tools helping to answer the question of "given this design proposal, what might be the future use of the system?", collaborative scenarios were a fundamental cornerstone in the participatory design sessions with the users (see Bardram, 1996[2]). Moreover, scenarios are not "dead" documentation, but are alive throughout the whole design process and provides the basis for later construction of software and the final implementation of computer systems within organizations. In this way, scenarios can mediate an implementation and diffusion process of computer technology within an organization, by translating existing work practices into new ones using the system. Note that an implementation phase influences the creation of the organizational and work-oriented overviews (see figure 3). This is a result of the spiral model where experiences obtained during the phase of implementation — as the process of turning a computer system into tech-

nology for an organization — might provide a basis for further redesign or implementation of the system, either in the same organization or in similar organizations (e.g. another hospital).

Another, more theoretical, conclusion to be drawn from our use of scenarios is that they provide one solution to bridge "the great divide" within CSCW. This term labels the division between CS (Computer Support) and CW (Cooperative Work), the former focusing on technical innovations, and the later on social aspects of work. The problem with this division is that neither of the sides have been focusing on the process of getting from the one to the other — i.e. have not been addressing neither the issue of *designing* computer systems based on understanding cooperative work, nor the issue of *implementing* computer systems within cooperative work practices. Within the numerous workplace studies made within CSCW it is often argued that one of the main strengths of an ethnographic approach is that detailed analyses of social work can provide rich material on which to base recommendations for the design or re-design of a computer system. However, there is a big distance from having a good understanding of existing work practices to creating design solution for a future computer system, which is intended to *change* these work practices. Typical design recommendations from such ethnograpic workplace studies is enclosed as the classic "implications for design" section at the end of the paper (c.f. also Plowman et al., 1995[25]). In the SAIK-project collaborative scenarios proved to be a good way of both documenting experiences obtained during the workplace studies and at the same time they worked as design tools, helping to bridge the distance between present and future work practices. Moreover, as already emphasized, scenarios are "live documents" that are used active in cooperation with users. In this way, scenarios support a two-way communication between designers and users, where users inform designers about current work practices and designers inform users of potential future computer solutions. Hence, design and implementation is facilitated concurrently. Such a two-way comminication process is fundamental distinct from the classical use of workplace studies within CSCW, where the ethnographers are the ones in contact with the real work setting, and they are informing the design process though "debriefing meetings" (Hughes et al., 1994[16]).

7   Acknowledgments

References

[1]   Anderson, J. S. & Durney, B. (1992). Using scenarios in deficiency-driven requirements engineering. *Proceedings of the IEEE International Symposium on Requirement Engineering.* Washington: IEEE Computer Society Press,p. 134-141.

[2]   Bardram, J. E. (1996). Organisational Prototyping: Adopting CSCW Applications in Organisations. *Scandinavian Journal of Information Systems,* 8(1): p. 69-88.

[3]   Bardram, J. E. (in prep). *An Activity Theoretical Approach to the Design of Computer Support for Cooperative Work,* Doctoral Dissertation, University of Aarhus.

[4]   Boehm, B. W. (1988) A Spiral Model of Software Development and Enactment, *IEEE Computer,* May 1988, pp. 61-72.

[5]   Bürkle, U., G. Gryczan, & H. Züllighoven (1995). Object-Oriented System Development in a Banking Project: Methodology, Experience, and Conclusions. *Human-Computer Interaction* 10: p. 293-336.

[6]   Bødker, S. & K. Grønbæk (1991) Design in Action: From Prototyping by Demonstration to Cooperative Prototyping. In *Design at Work: Cooperative Design of Computer Systems,* eds. J. Greenbaum & M. Kyng, Hillsdale, New Jersey: LEA.

[7] Bødker, S., E. Christiansen, K Grønbæk, K. Halskov Madsen, P. Mogensen, M. Robinson, H. Kühn, S. Robinson, M. Türing, E. Hinrichs, P. Sørgaard, & P. Hennessy. (1993). *EuroCODE D-1.1: The EuroCODE Conceptual Framework.* Aarhus University, 17 June 1993. CODE-EMP-93-1.

[8] Bødker, S. & Christiansen, E. (1994) Scenarios as Springboards in Design CSCW, *DAIMI PB* no. 488, University of Aarhus.

[9] Carroll, J. M., ed. (1995). *Scenario Based Design: Envisioning work and technology in system development.* New York: John Wiley & Sons, Inc.

[10] Fowler, M. (1997) *Analysis Patterns: Reusable Object Models.* Reading, MA: Addison-Wesley.

[11] Friedman, A. (1989). *Computer Systems Development: History, Organisation and Implementation.* Chichester: Wiley.

[12] Gamma, E., R. Helm, R. Johnson, & J. Vlissides. (1995) *Design Patterns: Elements of Reusable Object-Oriented Software.* Reading, MA: Addison-Wesley.

[13] Grinter, R. (1997) From Workplace to Development: What Have We Learned So Far and Where Do We Go?, In Proceedings of ACM GROUP'97 Conference, Phoenix, AZ, ACM Press.

[14] Grønbæk, K., M. Kyng, & P. Mogensen. (1995). Cooperative Experimental System Development - Cooperative Techniques Beyond Initial Design and Analysis. *Proceedings of Computers In Context, Aarhus, Denmark.* Department of Computer Science, Aarhus University.

[15] Hsia, P., Samuel, J., Gao, J., Kung, D., Toyoshima, Y., & Chen, C. (1994). Formal approaches to scenario analysis. IEEE Software (March); p. 33-41.

[16] Hughes, J., V. King, T. Rodden, & H. Andersen. 1994. Moving Out from the Control Room: Ethnography in System Design. *Proceedings of CSCW 1994, Chapel Hill, North Carolina.* ACM.

[17] Jacobson, I., M. Christersson, P. Jonsson, and G. Övergaard. (1992). *Object-Oriented Software Engineering — A Use-case Driven Approach.* Reading, MA: Addison- Wesley.

[18] Johnson, P., H. Johnson, & S. Wilson. (1995). Rapid Prototyping of User Interfaces Driven by Task Models. In *Scenario Based Design: Envisioning work and technology in system development,* ed. John M. Carroll, New York: John Wiley & Sons, Inc.

[19] Jordan, B. (1996). Ethnographic Workplace Studies and CSCW. In *The Design of Computer Supported Cooperative Work and Groupware Systems.,* eds. D. Shapiro, M. Tauber, & R. Traunmüller, Amsterdam: Elsevier.

[20] Karat, J. (1995). Scenarios Use in the Design of a Speech Recognition System. In *Scenario Based Design: Envisioning work and technology in system devezopment,* ed. J. Carrot, New York: John Wiley & Sons, Inc.

[21] Kensing, F. & K. Halskov Madsen. (1991). Generating Visions: Future Workshops and Metaphorical Design. In *Design at Work: Cooperative Design of Computer Systems,* eds. J. Greenbaum & M. Kyng, Hillsdale, New Jersey: LEA.

[22] Kyng, M. (1995). Creating Contexts for Design. In *Scenario Based Design: Envisioning work and technology in system development,* ed. J. Carroll, New York: John Wiley & Sons, Inc.

[23] Nielsen, J. (1995). Scenarios in Discount Usability Engineering. In *Senario Based Design: Envisioning work and technology in system development,* ed. J. Carroll, New York: John Wiley & Sons, Inc.

[24] Patton, M. Q. (1990). *Qualitative Evaluation and Research Methods,* 2nd edition. Newbury Park: SAGE.

[25] Plowman, L., Y. Rogers, & M. Ramage. (1995). What Are Workplace Studies For? *Fourth European Conference on CSCW,* Stockholm, Kluwer Academic Publishers.

[26] Winograd, T. ed. (1996) *Bringing Design to Software,* New York, NY: ACM Press.

Design documents	Description	Produced in design activity	Special attention to
Organizational Overviews:			
Organizational overview	Provides the organizational and domain description necessary to understand the setting in which the system has to be developed and later used.	Exploration (and Implementation)	Organizational, Economical, Socio-political, Cultural Context of the collaborative work activities
Person-oriented records	Records the work practice of a person or a type of job within the organization.	Exploration (and Implementation)	Division of work, Roles, Status, Responsibility, Location, Managerial positions
Object-oriented records	Describes an artifact within the work setting, what it is made up of, who does what to it and when, etc.	Exploration (and Implementation)	Which tool are used for which activities, sharing of tools, coordination through tools, the history of tools
Setting-oriented records	Describes a particular setting within the organization and its relation to other locales.	Exploration (and Implementation)	Physical arrangement of setting, the location of things such as desks, telephones, wallboards, etc.
Work Activity Scenarios:			
Activity Map	Describes the overall web of activities, their interrelationships, and the relationship to the organizational context. Is used to interlink the organizational and work-oriented overview to the activity scenarios.	Exploration, Experimentation (and Implementation)	The interdependencies among activities, the contradictions between activities, and the relationships between existing and future computer supported activities
Work Activity Scenarios:	Provides an overview of the outcome of an activity, the purpose of it, how it is accomplished.	Experimentation & Construction	The purpose and outcome of the activity, the constraints put on the activity.
Analytical Scenarios:	Provides a detailed analysis of a collaborative activity including its division into different sub-activities and how these are distributed onto several actors, using different artifacts, are located in time and space, and each having a specific purpose.	Experimentation & Construction	The division of work in a particular activity, the detailed use of artifacts, the distribution in terms of actors, time and space, inherent problems and contradictions in the activity.
Analysis Pattern	Provides a generic solution to a specific design problem within a domain. Contains a scenario, describing the problem setting, and a OO diagram and a user-interface describing the design solution.	Experimentation & Construction (and later reuse)	Recurrent pattern in scenarios. Design solutions that are validated as useful through experimentation.

Figure 3: Design Documentation Summary.

207

Temporal Coordination

On Time and Coordination of Collaborative Activities at a Surgical Department

Jakob E. Bardram

Department of Computer Science, Aarhus University,
Ny Munkegade 116, Bldg. 540, DK-8000 Århus C., Denmark

August 29, 2000

Abstract

An activity is inseparably bound up with time and interdependent cooperative activities thus need to be coordinated in time. The nature of time is therefore an everpresent issue in the design of computer systems supporting coordination. Based on indebts studies of socio-temporal issues involved in the coordination of cooperative work at hospitals, this paper defines and explores the notion of *temporal coordination*. This definition helps us to identify some of the highly intertwined temporal problems, constraints, interests, and conflicts, which arise when work subject to temporal limits is to be coordinated. The paper discusses the use of computer technology as mediator for temporal coordination. The paper concludes by discussing the benefit of applying network-based computer technology for temporal coordination, but simultaneously underlines that any cooperative computer technology needs to address the underlying temporal problems and conflicts within modern organizations.

1 Introduction

Time is a particular important aspect of cooperative work. All activities have a temporal prolongation and the coordination of such activities has to — either explicitly or implicitly — take into consideration the timeliness of cooperative activities. Because salaries based on work-hours are by far the largest portion of an organization's total expenses, time is one of the scarcest resources within work practices, the use of which has to be prioritized and organized. Negotiations and conflicts within a work practice are often a direct result of trying to answer the questions of how to spend, allocate, and schedule time among actors. Within most organizations, the time period, and not the task, is the focal unit of production and the clock becomes a crucial technology for coordination and control within organizations (Scarbrough and Corbett, 1992[26]) — Mumford (1934)[23] argued that the clock rather than the steam engine may be seen as the key technology of western industrialization. Time thus constitutes a major dimension of social organization and the temporal rigidity of work is one of the key structural characteristics of modern organizations (Zerubavel, 1981[38]). This temporality of cooperative work has profound implications for how work activities are coordinated, and subsequently for the design and use of computer support for coordination and cooperation.

In hospitals — the empirical background of this paper — both the issue of time and coordination are particular important aspects of the work. The success of patient treatment is often related to its duration, and time thus has an impact on the life and well-being of patients. Due to the highly specialized nature of modern medical work, additional work is needed in order to assure that the staffs collective efforts add up to a coherent treatment — individual tasks do not automatically arrange themselves in proper sequence or with proper scheduling (Strauss et al., 1985[30]).

Within CSCW, coordination has theoretically been addressed by Coordination Mechanism, (Schmidt, 1993[27]; Schmidt & Simone, 1996[28]) and Coordination Theory (Malone & Crowston, 1990[18]; 1994[19]; Crowston, 1994[8]). Both of these theories define coordination as the management of interdependencies among activities in terms of actors, goals, time, space, quality of products, etc.; if there is no interdependencies there is nothing to coordinate. The framework of Coordination Mechanisms argues that ac-

tors engaging in cooperative work are mutually dependent *in work* meaning that A relies positively on the *quality* and *timeliness* of B's work and vice versa, and hence need to be coordinated or, in the words of Strauss et al.[30], articulated. Unfortunately, the framework does not provide any details of this notion of relying positively on the 'timeliness' of another person's work. Coordination Theory identifies three general interdependencies between activities: (i) prerequisite — that the output of one activity is required by the next, (ii) simultaneity — that more than one activity must happen at the same time, and (iii) shared resource — that the same resource is required by multiple activities. Even though the two temporal concepts of prerequisite and simultaneity might sound reasonable at a first glance, the difference between them seems to blur depending on the time span in which we analyze an activity. For example, analyzing the timing of the activities involved in a surgical operation according to the time span of the whole operation, the work of the surgeon and the anesthesiologist happens simutaneously. Analyzing the operation according to the time management of the surgeon, there is a sequential order to the work, the anesthesiologist initiating the operation before the surgeon enters the operating room.

The aim of this paper is to define and discuss such temporal aspects of coordinating cooperative work — *temporal coordination*. This definition is to be based on a strong theoretical basis and should not be limited to a functional analysis of temporality, such as simultaneity and sequence, but should incorporate the sociological and organizational aspects of time as well. We need to understand, for example, how work is synchronized and scheduled, why fairness in scheduling plays such an important role in many work settings, and how the ever-present lack of time influences the coordination of work. Furthermore, we need to understand how temporal problems emerge and are being solved within a work practice, and how temporal conflicts and interests are inextricably tied into the organizational context in which the collaboration takes place. Such an understanding of temporal coordination is the foundation for the father design and implementation of computer support for coordination.

The structure of the paper is as follows: Section 2 gives an overview of the empirical background and focuses on the coordination of operations at a surgical department within a particular hospital. Section 3 introduces Activity Theory, which provides the theoretical background for defining, analyzing,

and understanding the temporal coordination of collaborative and distributed human activities. Based on Activity Theory, section 4 defines the notion of temporal coordination. Section 5 to 7 analyze temporal coordination as it takes place at the surgical department. In these sections different aspects of temporal coordination are revealed and discussed. Section 8 introduces the PATIENT SCHEDULER, which is an example of computer technological support for temporal coordination within hospitals, and the benefits of a computer system is discussed according to the analysis made in the previous sections. Section 9 concludes the paper.

2 The SAIK-project

The SAIK project[1] was launched as an experimental pilot project in an attempt to redesign a national-wide Hospital Information System called the Green System (GS). Currently GS is a large mainframe-based information system used by most hospitals in Denmark. The aim is to redesign GS into a client-server architecture, preserving the mainframe technology as a database server but building PC-based client applications dedicated to support the work at different departments within a hospital — e.g. at the emergency and casualty department, at a medical ward, and at a surgical planning office.

Due to the centralized and specialized nature of modern medical work, one of the main problems within Danish hospitals today is to coordinate the treatment made in the different departments. The purpose of the SAIK project is to investigate how coordination and planning of patient care happen today — both with and without computer support — and based on these investigations to reveal how coordination can be supported by computer technology. The PATIENT SCHEDULER is a prototype that illustrates how work within a hospital can be coordinated by computers — both within and between departments. Hence, the PATIENT SCHEDULER has been a continuous crystallization of requirement for the future version of the Green System and has been an important tool in the participatory action research done at different hospitals.

---

[1]SAIK is a Danish abbreviation for "Collaborative Informatics in Clinical Practice."

The methods for data collection involved workplace studies based on traditional qualitative methods; qualitative interviews, participative observations of daily work at the hospitals (c.f. Patton, 1990[25]), and studies of different documents, records and other tools (Jordan, 1996[14]). The data analysis was done by transcribing interviews, by drawing different rich pictures of the flow of documents within the hospital and by writing detailed scenarios describing the current work practice. Field studies were made in all 5 hospitals. Two of these hospitals were incorporated in the participatory design process of the PATIENT SCHEDULER. The participative design of the PATIENT SCHEDULER applied future workshops (Kensing & Madsen, 1991[15]), cooperative prototyping session (Bødker & Grønbæk, 1991[7]) and organizational prototyping (Bardram, 1996[1])

2.1 Temporal coordination at a surgical clinic

This paper will concentrate on the time management of a surgical department for urinary surgery, named U (a pseudonym). Department U consists of a surgical clinic with 6 operating rooms, an outpatient clinic, 3 wards, a uroscopy laboratory, and the secretariat containing the planning office. This study took place in a university hospital and whereas most hospitals are patient care and treatment centers, university hospitals have educational and research obligations as well. The paper will focus on the treatment of hospitalized patients, and not the activities in the outpatient clinic. This focus has been chosen because the planning and scheduling of operations within a large surgical department are some one the most complex coordination and scheduling challenges within modern hospitals. A previous paper by Egger and Wagner (1993)[9] has been looking into temporal issues of cooperative work at a surgical clinic too. In contrast to the paper of Egger and Wagner, however, this paper investigates the temporal problems arising from a need to coordinate and cooperate *across departmental boundaries*, it investigates the *artifacts* used in temporal coordination, and it incorporates a view on the organizational context causing the severe *temporal problems and conflicts* within a hospital.

Figure 1 illustrates the typical hospitalization of a patient admitted for an operation. The figure illustrates how the surgical operation of a patient typically involves admission to a ward during the whole period, and that several

examinations has to be made before the operation can take place. The typical examinations are a radiology examination, a blood test at the central laboratory, and a uroscopy test at the department's own laboratory. The operation itself is initiated by the head nurse of the surgical clinic, who calls the ward informing them that the patient should be prepared and sedated for operation. At the same time she notifies the hospital porter who goes and fetches the patient at the ward and brings him/her to a preparation room in connection to the operating room. In here the anesthesiologist gives the anesthetic and when anesthetized, the patient enters the operating room along with the surgeon and his assisting nurses. The operation ends with the termination of anesthesia and the patient being transported to the intensive care unit for recovery, where (s)he stays till his/hers condition is stable enough to be put back in bed at the ward.
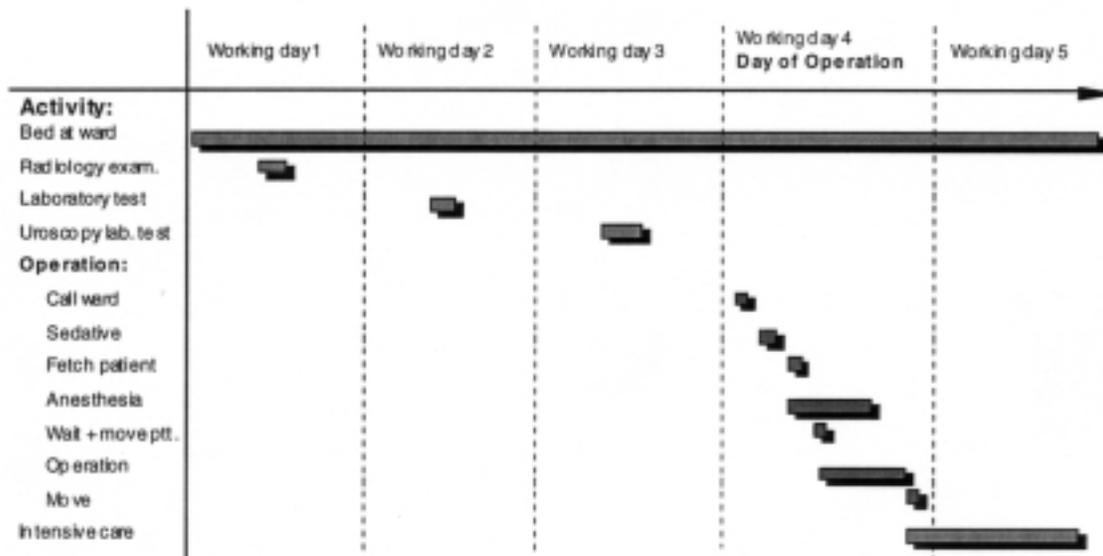

Figure 1: The core activities involved in a typical surgical operation at department U.

A huge challenge within the surgical department is the coordination of these many activities and actors, which are involved in even a fairly trivial operation. In this coordination, *time* is a particular important issue to consider; there is a profound need for synchronizing the actions involved in each of these operations. For example, the radiology examination needs to be done

at a proper time in advance, to ensure the availability of the picture at the day of operation; the patient needs to be present in the preparation room in due time for anesthesia, which needs to be done in time for it to be effective when the operation starts; and the intensive care unit has to be ready to take responsibility for the patient, at the latest when the patient has been operated. Hence, there is not only a certain sequence to an operation, there is also a necessary *timing* to it. Furthermore, the coordination of actions involved in one operation is further complicated by the need for coordinating one operation with the other operation, which takes place at the clinic.

3   Activity Theory - theoretical background

Activity Theory is the theoretical anchor point for the present analysis of temporal coordination. Activity Theory is a social and cognitive psychological theory, which at its core emphasizes a *dialectical* and *developmental* relationship between a human and the material and social environment in which (s)he acts[2].

The fundamental unit of analysis is the *human activity*, carried out by an active subject. Any activity is subjectively motivated and the motive point to some object in the world. Hence, an activity is directed towards a material or ideal object which distinguishes one activity from another. This is not necessarily a material object; the prestigious position as a neurosurgeon is an example of an ideal and culturally defined object, and becoming a neurosurgeon can therefore be a motive for a medical intern. Human activities are always embedded within a sociocultural context of other humans so work activities always take place within some community of practice. The relationship between the individual's work activity and the work activities of his fellow workers is subject to a division of work and is regulated by different more or less explicit rules and norms — e.g. that the surgeon can use nurses to assist the operation but not the anesthesiologist (Engestrom, 1987[10]).

---

[2]Some central references to Activity Theory is Leontjev (1979)[17], Engeström (1987)[10]. Vygotsky (1978)[34] and Wertsch (1981)[35] provide an essential background of the cultural-historical psychological thinking. Kuutti (1991)[16] has introduced Activity Theory in the field of CSCW and several inspirations for using Activity Theory in the design of computer systems can be found in the book edited by Nardi (1996)[24].

Human activity is always mediated by artifacts. These artifacts have been adopted and developed in ways so that they can mediate certain activities within a community of practice and an artifact hence becomes an intrinsic part of this community. For example, the surgical instruments used within department U are mediators for operating a patient, and they have been developed and specialized according to many years of experiences within the practice of uniary surgery. Vygotsky extended the notion of mediation by artifacts to include psychological artifacts. Examples of more psychological artifacts used at U are the different operating procedures, heuristics, individual and collective experiences, medical concepts and scientific results and methods. Vygotsky emphasized signs and language as psychological artifacts mediating activity directed toward other humans. A psychological artifact is subject to the same socio-cultural rules of development as any other artifact.

Human activity can be analyzed as a irreducible hierarchy with three levels: *activities* realized through chains of *actions*, which are carried out through *operations*. The level of activity describes the *intentional* side of the activity — i.e. the motive. The level of action described the *anticipatory* side of the activity because each action is controlled by a goal for action and the collection of the goals for action, which makes up the whole activity, is a plan for action. The level of operation described the *operational* side of the activity because each operation are realized according to the concrete conditions in the activity's environment at the time when it is being realized. Most human activities are highly collaborative in the sense that the different actions within an activity is distributed onto several actors, who in turn need to integrate the results of these actions in order to realize the object of work.

Human activity is subject to a constant dynamic development. First, there is a dynamic transition between the three levels: an activity can become an action by losing its distinguishable motive, an action can lose its conscious goal and become an unconscious operation, and vice versa. The transition from action to activity happens in particular in collaborative activities, when the action distributed to an actor becomes an independent activity, motivated in it own right (see Bardram, in prep.[4] for a detailed discussion on the consequences of this segmentation of a collaborative activity). Second, an activity is constantly changed and developed by having a looplike structure passing through the three stages of *planning, execution*, and *development.* The realization of the activity is guided by an anticipation, which is corrected

and enriched through feedback.

In summary, a surgeon's activity of operating a patient with appendicitis (the object of work) has the objective of curing the patient. Among other things, it is mediated by different surgical instruments as well as the accumulated experience of the surgeon. It takes place within a medical community of practice and is highly collaborative, which several actions distributed onto members of the medical community, like the radiologist, the nurses, and the anesthesiologist (c.f. figure 1). Each action is realized through the operations of each actor, which are adapted both to the conditions of the object of work — e.g. the type of operation and the patient's medical condition — as well as to the conditions of the material and socio-cultural environment — such as available surgical instruments and norms for who can assist the surgeon. The activity of the nurse and the anesthesiologist can be analyzed in a similar way.

4   Temporal coordination

Based on Activity Theory, temporal coordination can be defined as;

> *an activity with the objective to ensure that the distributed actions realizing a collaborative activity takes place at an appropriate time, both in relation to the activity's other actions and in relation to other relevant sets of neighbor activities. Temporal coordination is mediated by temporal coordination artifacts and is shaped according to the temporal conditions of the collaborative activity and its surrounding socio-cultural context.*

This definition consists of three parts.

First, temporal coordination is an activity. The object of an activity can be another activity and temporal coordination is thus in itself an activity that seeks to integrate distributed collaborative actions. The dynamic nature of any activity implies that temporal coordination can be achieved both as an action within the overall collaborative activity and as an activity in itself directed towards another collaborative activity. In this sense coordination can be achieved both *intrinsically* within a group of collaborating actors

sharing the same object of work — i.e. the actors organize and coordinate the actions themselves — and *extrinsicly* to the group — i.e. the actions are organized and coordinated by someone outside the group. The three levels of activity, action, and operation in temporal coordination can be identified as synchronization, scheduling, and time allocation, which correspond to McGrath's (1990[20]; McGrath and Kelly, 1986[21]) three "macro-temporal levels" of collaborative work. *Synchronization* is an ad hoc effort aimed at ensuring that action "a", by person "i", occurs in a certain relation to the time when action "b" is done by person "j" according to the conditions of collaborative activity. *Scheduling* is to create a temporal plan by setting up temporal goals (i.e. deadlines) for when some event will occur or some product will be available. *Allocation* is to decide how much time is devoted to various activities. The essence of allocation is to assign temporal resources according to the overall motives of the collaborative work setting and hence reflects a temporal priority according to different motives.

Second, temporal coordination is mediated by artifacts. Coordinating activities in time is essentially to determine exactly *when* some event will occur or some results will be available in relation to other activities and actions. A particular effective way to do this, is to establish starting times and deadlines according to some external and socially shared time measurement. Hence, a temporal artifact, such as the clock or the calendar, can be turned into a *temporal coordination artifact*, mediating the temporal coordination, when shared within a collaborating community of practice. Actually, Hutchins (1996)[13] argues that "the only way humans have found to get such [socially distributed /jb] tasks done well is to introduce machines that can provide a temporal meter and then coordinate the behavior of the system with that meter." (p. 200). Within hospitals the clock found in every hospital unit is "one of the major 'collective representations' of the sociotemporal order of the hospital" (Zerubavel, 1979; p. 108)[37] because it represents the official time according to which all activities are recorded and synchronized.

However, psychological temporal artifacts are important mediators of temporal coordination as well. The notion of time as a psychological faculty of the mind goes back to Kant, who viewed time as a category which is logically prior to the individuals construction of reality and without which reality cannot even be meaningfully experienced. Following this line of thought, Durkheim argued that the notion of time originated not in the individual but

217

in the group, arguing for a social origin and nature of temporality. Taken together, these two ideas give us a dialectical understanding of temporality as a cognitive structure that is shaped, developed and defined within a cultural-historical context. Therefore, the temporal reference frames in which we perceive, measure, conceptualize, and talk about temporality are cultural-historical developed and defined artifacts. Even though we might take for granted the use of seconds, minutes, hours, days, and weeks to denote time, the horological system of today and the Gregorian calendar has historically speaking just been one of many competing temporal frameworks emerged within different socio-cultural contexts (Zerubavel, 1981)[38]. The prevailing international use of the Gregorian calendar should be seen in the light of the need for temporal coordination across nations in a time of globalization of trade, production, and cultural interaction, by providing an "international temporal reference framework" (Ibid.; p. 100), synchronizing social interaction on a global scale.

Third, as any other activity, the practical process of realizing temporal coordination cannot be detached from the conditions of the concrete situation. Temporal coordination is shaped according to the conditions of its object (i.e. the collaborative activity it tries to coordinate in time) and the conditions of the socio-cultural environment in which it takes place. In collaborative work activities this environment is the organizational setting.

The following sections analyze the three aspects of temporal coordination taking place at the surgical department.

5 Temporal coordination at a surgical department

This section analyzes the three level of temporal coordination at department U: syncnronization, scheduling, and time allocation.

5.1 Synchronization - continuous temporal coordination

The activity of surgical operation is carried out by a collaborating ensemble of actors engaged in a *dynamic teamwork* characterized by continuous synchronization of the many actions and actors involved, according to the concrete conditions in the work. This dynamic teamwork takes place within the actors of the surgical clinic and especially within the operating room. The clinic's head nurse, located in the surgical clinic's office, works as the hub for most of the synchronization of the surgical operations (see figure 2). She is especially responsible for synchronizing actions and surgical activities at the 'border' of the operation itself. She ensures that the patient, the anesthesiologist, the surgeon, and the intensive care unit are 'at the right place at the right time'. This synchronization is extremely important, ensuring that the flow of work is maintained in a continuous rhythm leaving the staff in the operating room to concentrate on the operation itself. This continuous ad hoc coordination can analytically be divided into three types: *communicative, instrumental,* and *scripted* coordination [4](c.f. Bardram, in Prep).

5.1.1 Communicative coordination

Communicative coordination takes place when the participants discuss how to go on with the work or someone (typical the head nurse, as seen in figure 3) tells other actors to act. Examples of communicative synchronization are when the head nurse calls the ward asking them to start the action of preparing the patient, and when a surgical nurse calls the head nurse asking her to page a missing surgeon immediately, when the patient is on the operation table. Communicating is the prevailing method for continuous synchronization at the clinic and was mediated trough a wide variety of communication devises; intercom between the office and all operating rooms and the wards, telephones, pagers, paper notes, etc.

5.1.2 Instrumental coordination

Instrumental coordination is coordination according to an awareness about the activities of others, e.g. the anesthesiologist entering the preparation

Figure 2: The surgical clinic with the operation schedule.

room when he sees that the hospital porter arrives with the patient. The left-hand column of the wallboard (shown in figure 2) reflects the official status of the operation program at any time and is hence mediating instrumental coordination; the hospital porter would check whether the patient was marked 'ready for pick up' before going to the ward, the surgeon would check whether the patient was marked 'anesthetized' at the board before entering the operating room, etc.

5.1.3 Scripted coordination

Scripted coordination is coordination according to a script for action, in this case the operation schedule, which is distributed to all relevant personnel within the hospital (the surgeons, anesthesiologists, and nurses), and is tran-

scribed to the large, publicly available wallboard in the clinic's office. As a plan for which patients to operate, in what sequence, in which operating room, and by which surgeon, the operation schedule is the fulcrum of the work done at the surgical clinic. As long as the operations are done according to this operation schedule, it can be used to coordinate the work as it reflects the work of other, distributed in time and space, and all involved staff and support personnel can coordinate their part of the work according to this schedule. However, during the day ad hoc adjustments are made to accommodate unforeseen difficulties and constraints — e.g. complication during an operation, patients not being ready for operation, and illness among staff. In order to maintain the schedule as a mediator for scripted coordination, it was continuously changed to reflect such accommodations to unforeseen constraints in the work and the operation schedule is therefore malleable. This change was however only made to the schedule at the central wallboard and everybody thus had to consult the board frequently to see 'how things were going' as a way to align their personal temporal plan with the official one.

5.2 Scheduling – planned temporal coordination

There is a limit to temporal coordination through continuous synchronization. Often actions has to be coordinated beyond what is possible to do within dynamic teamwork. For example, when work has to be coordinated across (i) organizational and departmental boundaries, such as ensuring an examination at the radiology department; (ii) occupational groups, such as coordinating the work of surgeons and nurses; and (iii) professional responsibilities, such as coordinating each surgeon's operations with his/hers other responsibilities in term of out-patient clinical work, teaching, and research. Coordination beyond the limits of dynamic teamwork is achieved through *scheduling* — i.e. through making temporal plans and goals (i.e. deadlines). The operation schedule is the foundation for scripted coordination at the surgical clinic and shall thus be our main example.

Based on a referral letter from another doctor, the head surgeon in charge of the admission of patients gives the particular case a temporal priority — whether the patient should be operated immediately, within a short time horizon (typically 3 weeks), or whether to place the patient on a waiting list.

This decision is stated in a semi-structured 'dispersal note', which is attached to each referral letter, and the case is handed to the 'operation planner' (a secretary) for her to find an appropriate time for the operation. It is now the responsibility of the operation planner to schedule a suitable time for the operation, which necessitates taking into consideration numerous constraints emerging in each case. The final schedule for the operation is written (with an erasable pencil) into the operation book containing a large (A3) sheet of paper for each day in the 6 months ahead.

There are three central aspects of the activity of scheduling: (i) juxtaposing and negotiating temporal constraints, (ii) ensuring commitment to the schedule, and (iii) scheduling to a sufficient level of detail.

5.2.1 Juxtaposing and negotiating temporal constraints

The scheduling of operations can be described as juxtaposing temporal constraints and preferences for the many interdependent collaborative activities and actors, trying to arrive at a satisfactory temporal schedule for as many as possible, including the patient. This involves a considerable amount of communication and negotiation with the ward, the radiology department, the laboratory, and the surgeon. Often the temporal priority put up by the surgeon in the first place cannot be met, which forces the operation planner to consult the surgeon again and ask him what other possible timeframes might be appropriate.

As a secretary the operation planner is merely scheduling the operation on behalf of the medical professionals having the overall medical responsibility. Hence, the creation of the operation schedule is highly cooperative [9](c.f. also Egger and Wagner, 1993). Aside from the cooperation between the operation planner and the surgeon, other central stakeholders in the plan are involved as well. Two days before the day of operation, a transcript of the operation schedule is distributed to relevant staff in order for them to either fill in details, typically concerning which surgeon and nurses are responsible for each operation, or to ask for changes. The ability to allocate personnel and to change the schedule is closely connected to the person's place in the organizational hierarchy and the program is thus only distributed to managerial representatives — i.e. the head surgeons, the head surgical nurses, and the head anesthesiologist. Another cooperative aspect of scheduling

takes place once a week, on Wednesdays, when the head surgeon in charge of scheduling operations, the head nurse of the wards, and the operation planner meets in a 'scheduling meeting'. At this meeting all the 'hard cases' that the operation planner has not been able to schedule on her own is looked into and any free timeslots is filled in with patients from the waiting list. Necessary adjustments to the plan can be made later; for example rescheduling (or even canceling) a patient from the waiting list, – caused by the arrival of acute cases.

5.2.2 Ensuring commitment to the schedule

The usefulness of the plan as a coordinator is closely dependent on whether the actors can rely on the schedule to provide a trustworthy picture of the operations to be performed. An essential part of creating such a valid operation schedule involves ensuring that everybody actually follows the schedule — i.e. that there is a social commitment to the schedule. For example, it is necessary to ensure that the radiology and other examinations are made when agreed upon, that the patient has been hospitalized, and that the surgeon and nurses turn up for the operation. Hence, there is a basic mutual interdependency between the concern for validity of the schedule and the concern for commitments made to it, and these two concerns are therefore often addressed simultaneously. For example, the reason for the operation planner to phone the radiology department instead of sending a paper-based requisition note when asking for an examination, is to negotiate for a timeslot and thereby at the same time receive a commitment from the radiology department.

5.2.3 Scheduling to a sufficient level of detail

There is a limit to the degree of details, which it makes sense to schedule. The limit of scheduling goes where continuous synchronization can be achieved in the course of work. For example, the work of the surgical nurses are not included in the operation schedule because they decide among themselves at a morning meeting who is going to join which surgical team. This enables them to continuously cover for each other during the dynamic synchronization of the operations. Similar, the exact presence of the surgeon, surgical

nurses, and anesthesiologist in the operating room is not scheduled, even though they participate in the operation at different times and for different periods. Even though problems of synchronization arises when the work is not planned — e.g. when the surgeon is not present in the operating room when the patient is ready for operation — the work of producing such detailed schedules would often exceed their benefits. Furthermore, such detailed schedules would easily become obsolete as a result of the ad hoc adaptation of schedules to unforeseen contingencies in the flow of work.

5.3 Allocation - coordination temporal motives

There is a limit to temporal coordination through scheduling as well. No matter the amount of scheduling, there will always be limited resources, resulting in temporal scarcity. For example, at department U there is a limited amount of operating rooms, surgeons, nurses, etc. Furthermore, temporal scarcity at other departments — e.g. at the radiology and anesthesiology departments — adds to the temporal scarcity on the surgical department, because the work of these departments is heavily interwoven.

Therefore, when actions that are using the same resource are to be coordinated, a need for ensuring an adequate demand/capability match arises. This is done through allocation of resource-time to the different activities, which are to reflect the overall motive structure within the hospital. There are three aspects to temporal allocation: (i) calculating capacities based on allocations of temporal resources, (ii) turning allocations into an artifact mediating temporal coordination, and (iii) negotiating allocations.

5.3.1 Calculating capacities based on allocations of temporal resources

Overall, the surgical department has been allocated resources as a department within a hospital; a certain number and type of surgical staff (surgeons, operating nurses), a number of beds at the wards with adequate support in terms of nurses, cleaning personnel, etc.; and a number of operating rooms with adequate surgical instruments. Besides these allocation on a departmental level, department U has been allocated resources from other department

within the hospital: a certain amount of radiology examinations, a certain amount of anesthesiology assistance per week, and a certain amount of hospital porters.

Based on all these allocations the department can calculate their capacity for operations. However, allocations need to be aligned, in order to avoid a bottleneck in one place blocking for full utilization of the other resources. For example, at U the allocation of radiology and anesthesiology assistance are not perfectly aligned to maintain a full occupancy rate at the operating rooms, and some of these are therefore idle during the week.

5.3.2 Turning allocations into an artifact mediating temporal coordination

These allocations are fairly stable and can be used as a background for the scheduling of operations. Hence, in the operation book the capabilities of the department during the week is represented as different *reservations* stating the number and types of operation that can be performed each day in the week. For example, the capacity on Mondays are 3 large, 3 medium, and no small operations and the capacity on Thursdays — where more anesthesiology assistance is allocated to U — is 4 large, 3 medium, and 3 small operations. When the operation planner is scheduling the operations, she is using these reservations, relying on them to reflect that sufficient amount of resources has been allocated. Hence, there is no need for her to ensure that anesthesiology or the wards has the capacity as reflected in the reservation — she merely has to coordinate with them the different types of operation and their sequence. Furthermore, these reservations also reveal an allocation of operations to different surgeons and visa versa.

5.3.3 Negotiating allocations

Due to tight budget control in the Danish hospital sector temporal scarcity is an ever-present problem and has resulted in long waiting lists for different types of operations. There is thus a constant negotiation taking place between the advocates for more operations (the surgeons) and the different resources' owners (radiology and the surgical nurses). Furthermore, because the surgeon's professional career is closely connected to the operation (s)he

is performing, the allocation of operations among surgeons are also subject for negotiation and discussion internal to the group of surgeons. Allocating the capacity of an operating room to one surgical specialist excludes other surgeons to use the room and hence perform clinical work.

6 Temporal coordination artifacts

The two most important categories of temporal artifacts mediating temporal coordination of collaborative work are the schedule and the temporal reference frames. Let us investigate their use and role at the surgical department.

6.1 The schedule

If all were actors within the surgical department and its cooperating partners to behave spontaneously, they would probably not succeed in this highly cooperative task of operating a patient. No social action could ever take place if every individual were to have a say in deciding when it ought to begin or when it should be accomplished (i.e. setting a deadline). Intraorganizational coordination requires planning, and sophisticated temporal schedules become necessary to provide a degree of predictability. The operation schedule is clearly an indispensable mediator for temporal coordination at the surgical clinic.

However, as pointed out by Zerubavel (1981)[38], one of the most significant consequences of the invention of the schedule has been the consolidation of the element of routine in collaborative work, which is essential antithetical to spontaneity. And as we have seen in the last section, spontaneity as the need for accommodations to unforeseen circumstances in the flow of operations was essential too. Hence, there is an inherent trade-off between the static quality of preset plans and schedules and the dynamic quality of ongoing collaboration (c.f. McGrath and Kelly, 1986[21]; Suchman, 1987[31]) which plays out as a trade-off between the need for a stable schedule that is applicable as a collective temporal coordination artifact and a malleable schedule flexible enough to adapt to the dynamics of the flow of work.

On the one hand, the schedule reflects an official statement to perform a

certain amount of work (i.e. operations) in a certain temporal order. This means that many people act according to this official schedule and make other schedules based on this one. For example, all of the involved personnel (surgeon, anesthesiologist, nurses, radiologists, ward nurses, intensive care nurses, etc.) have made their preparations, and the different patients have been informed of and prepared for their operation. Consequently, the schedule represent a huge human commitment and can therefore only in special rare cases be changed, and only in certain ways. For this reason, a large amount of work were invested in trying to make as valid schedules as possible, enabling a quieter and less stressful coordination in an environment where the object of work (the different patients and the operations) creates sufficient contingencies. On the other hand, we saw the necessity for flexibility in the schedule in order to incorporate unforeseen contingen ties. Hence, there is fundamental difference between the plan and the instantiation of it (Bardram, 1997a)[2] and the official schedule, written on the wallboard, was continuously modified according to changes in the work. The wallboard thus becomes not only a temporal plan but a *temporal meter* as well, functioning as the central and *official* synchronization artifact.

To handle these inherent conflicting needs for both a stable and official schedule as well as a sufficient flexible one that can accommodate unforeseen difficulties, the schedule is inherently underspecified in several places (cf. also Schmidt and Simone, 1996)[28]. It is constructed to reveal sufficient detail for others to coordinate their work according to the operations, and still leave room for accommodations in some places. For example, the schedule do not state any time for each operation (except for the first one), only the sequence of operations, and there are officially no nurses allocated until the very last minute. The schedule however reveals which patients to operate where and by who — information that seldomly is changed.

6.2   Temporal reference frames

Not only tangible and physical artifacts such as the operation schedule and the planning book are important temporal coordination artifacts. The psychological and more intangible temporal reference frames used at the hospital are, according to Activity Theory, artifacts that mediates the activity of temporal coordination as well. At a hospital, clock time and calendar time are by

no means absolutely more valid than other time measurements frameworks, such as 'hospitalization time', for the purpose of measuring the passage of time and the duration of events (Zerubavel, 1979)[37]. Hence, a day in the planning book is not divided into timeslots of hours and minutes, but into timeslots reflecting the three operations types — small, medium, and large. As we saw, the capacity on Mondays is 3 large, 3 medium, and no small operations. These different temporal reference frames are cultural-historical artifacts that are developed and deployed according to the specific medical praxes within the department, and an operation's duration is always measured in these frames.

Moreover, the duration of such temporal reference frames is dependent on the particular temporal pattern of the work context. Therefore, there is a distinction between equal periods of time. Whereas weekdays from 8 to 16 are generally considered interchangeable with one another as equal coverage timeslots, they are not interchangeable with weekend days or nights. Thus, time is *epochal* not homogeneous; a given hour of the day, day of the week, week of the month, or month of the year is not like every other one (McGrath, 1990)[20]; an operation cannot be postponed to Sunday, for example. Moreover, for most practical purposes, different periods of time are not infinitely divisible because activities cannot be divided into, or combined into, units of any arbitrary size without cost; an operation cannot be spread out on several days, for example.

7   Temporal conditions

Above scheduling is described as 'juxtaposing and negotiating temporal constraints'. But a central question to ask is, what are these temporal constraints. So far we have studied how temporal coordination is achieved through synchronization, scheduling, and allocation, and how it is mediated through temporal coordination artifacts. Now we are turning to the third part of the definition of temporal coordination, analyzing how this activity of temporal coordination is shaped according to the temporal conditions of the collaborative work that has to be coordinated, on the one hand, and according to the organizational sociocultural context in which it takes place, on the other.

7.1 Temporal conditions of collaborative work

Using Activity Theory to understand cooperative work, temporal conditions can be identified according to each of the central characteristics of a collaborative activity: the object of work, the subject(s) of work, the mediating artifacts, and the distributions of the activity into actions.

First, temporal constraints arise from the object of work. This is clearly evident in the ad hoc synchronization of a change to the operation schedule due to unforeseen difficulties in an operation. In scheduling the operations, temporal conditions arise due to the nature of each operation — e.g. in the case of appendicitis the general condition of the patient and the nature of his illness can dictate the need for a surgical operation within three days. Finally, temporal allocation is often based on the nature of the operations, which has different temporal priority — e.g. life-threatening illness has higher priority that cosmetic ones.

Second, temporal constraints arise from the subject(s) of work, such as the schedule of the surgeons, his or hers other operations, out-patient clinical work, teaching, etc. In this case, individual preferences arise and the different actors are scheduled according to the value of their time, which varies dramatically with the person's position within the medical hierarchy (Egger & Wagner, 1993)[9]. Some temporal resources are extremely expensive (e.g. surgeons and surgical nurses) while others are more inexpensive (e.g. cleaning assistance and hospital porters) and even some are for free, such as the patients. Hence, the scheduling of the operations takes into consideration these costs, and provides a slack of 'cheap resources' to assist the expensive ones. Therefore, it is primarily the work of the surgeons, and partly the work of the nurses, which is scheduled and planned on before-hand; not the work of e.g. the hospital porter and cleaning assistant. Constant availability of these later employees are taken for granted. The patient's time as such is not planned at all; when (s)he has been admitted to the hospital, (s)he is expected to wait.

Third, temporal constraints emerge due to the artifacts mediating the activity. Some artifacts can only be used within limited periods of time (e.g. the operating room) and their use has a certain temporal extension to consider. Furthermore, in organizational settings central artifacts are often shared among many activities, and their accessibility and usage have to be coordi-

nated in time — e.g. the radiology equipment used by all clinical departments within the hospital.

Fourth, the division of an activity into several actions and distributing these actions onto several actors creates temporal interdependencies among the actions. *Within a specific temporal reference frame* (e.g. an operation) it makes sense to ensure that some actions happen *simutaneously* and others in a certain *sequence*. The operation, for example, is a collection of many simultaneous actions of the surgeon, operating nurse, and the anesthesiologist and it requires the radiology examination to be done before the operation.

7.2   Organizational temporal problems, interests, and conflicts

According to Valgårda (1992)[33] the arguments behind the evolution of the modern Danish hospital organization have been centered around the production factory as an equivalent analogy. Hence, a rationalistic approach to organizations — as evident in Weberian bureaucracies, Tayloristic management theories, and Fordist rationalization of the production of goods — has also been one of the most influential conceptualization of organizations and cooperation within hospitals. This rationalistic organization of collaborative work emphasizes that (i) there is a functional division of work, (ii) the responsibility for organizing work should be shifted from workers to management, hence separating planning from implementing work, (iii) control of time becomes the key to control labor, by paying salaries in based on workhours, and (iv) work is production-oriented. Furthermore, because the healthcare sector is publicly funded and subject to political management, Danish hospitals are highly political systems with inherent relations between interests, conflict, and power (Morgan, 1986)[22]. Interests reflects a complex set of preferences and predispositions embracing goals, values, desires, expectations, incentives, and other inclinations that lead a person or group of persons to act in one direction rather than another. Conflicts arise whenever such interests collide and may be personal, interpersonal, or between groups or coalitions and may be both explicit or covert. Power is the medium through which conflicts of interest are ultimately resolved.

7.2.1 The temporal problems of organizational specialization

The functional division and specialization of medical work creates a need for precise and unambiguous temporal coordination through predictable schedules and time allocations, which subsequently creates the problem of jeopardizing the need for dynamic synchronization in the flow of work. Furthermore, in order for this scheduling to be realistic it needs to be based on pre-made allocation of time to the surgical department. However, the allocation of temporal resources is a complex issue, which ties in consideration for many different temporal interests and motives in medical work. Temporal allocation is hence often at the very heart of temporal conflicts at all levels within hospitals. For example, there is a constant political fight between the hospital and the local government to get sufficient funds to fulfill the ambitions of the politicians; between the surgical clinic and the hospital's management to get more staff and resources in order to fulfill the ambition of reducing the waiting lists; between the surgical department and the radiology department for more timeslots, at more flexible hours; between the surgeons for allocation of more surgical time for clinical research, instead of out-patient time; etc. The power to resolve these temporal conflicts lies not with an omnipotent formal authority, but is distributed all over the organization. Hence, these conflicts are constantly negotiated and attempted to be resolved within different managerial meetings, but they nevertheless seems rather persistent within hospitals.

Temporal coordination of specialized activities distributed onto specialized departments and occupational groups also creates the problem of juxtaposing their different *socio-temporal frames* and *cycles*. A striking aspect of the unfolding of activities within a modern hospital is how each professional group has its own temporal structure, which is divided into cycles (Zerubavel, 1979)[37]. For each group the cycle of the year, the rotation, the week, the day, and the shift force both routine and non-routine events and activities into regular temporal patterns, thus introducing a rhythmic structure into hospital life. One of the biggest challenges to the operation planner in making the operation schedule was to coordinate the multiplicity of temporal frames and cycles running independently aside one another within a hospital. For example, when the operation schedule is scheduled in temporal frames of small, medium, and large operations it has to be translated into 'normal' time measurement in order to convince the employees that the program will

finish before their leaving time. Furthermore, the surgeon's temporal cycle involves e.g. teaching, consulting, and outpatient clinic work, the surgical nurses' cycles involves work hours from 8:00 to 15:30, and the anesthesiology department has a weekly temporal pattern for anesthesiological assistance. Sometime an operating room was unused because these temporal cycles could not be synchronized.

7.2.2   The problem of temporal segmentation

Because all departments manage time cost on a departmental level, such as in the case with department U's operation book, there is practically no way of establishing the time cost of an operation that takes into consideration the time cost of the many activities distributed onto other departments. For example, when radiology is unable to make an examination it prolongs the whole hospitalization of a patient and dramatically increases the overall time cost of the operation for the hospital to a cost that is far bigger that the one saved by postponing the radiology examination. Similarly, when the patient after an operation cannot be transported to the intensive care unit due to lack of resources there, the patient has to stay in the operating room blocking the rest of the operation scheduled that day. The overall time cost of this blockage again far exceeds the time cost of the saved resources at the intensive care unit. Hence, a core temporal problem, which is complicated by the specialized nature of operations, is to calculate a total time cost of the different operations, which again is a prerequisite for allocation of temporal resource in an optimal way. Such measurements of temporal costs can subsequently be turned into political tools as arguments in favor of an increasing allocation of temporal resources, or less demand for operation when there is not sufficient temporal resources on the service departments.

7.2.3   The problem of temporal inflexibility

One of the major structural characteristics of surgeons' work schedules is that they are temporally flexible, whereas the temporal cycles of the surgical nurses are far more inflexible and are generally characterized by a rigid temporal segregation of private and public life (cf. also Zerubavel, 1979)[37]. It is therefore easier to schedule the work of the surgeon than the work of

the nurses. This temporal flexibility can be partly ascribed to the notion of the surgeon's medical responsibility, which is not mechanical transferable from one surgeon to another, precluding temporally rigid cycles based on fixed leaving times. However, the surgeon also has an interest in operating because his career is more connected to the work he is doing rather than the time he is spending at the hospital, whereas the nurses' political power as a group resides in sustaining their occupational rights, which they have achieved through their labor union.

This problem of inflexible temporal resources has its roots in the rationalistic notion of controlling labor by controlling time. This means that most work is congested in the limited span of time between 8 and 15:30, Monday to Friday, and that expensive surgical, radiological, etc. equipment remain unused most of the time. This subsequently creates severe bottleneck in the work during normal working hours. The lack of more flexible use of the hospitals resources might sound strange, especially taking into consideration that patients' temporal preferences lies outside their own working hour. Treatments during the nights and weekends would hence oblige both the problem of scarce temporal resources and simultaneously address the patients' temporal preferences. However, as stated above, the work at hospitals are to a large degree organized according to the 'production' and not according to the 'customers'. Furthermore, the temporal interests of the employees precede that of the patients' during the political allocation of temporal resources at the hospital because the patients do not have any power within the hospital.

7.2.4 The problem of 'bad' and 'fair' schedules

Caused by the separation of planning from implementation of work, the temporal problem of unrealistic schedules emerge. This was one of the most prevalent problem for the users of the operation schedule at the hospital; a recurrent complaint from the surgical nurses was that the operation planner were too optimistic in her allocation of time for each operation, resulting in delays according to the schedule and subsequently need for them to work overtime. The schedule was considered 'unfair' from their point of view. Asking the operation planner in turn, she was not aware of the extend of this problem, because for one she could not compare her estimates with statistical data on actual operation times, and secondly there was no channel of

communication between the operation planner and the surgical nurses, who did not participate in the Wednesday meetings. The concern for a trustworthy operation schedule creates a concern for continuously enhancing the ability to create such valid schedules — i.e. to learn how to make better operation schedules. A necessary precondition for this development is the ability to somehow monitor the coordination of work based on the schedule, and learn from a comparison between the intend of the schedule and how it was subsequently used — i.e. where it was successful and where it failed as a coordinator. Unfortunately, this learning phase of an activity is seldomly supported very explicit within bureaucratic organizations (Senge, 1990)[29] which also was the case at the surgical department.

In a more general sense, fairness seems to constitute a fundamental rule of scheduling from which almost all hospital coverage schedules are generated (Zerubavel, 1979[37]; Bardram, 1997b[3]). The notions of fair and unfair are clearly vague and subjective terms, but they nevertheless play an important role in the temporal coordination of work. Basically the fairness in coverage scheduling is achieved by ensuring an even distribution of both the desirable and the undesirable coverage timeslots. This, however, is often closely tied to the temporal preferences and interest of the actors in the workplace, and subsequently to their power to address these preferences.

8   Computational support for temporal coordination

Technology which can support temporal coordination and can help address and overcome some of the temporal problems and conflicts described above, would indeed be useful within an organization. Let us consider how the PATIENT SCHEDULER (PS) addresses some of these issues — especially the creation of more 'valid' schedules. The PATIENT SCHEDULER is shown in figure 3.

8.1 The PATIENT SCHEDULER — the basics

The basic concepts in PS are an organizational unit, an appointment, a resource, a template, a program, and a note. Basically, PS supports the user to request or directly schedule an appointment, allocating some resources that belong to some organizational unit. Resources can for example be radiology machines, surgical equipment, examination rooms, surgeons, and physicians. If a patient is involved, (s)he is considered a resource too.

An *appointment* has three main stages: (i) proposed, (ii) implemented (or scheduled), and (iii) completed and usually goes trough all three stages. For example, the request for an X-ray examination would be sent as a proposed appointment from the surgical department U to the radiology department. At the radiology department the proposal is received in the communication center and is approved and implemented. To implement an appointment means that it is scheduled at one or more resources owned by the radiology department and is now appearing at each of these resources' calendar, including the patient's calendar.

A *resource* can be set up to be open, or active, in a certain temporal pattern, repeated on a daily, weekly, monthly, and yearly basis and hence supports different temporal cycles. Furthermore, a resource can be divided into (at the moment only equal size) *timedots*, and any scheduling of appointments has to use a whole number of such timeslots, and not e.g. a half timeslot. This means that the department can set up their own time reference frames and PS thus supports the scheduling of operations in terms of small, medium and large. These timeslots have, however, a corresponded duration in Newtonian time, since the computer as such is a mathematical machine. Each of these resources can be arranged hierarchically into *resource groups*. Typical resource groups at department U was the group of head surgeons, the group of surgical nurses, and the group of beds at the wards. An appointment can be allocated to a unique resource or it can be allocated to a resource group. This means that the appointment can be rescheduled to another resource within the same group; e.g. to another bed. The concept of a resource group is intended to support the continuous coverage evident in the surgical department. Hence, by allocating an operation to a group of nurses (e.g. 'team A'), it allows for them to cover for each other.

If a certain type of appointment recurrently has to be made, an appointment
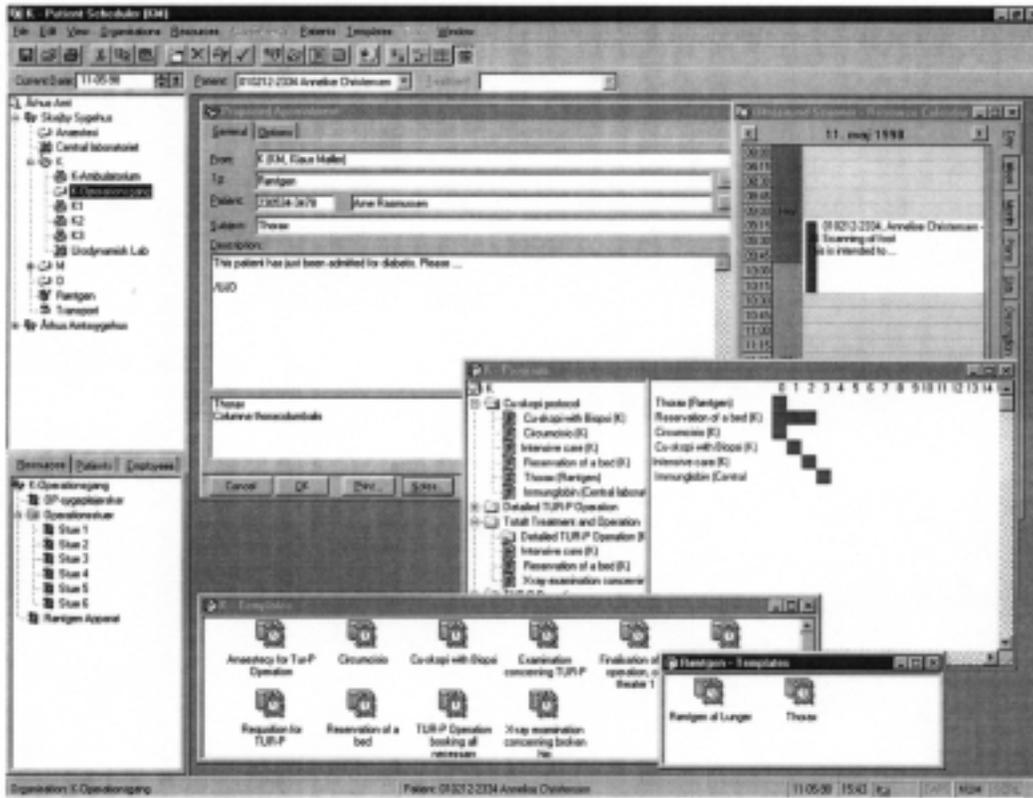
Figure 3: The PATIENT SCHEDULER.

template can be treated based on an existing appointment. For example, a frequent occurring type of operation at U is an operation called TUR-P. Thus, a template containing all the details for this operation can be made and used whenever a TUR-P operation is needed. These templates can be combined into a *program*, which is a list of appointment templates needed for a certain treatment. For example, the 'typical operation' depicted in figure 2 can be modeled in PS as a program that consists of 6 templates, namely: (i) reservation of a bed, (ii) radiology examination, (iii) laboratory test, (iv) uroscopy test, (v) operation — e.g. the TUR-P template, and (vi) intensive care.

8.2 Supporting temporal coordination through synchronization

The computerized operation schedule is intended to support scripted temporal coordination in the same way as the present wallboard schedule does. The progress of the work during the day is supposed to be reflected in the schedule and as a network-based technology, PS makes this temporal meter accessible from other places than the surgical clinic's office — e.g. at the intensive care unit, at the wards, and in the planning office. Tailorable status colors can be used to reflect status information for the individual operations, and can thus be used in instrumental synchronization. Notes can be used to send messages to other people and can be attached to the 'wallboard'. However, the scenarios describing the use of PS during the coordination of operations include the use of existing communication artifacts, such as intercoms, telephones, and pagers, which probably never will vanish from a hospital. Furthermore, the publicity and visibility of the wallboard are to be maintained because it was fundamental for the schedule to work as a coordinator in the continuous synchronization (c.f. also Whittaker & Schwartz, 1995)[36]. Thus, when implementing the PATIENT SCHEDULER in a hospital, similar arrangements should be made to make it public and visible using e.g. bacco canons or smartboards.

8.3 Supporting temporal coordination through scheduling

The operation planner will receive referral letters as proposals in U's communication center. After reading the proposal, she puts it into the appropriate surgeon's mail-folder for approval. The surgeon will attach a 'dispersal note' to the appointment, telling the operation planner how to handle the case. If the operation planner cannot comply with the constraints a new notes can be attached and an asynchronously conversation can be maintained between the surgeon and the operation planner in order to solve the problem.

As described above, one of the main temporal problem was the cumbersome juxtaposing of temporal schedules and constraints — e.g. ensuring a radiology examination before a certain deadline. In PS the operation planner has

three methods for achieving this: (i) the examination can be sent as a request and a proposed deadline for the latest implementation can be stated; (ii) if radiology has granted the operation planner access to a resources, she can look into their resource calendars and pick a spare timeslot and send them a proposal to have this slot; or (iii) if radiology has allocated time on the resource to U, the operation planner can schedule the appointment on her own, thereby ensuring immediate commitment to the appointment. Based on our previous analysis of the work of scheduling, it is evident that this later method is preferable — seen from the perspective of the operation planner at U.

Scheduling the operation itself involves allocating different resources and/or resource groups (belonging to U) to the operation appointment at a certain starting time and for a certain period. Some of these resources need only be present at some of the time — e.g. the anesthesiologist and the surgeon (c.f. figure 1). Therefore, the allocation of each resource can be further detailed by indicating a relative start and stop time compared to the whole span of time involved in the appointment. Such highly detailed planning is however completely voluntary and can be made in an iterative fashion if desired. At the most gross level an appointment need not even be scheduled at any particular time, thereby resembling the way it is done today at U.

Furthermore, to help the operation planner to find a suitable schedule where all such temporal constraints are fulfilled PS has a semi-automatic scheduling algorithm similar to many standard groupware calendars. Automatic scheduling (as e.g. suggested by Ephrati et al., 1994)[11] was abandoned early in the design because such optimization algorithms would require a huge amount of work in maintaining the many temporal constraints and priorities, necessary in order to arrive at a sufficient valid schedule (a similar conclusion was reached by Erhlich, 1987[12], and Egger & Wagner, 1993[9]). This is just further complicated because of the epochal nature of time, making it an almost impossible task to represent in the computer which timeslots are interchangeable and divisible. The work of maintaining such computerized representation of temporal constraints would, in our opinion, far exceeding the benefit of automatic scheduling and would at best only result in sub-optimization.

Finally, PS saves a copy of an appointment in each stage — the proposal, the implementation and the completion. This provides the foundation for further

organizational reviews into the balance in time allocation and for calculating more accurate and realistic duration figures for the different operations. The concept of a template then makes it possible to save such information for later use. For example, a template with the proper information and duration concerning a TUR-P operation can be made and henceforth be used whenever a patient is scheduled for such an operation. Subsequently, a program for the whole operation, including examinations and reservation of a bed, can be made. In this way, PS enables the department to save 'best practices'.

8.4 Supporting temporal coordination through allocation

The sharing module in PS allows the owner of a resource to share it with others within the hospital. Basically, the sharing module lets the owner of a certain object (resource, note, appointment, etc.) specify who can do what with this object. Hence, the owner of the resource named "PET Scanner" can allow department U to access the PET Scanner's resource calendar, which enables them to see it, and find a vacant timeslot and send a proposal to the radiology department for this timeslot. Furthermore, because each timeslot is an object, the radiology department can set up permissions for each timeslot, hence enabling the U department to implement (i.e. schedule) an appointment at particular timeslots. Thus, the access mechanism in PS, and its granularity, enables the radiology department to allocate time to the different department within the hospital, which in turn can schedule appointments directly at these resource calendars.

9 Conclusions

The field of CSCW research shares the common awareness that it is essential to understand the ways in which work activities are cooperatively realized in practice in order to design efficient cooperative technology. Based on Activity Theory this paper has discussed how temporal coordination was achieved within a highly complex work situation as a three-level activity of synchronization, scheduling, and temporal allocation, and how this activity was mediated by temporal coordination artifacts and shaped according

239

to the broader organizational context. The PATIENT SCHEDULER was introduced and discussed as a computer technological temporal coordination artifact mediating synchronization, scheduling, and temporal allocation. The main benefit of using such a technological solution for temporal coordination resides in its support for:

- dynamic and integrated synchronization through communicative, instrumental and scripted coordination mediated by notes, status colors, schedules, and distributed across a local area network

- creating better schedules through juxtaposing different temporal constraints represented as resource schedules and temporal allocations

- ensuring commitment to an appointment through access to other department's resource calendars

- calculation of time costs of activities leading to better schedules and support for more optimal allocation of time

- support for flexible planning through incremental detailing an appointment in terms of resources and time

- handling the socio-temporal aspects of cooperative work, such as temporal frames, temporal cycles, and the 'relativity of simultaneity'

- addressing the temporal preferences of the patient through the patient calendar

Activity Theory helped us identify not only tangible mediating temporal artifacts — such as the operation schedule and the booking book — but also the more intangible and psychological mediating artifacts, such as the temporal reference frames developed and deployed within the different departments. Activity Theory also emphasizes the developmental stage of a collaborative activity, which helped us to understand, and hence design for, the need for continuously comparison between the plan and the work as guided by the plan as a way to enhance the creation of schedules.

The definition of temporal coordination brought forward in this paper also forced us to pay attention to the temporal conditions inherent within the organizational context in which the collaborative activity being coordinated

takes place. There is a constant tension between the need for better temporal coordination and its organizational circumstances. The sharing of the service department's resource calendars is a particular important example of this tension, which emerged throughout the entire project. Looking at the PATIENT SCHEDULER, it only creates a real benefit if the different departments and actors are willing to share information and resources and thereby support a more efficient juxtaposing of the different temporal constraints. Without access to scheduling resources at e.g. the radiology department, the operation planner at department U would quickly resign to use the telephone again. However, the hospital as a specialized bureaucracy and political system might oppose such collaboration modes. As for the former, the specialized departments — typical radiology — would lose any control over the activities and be completely unable to plan how to apply their scarce resources. From a specialized medical point of view, the requesting secretary is not trained as a radiologist, which makes her unable to judge exactly what kind of examination to book, what kind of equipment to use, and the length of the examination. As for the later, a political stumbling block against implementing more cooperative procedures is the degree of transparency which this would require — especially giving a longstanding tradition of granting medical departments, and within them senior physicians and surgeons, temporal autonomy (Egger & Wagner, 1993)[9]. These organizational conditions clearly point to risks of failure for cooperative technologies, such as the PATIENT SCHEDULER, if not addressed properly.

A similar tension exists in the PATIENT SCHEDULER's calculation of time costs; on the one hand, time cost measurement is a necessary prerequisite for optimal time allocation, on the other hand, they are (or can be turned into) political instruments. Basically, we are here dealing with a fundamental tension between the need for, and the politics of, organizational accountability (cf. the Suchman—Winograd debate in the Journal of CSCW, 1994).

Studies of collaborative work within hospitals have shown that conflicting goals and motives can in particular affect the coordination of activities (Symon et al., 1996)[32]. This analysis shows how *temporal* constraints and conflict in particular has a profound influence on the coordination of work across actors and organizational boundaries. The discussion of the PATIENT SCHEDULER illustrates how computer technology can support the creation of better work schedules and can increase communication and negotiation con-

cerning this schedule. However, some of the severe temporal problems and constraints discussed above cannot solely be addressed by computer technology because they are either a result of temporal scarcity due to lack of resources, or caused by the sociotemporal order of collaborative work embedded within a bureaucratic and political organization. This, nevertheless, do not lead to the conclusion of abandoning computer support for temporal coordination, but merely to the conclusion that the design and introduction of such technology within a work practice should incorporate a concern for the temporal aspects of collaborative work, as described in this paper.

10   Acknowledgments

References

[1]   Bardram, Jakob E. (1996): Organisational Prototyping: Adopting CSCW Applications in Organisations. In *Scandinavian Journal of Information Systems*, vol. 8, no. 1, pp. 69–88.

[2]   Bardram, Jakob E. (1997a): Plans as Situated Action: An Activity Theory Approach to Workflow Systems. In *Proceedings of the 5th European Conference on Computer Supported Cooperative Work*, Lancaster, UK. Kluwer Academic Publishers.

[3]   Bardram, Jakob E. (1997b): I Love the System — I just don't use it! *Proceeding of GROUP'97, ACM Conference on Supporting Group Work*, Phoenix, Arizona, USA, New York: ACM Press.

[4]   Bardram, Jakob E. (in prep.): An Activity Theoretical Approach to Design of Computer Support for Cooperative Work. Available as *Tech-*

nical Report (Daimi PB) from Dept. of Computer Science, University of Aarhus, Denmark.

[5] Bowers, J., Button, G., and Sharrock, W. (1995): Workflow from within and without: Technology and Cooperative Work on the Print Industry Shopfloor, In *Proceedings of the Fourth European Conference on CSCW, Stockholm, Sweden.* Kluwer Academic Publishers, pp. 51–66.

[6] Bødker, S. (1991): *Through the Interface: A Human Activity Approach to User Interface Design.* Hillsdale, NJ: LEA.

[7] Bødker, S. & K. Grønbæk (1991): Design in Action: From Prototyping by Demonstration to Cooperative Prototyping. In Greenbaum, J. & Kyng, M.: *Design at Work: Cooperative Design of Computer Systems,* New Jersey, Lawrence Erlbaum Associates, Inc., Publishers.

[8] Crowston, K. (1994): A Taxonomy Of Organizational Dependencies and Coordination Mechanisms. *MIT Center for Coordination Science Working Paper,* Massachusetts Institute of Technology, August 1994, (available from http://ccs.mit.edu/ccsmain.html).

[9] Egger, E. & Wagner, I. (1992): Negotiating Temporal Orders. The Case of Collaborative Time Management in a Surgery Clinic. *Computer Supported Cooperative Work, Klüwer, Dordrecht* vol 1, pp. 255–275.

[10] Engeström, Y. (1987): *Learning by Expanding: An activity-theoretical approach to developmental research,* Helsinki: Orienta–Konsultit Oy.

[11] Ephrati, E., Zlotkin, G. an.d Rosenschein, J. (1994): Meet your destiny: A Non-manipulable Meeting Scheduler, In *Proceedings of the Conference on CSCW, Chapel Hill, NC, USA.* ACM Press, p. 359–368.

[12] Erhlich, S.F. (1987): Strategies for encouraging successful adoption of office communication systems, *ACM Transactions on Office Information Systems,* 5, p. 340–357.

[13] Hutchins, E. (1996): *Cognition in the Wild.* Cambridge, MA, The MIT Press.

[14] Jordan, B. (1996): Ethnographic Workplace Studies and CSCW. In Shagpiro, D., Tauber, M. & Traunmüller, R. (Eds.) *The Design of Computer Supported Cooperative Work and Groupware Systems.* Elsevier, Amsterdam.

[15] Kensing, F. & Madsen, K.H. (1991): Generating Visions: Future Workshops and Metaphorical Design. In Greenbaum, J. & Kyng, M. (Eds.) *Design at Work: Cooperative Design of Computer Systems,* LEA, Hillsdale NJ.

[16] Kuutti, K. (1991): The concept of activity as a basic unit of analysis for CSCW research. In *Proceedings of the Second European Conference on CSCW, Amsterdam.* Kluwer Academic Publisher, pp. 249–264.

[17] Leontjev, A. (1978): *Activity, Consciousness, and Personality,* Prentice-Hall, Englewood Cliffs, NJ.

[18] Malone, T. & Crowston, K. (1990): What is Coordination Theory and How Can It Help Design Cooperative Work Systems?, In *Proceedings of the Conference on CSCW, Los Angeles, CA, USA.* ACM Press, p. 357–370.

[19] Malone, T. & Crowston, K. (1994): The interdisciplinary study of coordination, *ACM Computing surveys.*

[20] McGrath, J. E. (1990): Time Matters in Groups. In *Intellectual Teamwork: Social and Technological Foundations of Cooperative Work,* ed. Jolene Galegher, Robert Kraut, and Carmen Egido, 173–190. Hillsdale, NJ: Lawrence Erlbaum Associates.

[21] McGrath, J. E. and Kelly, J. R. (1986): *Time and Human Interaction: Toward a Social Psychology of Time.* New York, Guilford Press.

[22] Morgan, G. (1986): *Images of Organizations,* Beverly Hills, CA: SAGE.

[23] Mumford, L. (1934): *Technics and Civilization,* New York: Harcourt Brace Jovanovich.

[24] Nardi, B. A., (ed.) (1996): *Context and Consciousness: Activity Theory and Human-Computer Interaction.* Cambrigde, MA: MIT Press.

244

[25] Patton, Michael Quinn. (1990): *Qualitative Evaluation and Research Methods, 2nd edition.* Newbury Park: SAGE.

[26] Scarbrough, H. and Corbett, J. M. (1992): *Technology and Organization: Power, Meaning and Design,* London: Routledge.

[27] Schmidt, K. (1993): The Articulation of Cooperative Work: Requirements for Computer Support, in *Developing CSCW Systems: Design Concepts,* CoTech WG4 Report, February 1993, pp. 37–103.

[28] Schmidt, K. and Simone, C. (1996): Coordination mechanisms: Towards a Conceptual Foundation of CSCW Systems Design, *Computer Supported Cooperative Work,* vol. 5, pp. 155–200.

[29] Senge, P. (1990): *The Fifth Discipline: The art and practice of the learning organization.* London: Century Business.

[30] Strauss, A., Fagerhaugh, S., Suczek, B. and Wiener, C. (1985): *Social Organization of Medical Work.* Chicago and London: University of Chicago Press.

[31] Suchman, L. (1987): *Plans and situated actions. The problem of human-machine communication.* Cambridge: Cambridge University Press.

[32] Symon, G., Long, K., and Ellis, J. (1996): The Coordination of Work Activities: Cooperation and Conflict in a Hospital Context, *Computer Supported Cooperative Work,* vol. 5, pp. 1–31.

[33] Vallgårda, S. (1992): *Sygehuse og sygehuspolitik i Danmark: Et bidrag til det specialiserede sygehusvæsens historie 1930-1987. [Hospitals and hospital politics in Denmark: A contribution to the history of the specialised hospital sector 1930-1987].* København: Jurist- og Økonomforbundets Forlag.

[34] Vygotskij, L. S. *Mind and Society.* Harvard University Press, Cambridge MA, 1978.

[35] Wertsch, J. (1981). (ed.) *The concept of activity in Soviet psychology.* Armonk, NY: Sharpe.

[36] Whittaker, S. & Schwartz, H. (1995): Back to the Future: Pen and Paper Technology supports Complex Group Coordination. In *Proceeding of CHI'95*, Denver, Colorado, USA, ACM Press.

[37] Zerubavel, E. (1979): *Patterns of Hospital Life: A Sociological Perspective*. Chicago, University of Chicago Press.

[38] Zerubavel, E. (1981): *Hidden Rythms: Schedules and Calendars in Social Life*. Chicago, University of Chicago Press.