

# Designing for the Dynamics of Cooperative Work Activities

Jakob Bardram

Aarhus University, Computer Science Department  
Ny Munkegade bldg. 540, 8000 Aarhus C., Denmark  
bardram@daimi.aau.dk

## ABSTRACT

CSCW seems to have a persistent problem of understanding the nature of “cooperative work”. This paper argues that this problem is a direct result of not looking at the dynamic aspects of work – i.e. that cooperative work is not one thing, but different things at different times and in different places. Based on Activity Theory the paper gives a conceptual frame for understanding the dynamics of collaborative work activities, and argues that the design of computer support should view cooperative breakdowns not as a problem but as an important resource in design. These arguments are based on empirical studies of healthcare work and the design of a computer support for planning and scheduling operations and other activities within a hospital.

## Keywords

Cooperative work, dynamics, Activity Theory, design, healthcare

## INTRODUCTION

This paper is about the nature of “cooperative work”. Explicitly, it addresses the *dynamics* of cooperative work, such as when cooperation breaks down, changes over time, and is perceived differently by different actors involved. Understanding the dynamics of cooperative work is extremely important as a way to understand how to design computer systems supporting cooperative work. If computer technology does not take into account support for the dynamic development, change, and breakdown in cooperation the system fails. This has been shown in numerous workplace studies [3, 6, 12, 22, 23]. Actually, the implicit assumption in many of the ethnographic studies made within the realm of CSCW is to study the dynamics, and especially the breakdowns, in cooperative work as a way to understand the ‘normal’ flow of work (c.f. [6, 23]). Unfortunately, the dynamics of cooperative work has not explicitly been addressed within CSCW. Questions like “how does cooperation develop and change over time?”, “what is cooperation anyway? – can we identify different types of cooperation?”, “and if so – how, when, and why does one type of cooperation transform into another?”, “why does cooperation sometimes break down, and how do people re-

cover from such breakdowns?”, and “why is the same work viewed as cooperation in one situation and as competition in another?” are extremely important, yet unanswered questions in our attempts to support cooperative work by computer technology.

This paper takes a theoretical starting point in understanding the dynamics in cooperative work, and provides a conceptual frame for identifying, analyzing, and hence designing for cooperative work. The paper builds on extensive workplace studies within the Danish healthcare sector. Based on this empirical basis the dynamics in hospital work is analyzed and discussed, and computer support for the dynamics in cooperative work is discussed with a booking and scheduling systems as the focal point.

## THE NOTION OF COOPERATIVE WORK IN CSCW

Before turning to the framework and the hospital case, let us shortly consider the background for the present discussion.

### The Notion of “Cooperation” in Cooperative Work

By now – 14 years after Greif and Cashman’s workshop in 1984 – it still seems like the research field of CSCW struggles with the issue of what CSCW exactly means. Bannon [1] argues that the term CSCW seems to be an “umbrella term” covering a loose agglomeration of communities. Hence, browsing through the proceedings of the different CSCW conferences and the journal, we find papers on a wide variety of issues, such as workflow technologies, groupware, ethnographic workplace studies, participatory design, labor issues, group psychology, etc. Even though this in itself might not be a problem – this diversity of background might even be advantageous, as argued by Bannon [1] – it still leaves problems in fostering an internal and external discourse of ideas that we want to dedicate the term CSCW for. Because we do have a pretty good idea of what is meant by “computer support” this confusion lies in an understanding of what we mean by “cooperative work”. And, as argued by Bannon and Schmidt [2], 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.

CSCW has been identified with the increasingly commercial interest in “Groupware” and thereby identifying cooperative work with group work (c.f. [13]). However, narrowing down the definition of cooperative work by using

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the psychological notion of a group with its social psychological characteristics such as norms, roles, group pressure, and conformity, does not seem to quite encompass the intent of the CSCW field. Generally, a group is defined as a relatively small ensemble of people, who interact and communicate closely and who share the same goal. The notions of cooperation solely through communication and of a shared goal are dubious, however. As a description of the medical trajectory of a patient, the medical record fosters cooperation across departmental and professional boundaries without intense communication, and the cooperative process of decision making in a surgical department's managerial group is a very differentiated process involving the interaction and trade-offs between multiple goals, preferences, values, incentives, and inclinations. By focusing on the positive aspects of how people carry out work together, such as cooperation, collaboration, and commitment, instead of the difficult aspects, such as competition, conflict, and control, the field of CSCW has been criticized for being limited in its understanding of cooperative work [14]. When looking into the organization of hospitals, an important aspect of work coordination includes the conflicts between work goals and motivations for coordination activities [23].

#### **The Notion of Dynamics in Cooperative Work**

Trying to conceptualize "cooperative work" needs however to address the dynamics of this work. Without mentioning it explicitly, it seems as if such dynamic aspects of cooperative work play a major, but implicit role in many of the investigations of cooperative work done within CSCW. Let me illustrate this with three examples.

A central debate within CSCW concerns the notion of workflow systems. Many of the ideas of workflow systems came out of the office automation movement, viewing office work as routine work ready for rationalistic automation efforts. Hence, workflow systems embed standard operating procedures for routinely handling office work, and have as such been viewed as the assembly line of the office. The well-known work of Wynn and Suchman [22], however, has shown that office work – even in the most routine cases – is cooperatively handled in an ad hoc manner within the cooperative work ensemble, where operating procedures do not in any sense control the flow of work. This notion of work is widely accepted within CSCW and helps distinguish the field from the former field of office automation. But the 'survival' of workflow systems, and their commercial success, still gives credit to its advocates' argument that much work is characterized by routine that can be coordinated effectively by formal procedures and scripts for action. This tension points to a need for understanding that cooperative work is not one or the other, but might be both routine and cooperation at the same time. In this sense, concepts like routine, cooperation, conflicts, etc. might be viewed not as distinct categories of work, but as different *aspects* of the same work effort.

The conceptualization of cooperative work within the framework of Coordination Mechanism [21] makes an analytical distinction between "cooperative work" and "articulation work", the later being the work actors do, caused

by their interdependency, in order to coordinate, schedule, mesh, integrated, etc., their cooperative work. Hence, articulation work is an overhead to the cooperative work. However, this view does not incorporate any dynamic understanding of work in the sense that what is cooperative work in one situation might be articulation in another, and vice versa. This is nicely put by Bødker and Mogensen [7] when they, based on an analysis of the cooperation between a labor inspection officer 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*.

The dynamics of cooperative work over time is also particular important in understanding work. Several sociological studies of the introduction of computer technology have adopted a "before-after" scheme of investigating the impact on the work practices (e.g. [6, 12]). These studies have tried to provide information about how work groups develop, function, and change over time. Often cooperative work can only be understood by studying the temporal unfolding of the work practices involved. In some cases, cooperation is temporarily initiated in response to the requirement within an organization (e.g. task-force groups). In other cases, in emergency situations at hospitals for instance, cooperation can have a more spontaneously instantiation and course. And in still other cases, cooperation has a quasi-permanent character like in project teams and, finally, cooperation is in many cases of a permanent character within fixed organizational roles and responsibilities.

Hence, cooperative work seems (at least) to be dynamic across types of interaction, actors, and time; what might be close cooperation in one situation might be routine in the next; what is coordination for one actor is the work of another, and cooperative efforts are constantly initiated and finalized over time. Hence, a framework trying to conceptualize cooperative work activities needs to address such dynamics in work.

#### **The Notion of Breakdowns in Cooperative Work**

Closely tied to the notion of dynamics in cooperative work is the notion of a breakdown in the flow of work. This notion of cooperative breakdowns has been a foundation for most of the sociological research done within CSCW and has been common to most of the workplace studies. Attention has been paid to studies of how people manage the contingencies inherent to cooperative work and the methods they apply in order to recover from different breakdowns in the flow of work. The classic study of Suchman [22], for instance, investigates how purchasing staff worked together to solve a problem of an incomplete invoice, and Symon et al. [23] focus on hospital staff's numerous deviations from 'normal' cooperative work and their coping strategies, as a method to understand cooperation and conflicts within hospitals. Moreover, several CSCW studies have, not surprisingly, paid special attention to cooperative breakdowns caused by the introduction of computer technology. For instance, how the smooth flow of work at a print shop is disrupted by the introduction of computers [6] and how general practitioners in the

UK encountered several breakdowns in their work, when a new computer-based medical record was introduced [12].

The notion of cooperative breakdowns in work hence exists as an important, but often unarticulated background for much of the work done in CSCW. The intent of this paper is to address the dynamics in cooperative work arising from such breakdowns and view such breakdowns as important places to look for an understanding of cooperation. The importance of understanding cooperative breakdowns, however, lies in the importance of supporting such breakdowns in the design of computer technology. Failures and problems with cooperative computer technology, as the ones mentioned above, arise precisely when the computer artifact leaves no support for handling breakdown situations in the flow of work. Hence, we need to study and understand cooperative breakdowns in order to design for recovery from them.

### THEORIZING THE DYNAMICS OF COOPERATIVE WORK

As a social psychological theory focusing on the developmental transformations and dynamics in collective human work activity, Activity Theory seems to provide appropriate conceptualizations, suited for analyzing cooperative work, its dynamic transformation, and the importance of cooperative breakdowns.

#### Activity Theory<sup>1</sup>

The fundamental unit of analysis in Activity Theory (AT) is the *human activity*, carried out by an active subject. Every activity is specific and activities are distinguished from each other by their respective *objects*. It is the activity's object that gives it a specific direction, i.e. is the *objective* of the activity. The notion of object in AT is not limited to physical entities; the prestigious position as a neurosurgeon is an example of an ideal and culturally defined object, and becoming a neurosurgeon can hence be an objective for a medical intern. Human activities are always embedded within a socio-cultural context of other humans and work activities thus always take place within some community of practice. AT describes cooperation as a *collaborative activity*, with one objective, but distributed onto several actors, each performing one or more *actions* according to the overall and shared objective of the work. 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 [8].

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 a surgical department are mediators for operating on a patient, and they have been developed and specialized according to many years of experiences within the practice of the specific surgical speciality. Vygotsky extended the notion of mediation by artifacts to include psychological artifacts. Examples of more psychological artifacts used at surgical departments 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.

#### Levels of a Collaborative Activity

AT identifies a three level hierarchical structure of a collaborative activity [9]: co-ordinated, co-operative, and co-constructive collaborative activity.

The *co-ordinated* aspect of work captures the normal and routine flow of interaction. In co-ordinated work the various actors are gathered together to act upon a common object, but their individual actions are only externally related to each other. Individuals are following their scripted roles, each concentrating on the successful performance of their assigned actions. 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 [9]. In this sense the actors are passive participants – not active subjects, but “wheels in the organizational machinery” [15]. 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 object, e.g. treatment of a patient, but they do not relate to the common objective of their activity. The subjects only realize the whole of the activity from the point of view of their individual activity.

By *co-operative* collaborative work is meant a mode of interaction in which the actors, instead of each focusing on performing their assigned actions and roles, they focus on a common object and thus share the objective of the collaborative activity. With regard to the common object, each actor has to balance his own actions with the actions of his partners, and it might even be necessary to influence his partners' actions, with regard to achieving the common task.

In co-operative 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 onto several actions and actors, and the mediating artifacts. This does not mean that the artifacts necessarily have to be constructed (fabricated) as such. It merely means that an artifact is not recognized as a mediator in the action but merely exist as an object in the world. As a part of realiz-

<sup>1</sup> Some central references to Activity Theory are Leontjev [16], Engeström [8]. Kuutti [15] 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 [18]. Further elaboration on the use of AT as a foundation for CSCW research and design is presented in [5].

ing 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 sharing of the objective, which enables the participants in the distributed activity to relate to each other and make corrective adjustment to their 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.

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 motive of the health-care professionals of treating the patient, we talk about coordinated work activities. However, if the kitchen shares the motive of treating the patient with the ward we talk about cooperative work. In the later case, the sharing of the motive enables the kitchen to adjust their activity not only to the request but also to the overall motive. Hence, if the ward orders the normal dinner for a patient with a cardi-ological 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 motive of treating the patient.

By *co-constructive* collaborative activity is meant interactions in which the actors focus on re-conceptualizing their own organization and interaction in relation to their shared objects. Both the object and the script are re-conceptualized, as is the interaction between the participants [9]. At this level of collaborative activity the object of work is not stable – or is not even existing – and therefore has to be collectively 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 the objective still relevant or has the whole activity become obsolete?”

Transitions to the co-constructive level of collaboration are seldom in the ongoing flow of daily work actions [9]. 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” at one of the hospitals involved in the project, the patient treatment and care was 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.

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-ordination, co-operation, and co-construction are *analytical distinctions* of the same collaborative activity. This means

that an analysis of even the most routinized work, seemingly only realized as coordinated 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 some common object through cooperation. There are examples of work actions that seem totally without purpose and without any reasonable objective – for instance, filling out forms in a bureaucracy. But this does not mean that the levels of cooperation 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. To fully analyze a cooperative work activity, we therefore need to look at it from a *cultural-historical perspective* in order to reveal its different components and how the common object, the means for work and the use of these means are established within a community over time.

### 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 caused by reflections on the means for doing the work or reflections 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-embodiment of the resolution in the lower level. The dynamics are illustrated in figure 1.

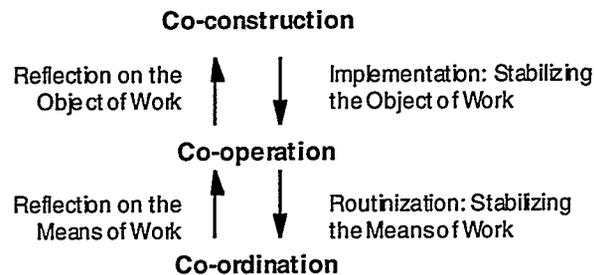


Figure 1: The Dynamics of Cooperative Work

*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 breakdown* 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), done merely based on the information written at the requisition. In some problematic cases, however, a closer cooperation between the physician and the radiologist was necessary in order to establish exactly what kind of radiology examination would provide the best means of establishing a exact diagnosis.

*Routinization* works in the opposite direction by re-establishing co-ordinated work where the means for col-

laboration 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 coordinated flow of routinized work.

*Reflection on the object of work:* Co-ordinated and cooperative 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, 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 re-conceptualize 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. This implementation process stabilizes the common objective of the activity. For example, the degree to which the individual physician should attend to the social background of the different patients 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.

### The Role of Theory in CSCW

After having presented these basic tenets of AT, we are now equipped with some analytical concepts, which can help us address the core questions raised in the beginning of the paper. We have expanded our concepts on cooperative work to include co-ordinated as well as co-constructive work, and we have provided concepts for analyzing and understanding the dynamics inherent to cooperative work, including breakdowns.

But before turning to the hospital case, it might however be appropriate to shortly discuss the role of theory within a design discipline, such as CSCW. Activity theory views theories (including itself) as special kinds of artifacts (c.f. [18]). This implies 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 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 aim of the rest of the paper is to demonstrate, that the framework has helped inform the analysis and design made within the hospital project, and hence hopefully can inform other design endeavors as well.

### THE SAIK-PROJECT

Due to the centralized and specialized nature of modern medical work, one of the main problems within Danish hospitals today is to coordinate distributed patient treatment. The purpose of the SAIK<sup>2</sup> 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 coordination can be supported by computer technology. The PATIENT SCHEDULER (see figure 3) is a prototype that illustrates how work within a hospital can be coordinated by computers within and between departments. The methods for data collection involved workplace studies based on traditional qualitative methods; qualitative interviews, participative observations of daily work at the hospitals, and studies of different documents, records and other tools (c.f. [19]). 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 5 hospitals. Two of these hospitals were incorporated in the participatory design process of the PATIENT SCHEDULER, applying techniques such as future workshops, cooperative prototyping session, and organizational games (c.f. [10]).

The following analysis of the dynamics in work is based on investigations of, and design in cooperation with, 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 a planning office. At U the PATIENT SCHEDULER (PS) was designed to support the planning and scheduling of operation, and to support the request and booking of examination at other departments, e.g. at radiology and at different laboratories. For each operation a *patient appointment* is made in PS, to which is allocated different *resources*, such as a surgeon, a team of nurses, an operating room, etc. For each resource a *calendar* can be shared among different users with different levels of access rights. If certain types of appointments are made frequently – for instance a certain type of operation – an *appointment template* can be made, saved, and reused in later cases. These templates can be combined into a *program*, which is a collection of templates needed in a particular treatment. A program can for instance consist of the necessary radiology examinations, the operation itself, and subsequent intensive care treatment. When the schedule has been made it can be used in the coordination of work at the surgical clinic and different status colors can

<sup>2</sup> SAIK is a Danish abbreviation for “Collaborative Informatics in Clinical Practice.”

be attached to each operation in order to reveal the state-of-affairs for each operation. PS also supports easy re-scheduling if changes to the plan have to be made during the day.

### ANALYZING THE DYNAMICS OF COLLABORATIVE ACTIVITIES

In this section we shall analyze the highly cooperative activities surrounding the operation of a patient based on the framework presented above. We shall not focus on the activity of operating a patient as such, but concentrate on the activities, which ensure that the operations can be successfully achieved – such as planning, scheduling, synchronization, and coordination of the numerous actors involved in the operations. The section seeks to show how the presented framework can inform the analysis of cooperative activities, by conceptualizing, and thereby identifying, different aspects and dynamics of cooperative work.

We shall analyze three important examples of the dynamic transitions between the levels of a collaborative activity. The examples are labeled A, B, and C and are illustrated in figure 2.

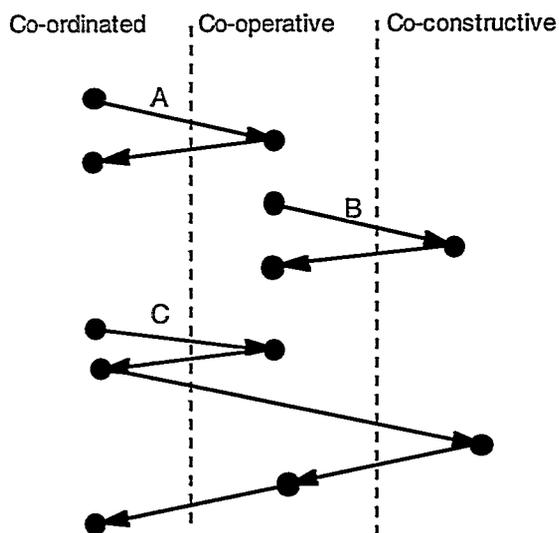


Figure 2: Examples of Dynamic Transitions

#### A: Transition from co-ordinated work to co-operation and back

The routine flow of operations at U is co-ordinated based on the operation schedule, which reveals which patients to operate when, where, and by who (i.e. surgeon, anesthesiologist, and scrub nurses). Based on this schedule, the head nurse is responsible for synchronizing the different operations and the actions involved in each. For instance, ensuring that the patient, the anesthesiologist, the surgeon, and the intensive care unit are “ready at the right place at the right time”. This coordination is extremely important, ensuring that the operations are done in a continuous rhythm, leaving the surgical staff in the operating room to concentrate on the operation itself.

However, during the day unforeseen difficulties and constraints arise – e.g. complications during an operation, patients not being ready for operation, and illness among

staff. Such co-ordination breakdowns imply that relevant staff engage in a co-operative problem solving activity trying to accommodate the problems. When a solution to the problem has been reached it is routinized back into the normal co-ordinated flow of work. This is typically done by re-scheduling the operations, creating a new schedule to be used as a coordinator, or is done by re-allocating e.g. scrub nurses to other operating rooms.

The creation of the schedule is done by the “operation planner” (a secretary), who schedules 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. The operation planner schedules a suitable time for the operation, taking into consideration all the constraints that have to be considered in the different cases; e.g. ensuring a vacant bed at one of the wards, that the appropriate radiology and laboratory examinations can be made in time for the operation, and finding a time for the operation according to the surgeon’s other commitments. Hence, normal planning of operations takes place as co-ordinated work where both the means for work and the object of work is stable. The object of work is stable in the sense that the operation is prescribed via the referral letter. The means are stable in the sense that a strict division of work among departments, occupational groups, and individuals exists: there are fixed rules and norms for how to schedule certain types of operations and to put others on the waiting list, and standard artifacts exist to mediate this scheduling (the operation book, the telephone, etc.). In these routine cases the operation planner could 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 are 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 type of cooperation has been institutionalized within U in the so-called “Wednesday meeting”. Here the head surgeon in charge of scheduling operations, the head nurse of the wards, and the operation planner meet once a week to co-operatively schedule all the ‘hard cases’ that the operation planner has not been able to schedule on her own, and any free time-slots are filled in with patients from the waiting list.

#### B: Transition from co-operative work to co-construction and back

Because the surgical staff needs to concentrate on the operation, transitions to the co-constructive level of collaboration are rare in the daily flow of operations – the surgeon and the nurse do not start questioning the purpose of operations while the patient is on the table! However, transitions to co-construction did happen occasionally at the surgeons’ morning conference. The morning conference at U was the primary place for co-operation among the surgeons, and between the surgeons and the radiologists, who participated in the conference. The cooperation was pri-

marily focused on the different operations and patients, but also more general concerns for the way the work was done at U were addressed. And sometimes this was questioned loudly. For example, the distribution of available operation rooms among surgeons gives room for conflicts, because their professional career is closely connected to the operations they are performing. Also the issue of lack of resources at radiology was often raised (the radiologist being there) with the arguments that the cost of a simple radiology examination is incomparable with the extensive cost of postponing an operation. Radiology was asked to rearrange their allocations in order to comply to the demand for examinations.

The resolution to such co-construction of the object of work has subsequently to be implemented in the collaborative activity of scheduling operations. Hence, if U managed to get more radiology resources allocated, this allocation was to be incorporated in the operation planner's scheduling tools (the booking book and her knowledge of available resources at radiology). It is often also the case that such allocations are dedicated to special operations, or even surgeons, and this decision similarly needs to be implemented in the collaborative work of scheduling. Similarly, the operation planner needs to know the distribution of operating rooms among surgeons.

### **C: Expanding co-ordinated work through co-construction**

A frequent complaint from the scrub nurses was that the operation schedule was too optimistic. Caused by the inevitable contingencies arising in such delicate work, operations often took longer than scheduled, hence leading the surgical team to work overtime. This turned out to be a bigger problem for the nurses than the surgeons, the former having a more rigid segmentation between working and leisure time (c.f. also [24]). This problem was well-known within the department, and before our investigations were initiated, several attempts had been done to cooperatively settle these problems. Especially the Wednesday meeting was a forum for this cooperative effort into making more 'valid' schedules. The problem nevertheless persisted. As a part of the participatory design process in the SAIK project, we therefore initiated a co-constructive workshop with the purpose of addressing this particular problem [4]. This workshop revealed several rather deeply rooted problems that lead to the overall problem of too optimistic schedules. For example, the fact that neither of the persons involved in the Wednesday meeting ever actually saw how their schedules were carried out, and the lack of institutionalized channels of feedback to the scheduling team and the operation planner, were identified as fundamental causes of the problem. Moreover, the problem was deeply rooted in the department's organizational culture and politics. Hence, the surgeons' conception of the job of the operation planner was that she was planning "on behalf of them" and that she therefore primarily had to comply to their concerns. Furthermore, each surgeon was allowed to schedule "his own patients", which often was done without the necessary understanding of the overall picture, again

leading to too tight schedules. An often heard phrase was that a "patient needed to be squeezed into the schedule."

These problems were identified during the workshop and solutions were constructed and decided upon. For example, in the future the head nurse from the surgical clinic was invited to the Wednesday meetings too, and the operation planner was to be moved from the secretariat to the clinic, in this way being able to see how "her" plans actually played out. Moreover, a new organizational rule was established: no one was allowed to schedule operations after a 'one-week-deadline' on their own, but had to consult the operation planner, having her to do it. This rule, however, was bound to fail if it was not implemented correctly; a surgeon does not take orders from a secretary. Therefore, a considerable effort went into a cooperative implementation of these new ways of scheduling operations, involving all relevant personnel. After this co-operative effort, the new way of scheduling was to be routinized into new standard ways of scheduling, and the operation planner had to become accustomed to sitting at the highly hectic clinic rather than in the more silent secretariat.

A point to be emphasized in this example is that even though this co-constructive collaborative effort might seem removed from the scheduling itself, it becomes essential to view it as a part of the same activity, exactly because it helps us improve the scheduling activity. And helping improve collaborative activities (also by applying computer technology), is definitely a goal of CSCW.

### **DESIGNING FOR THE DYNAMICS OF COLLABORATIVE ACTIVITIES**

The first and foremost conclusion to be drawn from the present understanding of collaborative work activities is to design for supporting the different levels of collaboration, and design for supporting the dynamic transformation of the work between the levels – once identified.

Communication is the primary way in which collaborative activities are accomplished by humans in a social setting, whether focused on coordination, cooperation, or co-construction and re-conceptualization. This explains that computer-based communication technology – such as electronic mail and conference systems – is the most successful category of CSCW application to date [11]. However, problems with communication technologies do emerge. Robinson [20] notes that the main complaint against the Coordinator has been that it seems to exclude negotiation, or – to put in our words – that it does not support a transition to the co-constructive level of collaboration.

However, the object of work is often not solely communicative; work cannot be achieved by just talking about it. Therefore, computer technology needs to support both the instrumental as well as the communicative aspects of work – both the 'doing' and the 'talking'. Hence, the second conclusion to be drawn is to integrate support for different levels of collaboration within support for the object of work as such. These two conclusions can be illustrated by some examples taken from the PATIENT SCHEDULER. Figure 3 shows a screenshot.

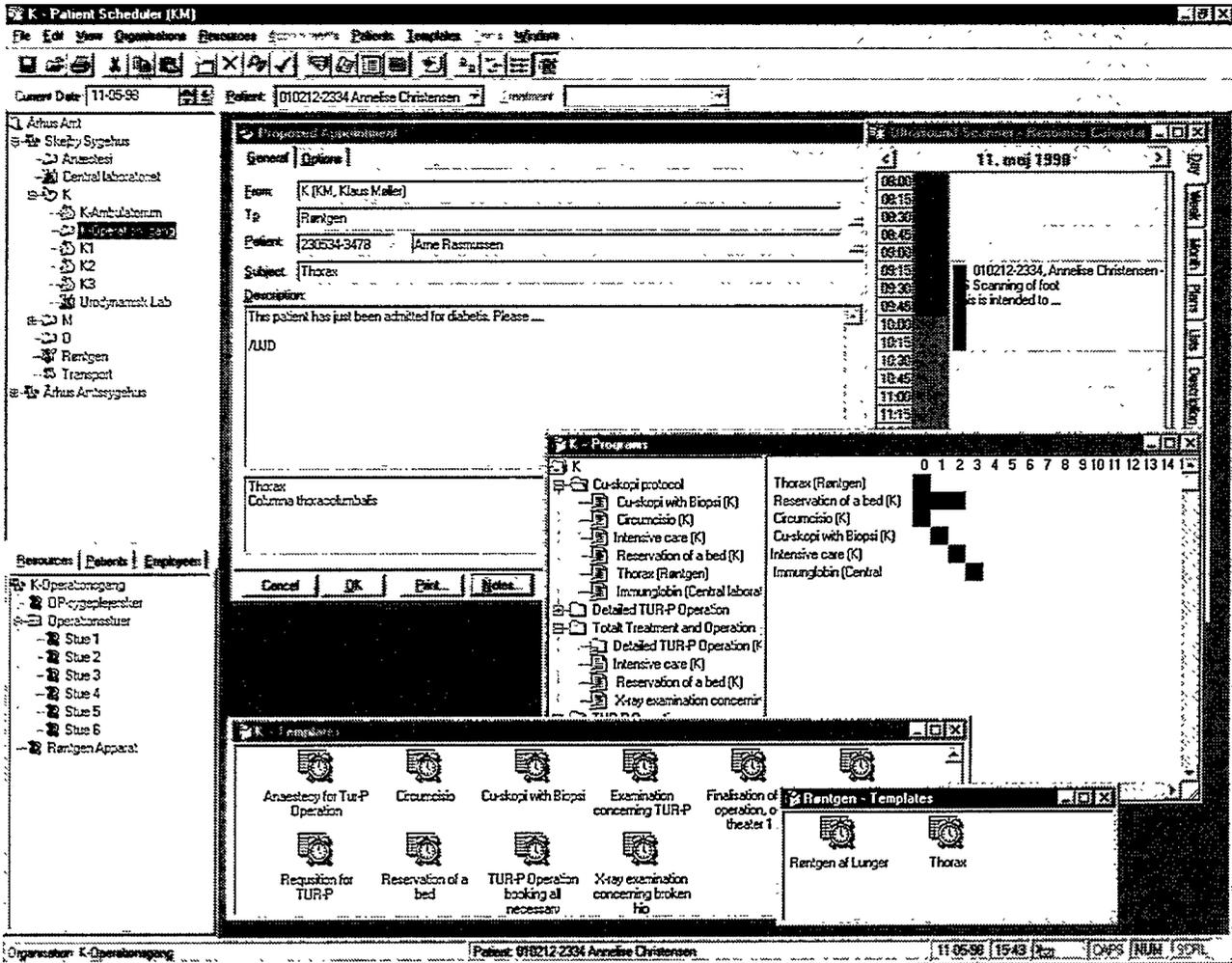


Figure 3: The PATIENT SCHEDULER. 'K' is a surgical department, and 'Røntgen' means Radiology.

### Coupling communication with the object of work

Initially the PATIENT SCHEDULER only supported the creation of one operation plan, which implied that the plan could not be changed during its execution – i.e. during the operations. However, based on the analysis of the dynamic re-scheduling of operations due to diverse contingencies arising in the work (see example A), this design had to be changed. Therefore, the PATIENT SCHEDULER was re-designed to support the transition to the co-operative level of coordinating the operations by allowing ad hoc re-scheduling during execution. Furthermore, support for asynchronous communication through message notes was introduced into the design as a way to communicate to others the need or reason for changes to the plan.

Example A also described the case of the operation planner and the surgeon engaging in a co-operative effort aiming at finding a satisfactory operation plan for a patient. One of the main problems at U was that when the operation planner got stuck, and hence needed to cooperate with the surgeon, the surgeon was often operating and thus inaccessible. Asynchronous communication, as in electronic mail,

would be a solution to this problem. However, after some initial experiments with using the notes as email, this suggestion was abandoned; notes detached from the concrete case, as described in the referral letter and other relevant documents, simply did not provide enough information to foster any cooperation. The notes in the PATIENT SCHEDULER were hence extended to be attachable to the different cases and operations. Of course these notes did not influence the accessibility of the surgeon, but they did provide a more flexible way of coupling communication with the case in question (i.e. the object of work).

### Cooperation through sharing the object of work

The main prerequisite for engaging in cooperative problem solving is to share the objects of work, as e.g. illustrated in the hospital kitchen example. Basically, the PATIENT SCHEDULER has been designed to support sharing as much as possible. By sharing their resource schedules radiology gives the surgical department an opportunity to cooperatively plan their operations not only according to their own concerns, but also according to the distribution of exami-

nations at radiology. Similar with other departments. Consequently, by sharing resource schedules, U and radiology has the shared basis for establishing a more optimal (in the sense optimal for both parts) plan through cooperation and communication.

In a similar way the operation schedule used in the coordination of work at the clinic can be shared. This makes for considerable ease in the daily cooperation among the many people involved in operating patients. By just monitoring the progress of operations, as evident in different status colors and changes to the schedule, the distributed staff can coordinate their work according to the operations, i.e. according to this representation of the object of work. Hence, the ward can start preparing the next patient for operation when they see the previous has been marked 'finished' on the schedule and the surgeon can see when the patient has been anesthetized and postpone his entrance to the operation room till then.

#### **Supporting co-construction of the object of work**

Analyzing the activity of scheduling and coordinating operations 'all the way up' to the co-constructive level (example B and C) also helped us initiate design actions directed towards supporting this level. This was, however, not at all trivial. It quickly turned out that supporting co-constructive activities – answering question concerning the overall objectives of operating patients in Denmark – were out of the scope of the project. However, what could be designed for was to provide input to such co-constructive activities. One of the main problems of 'invalid' operation schedules (see example C) was the lack of some accurate information on the average duration of an operation according to the involved staff, especially the surgeon. Therefore, the discussion involved in the co-constructive workshop became meaningless without just some sense of valid information on the object of work, i.e. information on how much delay each operation had compared to the schedule. Hence, an important feature in the design of PATIENT SCHEDULER was to save both the schedule and the actually completion of the operations, which later provided the data for making comparison and statistical information on average operation time, etc.

This example hence illustrates the importance of incorporating a concern for the three levels of any cooperative activity in the design of CSCW technologies, even though they might not be supported as such.

#### **Supporting 'downward' transitions between levels of collaboration**

The examples above show how the PATIENT SCHEDULER supports the 'upward' transition between the levels of collaborative activity. However, supporting the 'downward' transition – i.e. implementation and routinization – is equally important. A particularly severe difficulty at the hospital, and one of the reasons for the recurrent nature of some of the presented problems, was to implement the decisions made in these co-constructive sessions. In the co-construction of the cooperation between U and radiology (example B), there is a need for implementing the allocations decided upon, and in the example of co-constructing

the scheduling activity towards more 'valid' schedules (example C), there is a need for routinizing the new scheduling practice. The PATIENT SCHEDULER supports the former through timeslot allocations on shared resource calendars, and the later through the creation and use of templates and programs for operations. Hence, when an allocation of radiology examinations to U has been decided upon, this decision can be implemented in the PATIENT SCHEDULER, and the operation planner and the surgeons can start using these allocations without the tiresome negotiation with radiology in each case. Creating a template for an particular operation for a particular surgeon helps routinize the creation of fair schedules, because the template reveals (among other things) the average time used by this particular surgeon to perform this particular operation. This can of course be changed if the surgeon and the operation planner co-operatively decide that more or less time is needed in a concrete case.

#### **CONCLUSION**

This paper has argued for the need for addressing the dynamics of cooperative work and provided a theoretical solid framework for doing so. This framework identifies three basic levels of any collaborative activity – coordinated, co-operative, and co-constructive collaborative activity – and the dynamic transitions between these levels in terms of reflections and/or breakdowns, implementation, and routinization. The paper has argued that this framework helps conceptualize, and thereby analyze and design for cooperative work and its inherent dynamic nature. This point was illustrated through an empirical case of designing computer support for coordinating surgical operations within Danish hospitals. The framework helped us understand the dynamic nature of cooperative work, and to design computer systems, which view cooperative breakdowns not as a problem but as an important aspect of all work and therefore as an important resource in the design of such technologies.

The two main conclusions concerning design of computer support for cooperative work are to (i) support collaborative work activities at all three levels, and the dynamic transition between the levels, and (ii) integrate this support for dynamic cooperation in the support for the object of work. Hence, support for co-construction of the planning and scheduling activity at department U should be integrated in the support for scheduling and planning as such.

A final conclusion to be drawn from this conceptual understanding of cooperative work and the presented study in the hospitals is that external intervention from e.g. action researchers or consultants can provide the platform for a development and co-construction of a working community. Moreover, the design of computer systems supporting some particular work-practice within an organization is essentially a co-construction of that work practice, and demands, as such, a concern for implementing and routinization to be viewed as a part of the same design effort.

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