

# Collaborative Workspaces for Time Deferred Electronic Cooperation

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## ABSTRACT

This paper proposes collaborative workspaces as an electronic environment for time deferred team-like cooperation. The design requirements are derived from an investigation of work practices employing simple collaborative workspaces in ministerial units. In addition to facilities for sharing of material among a dedicated group, a collaborative workspace needs to provide appropriate behavior and awareness information to support cooperation. A concept for the technical realization proposes CSCW enablers to allow flexible adaptation of collaborative workspaces to different purposes and to changing user needs.

## Keywords

Collaborative workspace, sharing, asynchronous cooperation, awareness, electronic behavior setting, CSCW enablers

## INTRODUCTION

Increased computer networking enables the interaction of geographically distributed partners. From practical experience we are convinced that the major advantage of electronic cooperation lays in its potential to allow for time deferred and distributed cooperation, since this relieves the partners from making complicated arrangements for meeting dates etc. However, being at the same place at the same time is basic to intuitive human cooperation habits and coordination abilities in the real world. This holds in particular for more informal and team-like cooperation.

Rather than modeling the cooperation process itself—as workflow systems would do—our intention is to provide a common electronic work environment. This environment should allow partners to coordinate the progress of their work as if their were in the same room—albeit at different times—rather than geographically distributed.

We call such a cooperation enabling electronic environment a „collaborative workspace“. It allows the participants' equal access to the objects of cooperative work as required for team-like cooperation. It intends to facilitate weakly

structured long-term cooperation processes in which coordination is done implicitly; the processing sequence is to result from the course of the participants' actions. Typical examples of processes that can be supported by collaborative workspaces are the joint authoring of texts, the coordination of document production (e.g. for the joint design of an object, simultaneous engineering), the collection of contributions, or the joint drafting of a proposed decision in a ministry.

In this paper we look at work practice from the designers' perspective with the aim to learn which kind of technical facilities are helpful or necessary to enable collaboration. For this purpose, we have studied users in two real work environments in two German ministries. We have introduced to the users a simple technical realization of the basic facilities of collaborative workspaces and want to find answers to the following questions:

- Do collaborative workspaces, which allow electronic sharing of material among a dedicated number of people, provide a useful cooperation environment?
- What is needed beyond shared access to material to stimulate the social mechanisms needed in collaboration?

With this work we would like to contribute to the understanding of user needs in time deferred collaboration processes<sup>1</sup>.

This paper first introduces the idea of collaborative workspaces. The second section reports about the experiences made in ministerial work practices, focusing on what we learned from practical use. The third section discusses design issues for collaborative workspaces based on these findings. In the last section we propose a technical solution which allows the flexible construction of collaborative workspaces and their adaptation to specific working modes of users.

## BACKGROUND OF THE WORK

Electronic collaborative workspaces are intended to allow cooperation in smaller groups (approx. 5 to 10 persons).

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<sup>1</sup> In literature mostly the term “asynchronous” instead of “time deferred” is used. However, we prefer the latter one since it addresses the matter more explicitly.

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Like a real room, a collaborative workspace is to be recognizable as an action environment: it should stimulate the wanted action and behavior; the responsibility for coordination of their actions is left to the present actors and is not delegated to or prescribed by system facilities. In addition a collaborative workspace must allow its participants to perceive and produce all what is relevant for the intended actions.

### Electronic Collaborative Workspaces

A collaborative workspace must provide the material which are subject of cooperation to the collaboration partners (cf. Fig. 1). Thus we need an electronic sharing mechanism which allows to explicitly define the partners of sharing and gives access to the material. Since in most cases the cooperation partners need access to several objects, a collaborative workspace needs to provide facilities to administer many objects. In order to interweave the actions of the collaboration partners, any modification of material must be made recognizable to others.

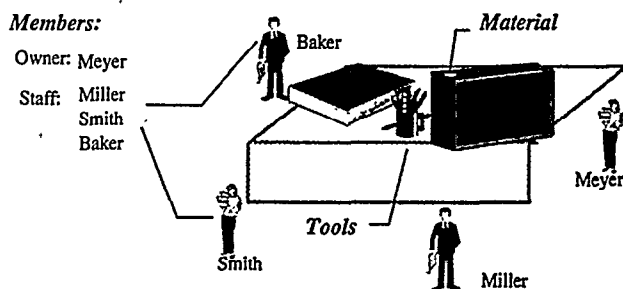


Figure 1: Elements of a collaborative workspace.

### Available Means for Time Deferred Cooperation

In the following we will see which support for time deferred work is already available. Ellis et al. [9] distinguish three categories of cooperation support functionality: communication-enabling functionality, coordination-supporting functionality, and functions allowing the shared usage of common material.

Communication in time deferred environments is provided by e-mail, computer conferences, WWW (World Wide Web) etc. They support the explicit exchange or provision of explicit verbal information.

For the time deferred coordination workflow systems are available and used in practice. Swenson & Irwin [22] give an overview on workflow systems. In contrast to collaborative workspaces, these systems model the process itself and solve the problem of coordination through prescribing the order of actions. They are suitable mainly for frequently recurring routine administrative procedures but not for team-like processes for which the prescription of the course of actions may not be adequate.

A concept of sharing helps to overcome spatial distances. This is provided through databases or directories which may be shared by different users. In practice, the WWW has become a very intensively used medium to disseminate and access information world wide. These techniques allow several people to access the same material. However, they do not support to recognize who else uses the same material. Thus they provide only very limited support for cooperation and none for coordination.

Collaborative workspaces extend sharing facilities and enable coordination and cooperation. For example, the BSCW [4], a collaborative workspace system, provides special purpose collaborative workspaces for time deferred joint editing and filing on top of the WWW.

### EVALUATION AT WORK

Based on our knowledge about the development of a basic concept for collaborative workspaces called GroupDesk [1] we wanted to evaluate its applicability in practice and to investigate the requirements for further development. The POLiTeam project allows us to do this evaluation in work practice of ministry workers. The present section reports on this experience. First, the conditions given for the design process in the POLiTeam project are outlined. Then the technical realization is briefly described. Following this we will report the results beginning with examples from practical use, how the user rate it, and ending with proposals for design improvement we received from the users.

### Preparation

The POLiTeam project started in 1994. The goal of the project is to understand the needs of ministry workers for the support of electronic cooperation and to develop adequate systems. The POLiTeam approach allows user requirements to be articulated through an actual use of a system in practice as Kyng [15] requires for CSCW systems. Further system design is based on these requirements.

The basic features of POLiTeam are provided by an existing groupware product, namely LinkWorks [7]. Metaphors chosen from office environments are applied to name the items offered. Thus POLiTeam provides each user with a private electronic desk. Folders, drawers and cabinets may be used to organize private material on the desk. For the support of group work POLiTeam provides e-mail and electronic circulation folders, the latter allow to distribute a folder according to a predefined route.

For the realization of simple collaborative workspaces we use the sharing facility of LinkWorks. From containers including their contents or from single documents shares may be created and distributed to those POLiTeam users who should become collaboration partners. These shared objects appear on the desk of each partner and may be handled just like private containers or documents. The sharing property is indicated through a dark blue line under its name (see figure 2). However, when introducing these facilities to the users, we used the term „collaborative workspace“ and introduced it as a means for cooperation.

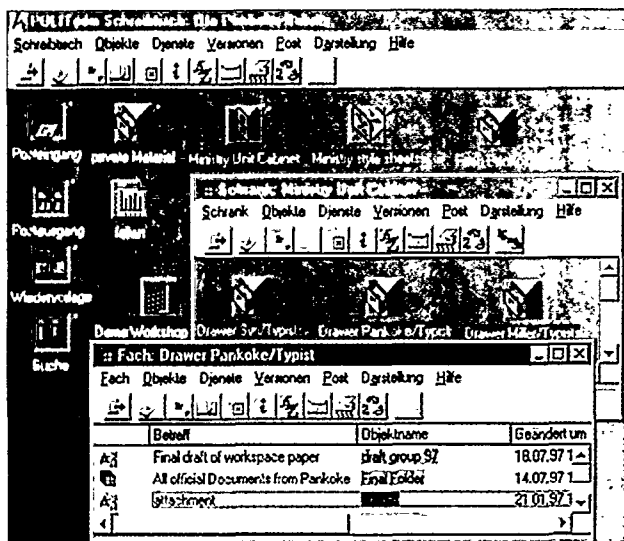


Figure 2: Private desk and collaborative workspaces.

### Evaluation through Interviews

Before introducing the system itself we conducted interviews with the users to find out about their work practice and their expectations. The staff of three selected units in a federal ministry and the whole staff in the Landesvertretung (State Representing Body) of a state ministry are using the POLITeam system (now in total about 50 persons). The task of a unit in the federal ministry is to prepare policy for senior citizens. The units in the Landesvertretung have the task to represent their state in the Bundesrat (Federal States Council).

In order to allow the reader to understand the work practice in which collaborative workspaces are used and evaluated, we first explain what we learned about the specifics of ministry work. In ministries the work is organized according to the Common Rules of Procedure of the Ministries (GGO) [16]. The rules prescribe a schema of distributed hierarchical responsibility. Work is assigned down the hierarchical lines to the responsible unit. Subsequently a responsible staff member prepares a proposal for a solution and collects the necessary material. This proposal is discussed with the unit leader before it is passed, commented, and approved along the hierarchical line. All work is to be documented on paper. The interviews with the users confirmed, that they are all aware of these rules for formal collaboration and know the procedures they are supposed to follow. They consider themselves being part of the process and contribute, but not as being collaboration partners. This even leads to the feeling of "we are not cooperating" as one ministry employee reported.

In interviews, we proposed the basic features of the system to the potential users and asked to specify their expectations of IT support. Most of the interviewees had no experience with computers. They could well imagine having an electronic desk and using electronic mail. They expected electronic circulation folders [19], enabling the forwarding of documents along a specific path through the organization, to be helpful, since it maps very well with their formal

cooperation habits and the GGO. However, they did not think collaborative workspaces could be of any use for them. Our explanation for this finding is twofold. First, jointly processing of the same material, although the participants are at different locations and operating at different times, have no analogy in the real world. Second, collaborative workspace facilitate informal cooperation and the users in the ministry are not aware of their informal collaboration as the above statement confirms.

Despite this discouraging results, we wanted to explore in practice whether the simple collaborative workspaces may be useful and how they should possibly be improved. During the training of POLITeam in spring 1995 the sharing facilities were explained and trained as well as text editing, working on the individual desk, using e-mail, and electronic circulation folders. Shared drawers and cabinets were introduced as collaborative workspaces.

### Collaborative Workspaces Used in Ministry Units

In the following, we will outline, how POLITeam was used at the users sites and what we learned about collaborative workspaces in practice.

*Methodology:* Intensive active user services provided by so called user advocates [18] allow us to watch users at their work practice with the system. User advocates regularly visit the user sites every two weeks, asking how things are going and help and advise users. This method to evaluate system use could be considered as an ethnomethodology [5] adapted to the use of a technical system. It allows to get an inside view and requires to learn about the users' problems in practice. In addition, user workshops were held twice per year to discuss, with the users altogether and with the designers, the experiences made with the POLITeam system. Furthermore, the users were interviewed individually after four months of usage and again one year later. The majority of the findings, presented in the following, result from the site visits and the user workshops. However, they were confirmed during the interviews.

### How are Collaborative Workspaces Used?

Surprisingly, from the very beginning in both participating ministries the sharing facilities were used intensively for organizing their work and their collaboration. In the following, we will outline the most typical applications of collaborative workspaces in the field.

*Organizing joint text production and archiving:* Joint text processing in a unit in collaboration with the typists office is organized with POLITeam in the following way: For each staff member a separate shared filing drawer was installed and shared with the typists office and the head of the unit. The users have established a convention to put all texts into these drawers which are to be worked on by both, the typists office and unit members. In most cases the name of the drawer indicates the owners of the shares (see fig. 2). Both, the typists and the owner have the drawer on their desk and may work on any document it contains. In general, the initial text entry is done by the typists office which moves the text into the staff member's shared filing drawer. Thus

the document is now available to the staff member, who may revise and edit it. The unit head, who can access the shared filing cabinet which contains all the drawers, can then comment on or edit the document. Cooperation between unit staff, head of the unit and typist office is thus facilitated through these shared drawers and cabinets. Further processing along the hierarchical lines is then done, as before, using a paper copy, on which comments, annotations and signing according to GGO will take place.

*Fast collection of reports:* The users create task specific shared documents for preparing the position statements for the next plenary meeting. For each of about 80 topics on an agenda, the brief reports of about 10 to 15 subcommittees have to be collected within only two days. For each plenary, one folder is created by the responsible staff member. For each topic of the meeting the staff member creates an extra document (a form) containing the issue, and an extra line for each affected committee. Shares of this document are distributed to all staff members responsible for supplying the reports from the committees they attended. When all the reports are completed for all the topics, a copy of the folder is e-mailed to the responsible unit leader who is then forwarding it via e-mail along the hierarchical lines in the ministry.

#### *How Do the Users Like Collaborative Workspaces?*

The shared filing cabinets and the shared filing drawers are heavily used and accepted by both, the staff members and the typists.

*Reports from users:* The shared drawers facilitate their cooperation considerably, they understand it as a means to prevent multiple parallel versions to occur and thus, it reduces coordination effort. The *unit members* appreciate, that they are now able to make text corrections themselves. This saves a lot of transportation time to and from the typists office. The *typists* find the collaborative workspace superior to the use of e-mail for the communication of text files since they are now sure, they have access to the most recent version of the document in the collaborative workspace. This relieves them from searching for the actual version of a document at various places. The production of the final version of a document, including all hand-written annotations made on its way through the hierarchy, is therefore much easier now.

The POLITeam users report, that the collection of reports from the committee meetings is now improved considerably. The reports on the topics may be contributed in parallel, this relieves the responsible staff member from phone calls to all involved staff members and reduces the stress caused by the tight time schedule. In addition, it is considered as an advantage, that every one involved may see the reports of the others and may provide written comments on their reports. In particular, the tight time schedule could be easily met with the shared objects. Although this is a routine procedure, repeated every three weeks, workflow systems prescribing the sequence of actions would not be an adequate tool.

*Proposals for further applications:* An expansion of the system into a ministry as a whole may lead to more complex applications. To this end, the users proposed to use collaborative workspaces whenever a group of people needs to work or contribute to a particular task. These groups may span across hierarchy and across departments. For example, in case of the preparation of a reply to a parliamentary request, a collaborative workspace will be helpful to coordinate the contributions from several departments required for the preparation of the answer. As another example, the users have proposed, to use collaborative workspaces to support ministry internal work groups in which people from different departments and in different hierarchical positions are participating. The users suggested to combine the use of collaborative workspaces with circulation folders used for the approval of a proposal along the hierarchical lines.

*Collaboration between the directors and their secretaries:* The tight cooperation between the secretary and the director requires to keep both informed about what goes on in their office. However this is difficult to guarantee when introducing PCs in their offices. To this end, a collaborative workspace could help, which is shared between the secretary and the director. Both may file all non private documents into this collaborative workspace. However, much more is requested. For example, they want mail-inbox and mail-outbox, agenda, and calendar to be collaboratively usable as well. This example gives evidence, that the behavior of a collaborative workspace may become quite complex and needs to be adjusted to the specific purpose it should support.

#### *How Should Collaborative Workspaces be Improved?*

*Private spaces vs. Collaborative spaces:* The users clearly differentiate between their private space on their *desk* and the collaborative space in the shared containers. As one user said: "My desk is my private space, nobody knows what I am doing here. But the shared containers are public, when I do something there, I want the others to know." This implies they want to know who the others are and they want to be sure, that the others may be aware of what is going on. In fact, they have explicitly asked for more differentiated member administration tools and for the provision of awareness information.

Their work practice reflects this differentiation between private and collaborative spaces. When they want to edit a piece in a shared container, many of them move the object from the container onto their desk, open it there and when they finish editing they move it back into the shared container. Thus they keep their mode of editing private.

*Awareness information:* For letting the others know what they were doing, they have claimed for automatic provision of awareness information about the actions in a collaborative workspace. For example, in the case of the collaborative workspace for joint editing they want to be informed, when the typist office has finished editing of a text they were waiting for. In case of the collection of reports they want to be informed, when the voting list is

completed etc.

**Conventions for collaboration:** The users regularly ask for meetings to organize their work and to discuss and agree on conventions for the use of their collaborative workspaces. Typical examples for conventions that came up in a workshop were the agreement of a naming schema which allows to uniquely identify the contained documents. Another convention was agreed for organizing the documents in the collaborative workspaces. In general, conventions address the purposes of the different collaborative workspaces, define which objects are to be stored where, how to handle the contained objects.

In the course of using the collaborative workspaces, the conventions were modified and adapted according to the improved understanding of the collaboration process and according to the changing needs. However, although agreed by all cooperation partners, conventions were only followed if they do not cause extra work or when one immediately benefits from it. Consequently the users proposed to have the collaborative workspaces facilitating—but not enforcing—the associated conventions whenever possible.

#### *What Did we Learn?*

The observation of the practical experience during more than two years of usage as well as the user responses confirm, that the users accepted collaborative workspaces. In fact, they became the basic means to support the more informal cooperation on the level of units. In particular, it is useful for joint production processes. It is important to note, that the POLITeam system provides e-mail and circulation folders as well and that the users may combine these tools. However, for the tasks described they preferred collaborative workspaces. We have seen, that the organization of the collaborative workspaces reflects—to some extent—the different ways of organizing their work. Collaborative workspaces have not been used as a pure source of information but as containers for the material to be worked on collaboratively. From this experience, we learned, that collaborative workspaces are useful for medium term cooperation of a group of people where the hierarchy does not matter and where the ordering of tasks is not prescribed.

The users have risen a number of requirements which all give evidence that sharing is a precondition but that in addition social issues have to be considered for the design of collaborative workspaces. In particular an explicit management of membership is urgently needed, the support of awareness is required and flexible facilitation of conventions in collaborative workspaces is requested.

#### **SYSTEM REQUIREMENTS AND DESIGN**

In the following we will discuss the design issues of collaborative workspaces in order to enable more complex collaboration processes. We will base these considerations on what we learned from the users. In addition we use the metaphor of a room to guide the design of collaborative workspaces. Like architects constructing buildings focus on both, technical feasibility and the social needs of its future occupants, we are constructing electronic collaborative

workspaces under the same aspects. Since our building material is electronic, we need to abstract from what is given materially in a non electronic room, and understand its social facilitation properties and try to transcribe that into the electronic environment.

In psychology, a room is looked at as a behavior setting for cooperation and that associates behavioral conventions [2]. The room through its appearance may associate and support certain expectations and conventions and it may fit a particular purpose, like a meeting room, a theater etc. As Friedrich [10] stated, the spatial structure of an environment is the expression of social structures and vice versa. In particular, a room facilitates *non-verbal communication* which is important for the mutual understanding of the partners and for smooth communication and cooperation [24]. Thus collaborative workspaces have to provide facilities to allow the participants to “communicate without words”.

In practice, a room is seen as some passive environment. However, if we would like to use “room” as a model for the development of an electronic collaborative workspace, we have to pay special attention to the physical properties with particular attention to spatial and temporal aspects [17]. Basically, what is considered a passively given property of a room needs to become active on the side of collaborative workspaces to overcome spatial and temporal distances. We will call these active properties the “behavior” of a collaborative workspace.

#### **Behavior of a Collaborative Workspace**

The building blocks of a collaborative workspace are the *members*, the *material* to be worked on, their *arrangement* and the *tools* used to work on the material. It is the *behavior* of a collaborative workspace which enables the members to coordinate their actions and which facilitates *awareness* of the collaboration process.

The behavior of a special collaborative workspace must support the particular *purpose* it is used for, the *conventions* the users have agreed on for its use, and the *expectations* the users should share about the process that will take place.

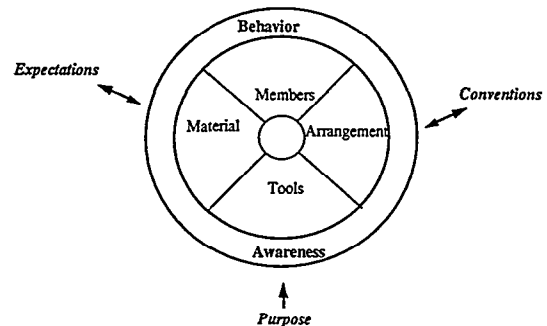


Figure 3: Design factors for a collaborative workspace.

#### *Equal Behavior and Appearance to All*

A basic requirement is, that the behavior and the appearance of a collaborative workspace is the same to all members,

like a room appears the same to all those present. This allows the partners to develop *expectations*, from their own use, how it appears to the partners. In particular, members should be enabled to recognize from the constitution and from the behavior of the collaborative workspace what they may possibly see from each others actions i.e. what kind of mutual awareness is provided.

#### *Visibility of the Audience*

Like in a room, it is of high importance that the audience of a particular workspace is recognizable to its members. Members should get a feeling of acting in a group rather than in their private environment. Recognizing the members as well as their hierarchical position will stimulate in a quite subtle way the individual behavior like the presence of ones boss in the real world may change behavior or attitude.

Thus the *visibility* of who the members are is of high importance. The POLITeam users have solved this through giving the collaborative workspace the names of its users or the organizational unit it presents. However this is not sufficient, instead the membership should be explicitly visible when accessing the collaborative workspace. The introduction of different *roles* related to particular competencies or duties will allow for the provision of more differentiated behavior. An example of a particular role is the *owner* of a collaborative workspace. This role may *administer* the membership which is one way to maintain a boundary. In practice, the users have requested the support of this role which is allowed not only to give a share but also to withdraw a share once given, i.e. to change membership.

#### *Common Arrangement of Material and Tools*

The arrangement of things in a real room is given physically and visible to all those present. It suits and stimulates the ongoing cooperation process and implies cues for actions. The arrangement of objects itself is a means for non-verbal communication and facilitates coordination. The ordering or structuring of the material—such as the arrangement of the documents on one's own desk [3]—must be suitable for the member tasks. This arrangement is important both, for the retrieval of objects and as reminder for pending tasks. A user may, for example, want to put an object to a distinguished place in collaborative workspace, thus implicitly drawing the attention to it or she may want to communicate about an object and instruct her partner “please take the object from the upper left corner ...”. Consequently, a collaborative workspace must provide an official common appearance of the contained material equally to all members.

In addition to containers and documents, a collaborative workspace may also contain tools to explicitly assign tasks to individual members or to particular material indicating what action is expected. A tool like the TaskManager [14] may be provided in a collaborative workspace. It supports to-do-lists as a means to define tasks, assign them to persons, but without prescribing an order for their execution. This will allow to better support goal driven cooperation in a collaborative workspace.

#### *Adaptable Behavior and User Conventions*

The particular behavior of a collaborative workspace should suit the purpose it is to be used for. For example a collaborative workspace used as a common archive should react differently and support different usage than another one which is used for the production of a report. In particular, the awareness information provided and the reaction to user actions should be adjusted to the purpose.

In addition, the behavior of a collaborative workspace needs to facilitate the conventions and the code of conduct the users have agreed on for its use. It must inform the users about the user conventions it supports. Cole and Nast-Cole [6] stress the importance of group dynamics concepts for the development of CSCW systems. They identify the following stages in a group's development: “forming, storming, norming, performing, adjourning.” Before cooperating effectively (“performing”), groups have developed a set of norms or group conventions as the POLITeam users did during workshops.

As we have seen in practice, it is very difficult to specify the wanted behavior and conventions in advance. Furthermore, they may change in the course of the cooperation. Thus it is required to provide means to adapt the behavior of an already existing workspace. Thus its users may try it and rearrange it until it suits their current needs.

In the following we will pay particular attention to the behavior a collaborative workspace should develop to provide awareness information adequate to time deferred cooperation.

#### *Awareness in the Collaborative Workspace*

The members of a collaborative workspace need to be provided with awareness information which allows them to watch the ongoing process as if being in the same room. It should allow to understand the current process, recognize the traces of changes, and to reconstruct modifications of material and their authors.

#### *Needs for Awareness Information*

Pure sharing allows access to material of collaboration, but in order to coordinate the actions on the material, it is necessary to inform and be informed about past and current actions performed by the other users of the shared material.

*Understanding the system behavior:* For the understanding of the behavior of a collaborative workspace it is necessary to recognize the causes for changes. The following example from practice emphasizes this need. In the learning phase, each user established a mental model of how the system reacts. In their mental model they had a rule saying: “when I put something at a particular place, it will be there.” Thus a user came in trouble when a document disappeared since another member moved it on his desk for editing it. She could not understand why it disappeared and accused the system to fail. A „borrowed“ indication or an awareness information is needed, giving evidence, that someone else has temporarily removed the document.

*Coordination of actions:* In order to continue the cooperation process, for example when a staff member is waiting

for a change of a document, awareness information about completed actions is required. This may be handled through “social protocols” outside the collaborative space through explicit verbal communication using e-mail, or phone calls. In practice, the users considered it as an unwanted burden, if they had to explicitly produce information about their action and stage of work. For example, the typists complained about the extra work required to inform the staff member via e-mail when they have finished a document.

#### *Production and Provision of Awareness Information*

Awareness information about the actions of the participants are required to allow the non-verbal communication needed for implicit coordination. In a room, it is the ability of those persons present to cause and perceive awareness information.

In so called synchronous systems, awareness information provided through extra voice or video communication channels facilitated, for example, the joint editing process considerably, as Dourish and Belotti [8] report. Media spaces [12] provide awareness of telepresence through video channels, thus supporting the maintenance of relationship for physically separated people in long-term projects. However, although all these systems span across spatial distances, they rely on the potential of having the partners available at the same points in time.

In contrast, it must be the collaborative workspace itself which explicitly record awareness information about actions and disseminates them across time and space to the participants. Awareness information should be provided, when it is relevant for the orientation in the collaboration process or when a participant explicitly asks for it [11].

*Persistency of awareness information:* In simultaneous cooperation processes like in face-to-face meetings in a room or in video conferences, awareness information is volatile. It is provided to the partners in the moment an event occurs. The partners may permanently watch each other and recognize to be watched.

In time deferred cooperation processes the partners should be relieved from being continuously present and watch the process. This implies, awareness information cannot be volatile but needs to have some persistency. Awareness information should be visible if relevant for the current action, it should be available after a while of absence to inform about the intermediate progress, or on request to give more details, or to inform about the history of an object. Awareness information needs to persist as long as it may be necessary in the process. At least, over time, details may fade out and become obsolete or be aggregated with others. Process specific aging of awareness information will be required.

*Scope of awareness information:* Awareness information needs to occur, before the participant initiates the next action in the effected context. It may be propagated outside the collaborative workspace—for example it may occur on the private desk of the user when an attention to the workspace is requested from her. Or it may be local to the object where

it occurred and be available only when the object itself is accessed.

#### *Distance and Provision of Awareness*

The provision modes should range from drawing attention, via displaying when relevant, to presenting on request only. Like in a real world room, the closer one is to the place of action, the more details of awareness information should be made perceivable. Being close refers here to a functional distance. In an electronic workspace the functional distance is complex, it may be *spatial*, *temporal* and *operational*.

*Spatial distance* refers to the context of a currently accessed object. If one thinks of a hierarchical tree organizing the documents and containers, the closer one is in the tree, the more detailed awareness information should be provided. *Operational distance* in a time deferred electronic environment becomes longer, the more changes have taken place, the most recent action is the closest and more details may be shown. There may be a total operational distance, this means a complete ordering of all actions, or a contextual operational distance, where only the actions relevant in the current work context are considered. The *temporal distance* depends on the frequency and order of actions and the real time passed. The temporal distance implies aging of awareness information, such that after a while only aggregated history information is available.

#### *Privacy and Information Overload Conflicts*

The explicit recording of awareness information and its explicit provision to the partners as well as its persistency may cause two major conflicts: the privacy conflict and the information overload conflict [13]. The privacy conflict results from the interest of the individual members in information about actions of others for a better orientation in the collaborative workspace, and from the privacy protection request from the actor whose behavior is recorded. Privacy protection may be alleviated if the actor is informed, before entering a workspace, of the public nature of his actions and of the awareness information provided. The information overload conflict may be relieved, if the provision of the awareness information depends on the spatial, operational and temporal distances. Aggregation and aging of awareness information may also help to overcome both conflicts. In addition, a history facility may give an overview on the story of the process on request only. However, it is necessary to have the possibility to adjust the amount of awareness information produced and disseminated by a collaborative workspace according the purpose and the conventions supported. Again, it is very important to note, that the awareness information provided, needs to be the same to all members. Thus they may conclude from how the collaborative workspace appears to them, how it behaves to the others, i.e. what the others may see from their activities.

The quality of the facilitation of awareness information is a key issue for collaborative workspaces. Although a lot of research is done on awareness, the design of smooth awareness facilities supporting intuitive collaboration across both *spatial* and *temporal distances* is still a challenge. Based on the experiences in the POLITeam project a prototypical re-

alization to facilitate awareness at the user interface [20, 21] has been developed and may now be experienced in practice.

### TECHNICAL REALIZATION OF COLLABORATIVE WORKSPACES

As we have learned from practice, the technical realization of collaborative workspaces requires high flexibility with respect to its behavior. It needs, in principle, to be the same to all members, to be specific to the particular purpose, and to support appropriate conventions. Furthermore, the behavior must be changeable in the course of time. To achieve this flexibility and to handle the complexity, we introduce a mechanism that allows to augment shared containers with the appropriate behavior using *CSCW enablers* and *CSCW mediators* [23]. The functionality is encapsulated in so-called enablers, which can be flexibly combined in order to realize complex cooperation support. A so called mediator administers all enablers belonging to one collaborative workspace and triggers their execution. This mechanism allows to dynamically add or remove collaborative functionality. In the following, we will briefly introduce this mechanism and outline how collaborative workspaces were implemented in the POLITeam project using these techniques.

#### From Containers to Collaborative Workspaces

The basic facilities of a collaborative workspace are given through the use of a shared container, allowing to move, remove, display, access documents it contains. In addition, a shared workspace has to provide at least member administration, access control, event and history services.

Each of these additional behavioral functions is realized through a particular *enabler* which may be attached to the container. The functionality of an enabler may augment the functionality of the container it is attached to. It may also provide additional functionality to the users. Each enabler specifies which of the methods of the original container it augments and whether it is to be executed before or after the latter.

The mediator allows to attach or remove enablers to or from a container. Every call to the container is first handled by the mediator which triggers the execution of the corresponding enabler.

Figure 4 gives an overview about the enablers that may be used for modeling a collaborative workspace. For example, the `member_admin` enabler offers methods like `invite_a_new_member()`, `exclude_a_member()`; the `notification` and `propagation` enablers provide awareness information. In order to model user conventions additional enablers are attached to extend the adding or removing operation appropriately.

**Invocation of a method:** Whenever a user performs an action on the collaborative workspace, its mediator is called. The mediator invokes the corresponding methods of the enablers that provide the behavioral facilities.

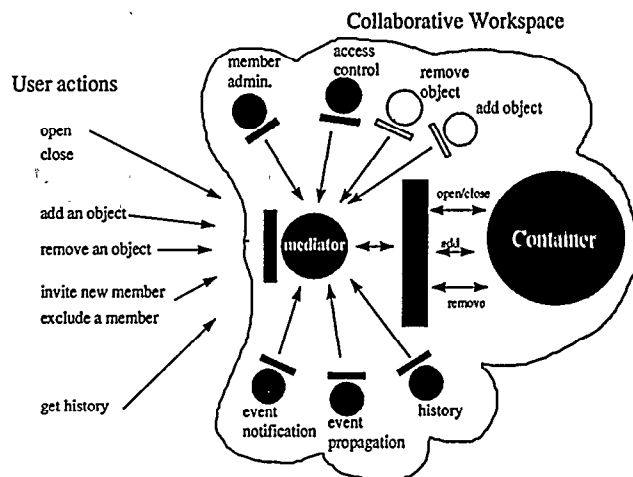


Figure 4: A collaborative workspace and its enablers.

#### Special CSCW Enablers for Moving Objects

In the following we will give two examples of how enablers may be used to support user conventions and workspace behavior.

For example, when a user wants to add an object to the collaborative workspace, he should first be informed, that he is now accessing a collaborative workspace making this object public. If the user agrees, membership and access permission should be checked, before the object is added to the container. Then information to the other members should be provided about the availability of the new object.

This requires, that enablers may directly interact with the users and report what they are doing. The invocation of the `add_object` to the collaborative workspace is first delegated by the mediator to the `add_object` enabler which first asks the user, "Do you want this document to be available to the workspace members?". If the user agrees, the `member_admin` enabler checks access permission. If access is granted, the mediator calls the corresponding basic `add_object` method of the container, followed by a call to the `eventNotification` enabler. If access is denied, no further methods are invoked.

In case of cooperation with users who prefer to edit documents within their personal electronic desk and to put them back in the workspace afterwards, or in case of collaborative workspaces providing archiving facilities, a convention may require to indicate what happened to a removed document. This convention prescribes, that a share of the document should be left when it is removed from a collaborative workspace. This secures, that the other members still have access to this object. A particular `remove_object` enabler may provide this behavior and be attached to the workspace.

#### Configuration

The basic functionality of a collaborative workspace will be configured by a designer or system administrator. In the course of its use, the users may adapt it to their special purposes and conventions by adding or removing enablers. This approach requires that the designer of the underlying plat-



form has already identified basic functionality and decomposed it into enablers.

*Configuration by designer and system administrator:* A system administrator can specify the default behavior of a collaborative workspace by assigning the enablers. She can differentiate between mandatory and optional enablers. Mandatory enablers are permanently assigned to a collaborative workspace, optional enablers can be removed during run-time under user control. When a collaborative workspace is created, a mediator for that object is instantiated and initialized according to the configuration file.

*Adaptation by users to support conventions:* The user can alter the behavior of a collaborative workspace. After the instantiation of the object itself and its mediator and enablers, the user can add or remove optional enablers from the object. Figure 5 illustrates this: The tree on the left contains the complete list of available enablers. The right box displays the selected enablers.

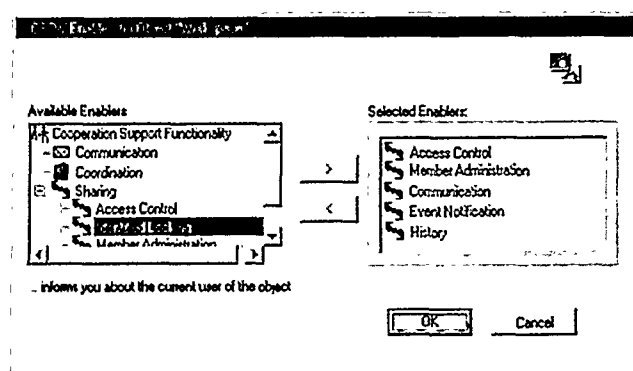


Figure 5 : User configuration for a collaborative workspace.

### Enablers and Behavior of Collaborative Workspaces

The different enablers allow the users to configure a collaborative workspace according to their needs and to experiment with associating different behavior. Since the enablers may modify the consequence of an operation of the user—like in the case of the `remove_object` enabler or `add_object` enabler—they allow to support different behavior; i.e. the result of the same operation may be different in different collaborative workspaces. However, they are the same to all users of the same one. Thus the collaborative workspace presents the same functionality and behavior to all users. The enablers used in the POLITeam system are designed to inform with the user about their special modification of the invoked operation. Thus they support the users to be aware of working in a collaborative workspace and of the specific behavior of this particular one. The enablers turned out to be a very flexible means for fine tuning the behavior of collaborative workspaces and allow to support different purposes and applications. However, the concept of CSCW-enablers and mediators is more general and may also be applied to other kind of tools which are to be used collaboratively.

### SUMMARY AND OUTLOOK

Collaborative workspaces allow the definition of settings for time deferred cooperation and facilitate the management of work material and awareness about the ongoing process. Thus, they go beyond the facility of shared containers. Unlike workflow systems, they do not prescribe the workflow but facilitate and document the course of actions instead. Collaborative workspaces are to be seen as part of a working environment that may also include other groupware tools, like e-mail or electronic circulation folders.

Collaborative workspaces turned out to be useful for collaboration processes where the sequencing of actions is not prescribed. The practical experience of user groups in two German ministries has shown that the collaborative workspace is an intensively used tool for team-like time deferred cooperation among people on the same hierarchical level. It has stood the tests in supporting the unit work in a ministry and was used for fast collection of reports, joint text production and processing by staff members, unit heads and typists office.

Collaborative workspaces are used for implicit coordination of weakly structured cooperation processes. This requires, a collaborative workspace should provide a behavior which allows its users to achieve and understand its purpose. In addition it should support the users to adapt and follow conventions for its use. The behavior of a collaborative workspace must be controllable and support the orientation of the members in the workspace and in the cooperation process. Provision of awareness information about the ongoing process, the most recent actions, the cause of changes and the documentation of actions in the history of a workspace are of primary importance for the orientation of the members and therefore for the progress of cooperation. For special purposes specific kinds of collaborative workspaces are needed which differ in respect to their behavior, the conventions they support and the awareness information they provide.

To achieve the necessary flexibility to the configuration of collaborative workspaces both for the designers and the users, we have suggested to use CSCW enablers for their implementation. Having stressed the demand for the support of group conventions within collaborative workspaces we expect that the users experiment with CSCW enablers representing conventions.

We are still at the beginning with the investigation of the potential collaborative workspaces will have for time deferred cooperation and have been able to highlight only some aspects in this paper. The POLITeam project will pursue the development of collaborative workspaces.

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