ABSTRACT

This paper is about the definition of multi-context systems as a model consisting of content and meta data enriched with add-ons and attachments to map multi-level, multi-version cooperative data in a collaboration. Based on ethnographic empirical evidence, the use of to-do lists as multi-context systems are illustrated, analyzed, and used to derive design implications for systems supporting crossing boundaries in projects. Different perspectives from product, process, and interaction point of view facilitate considering circumstances, under which protection and sharing of resources in a work environment may occur, in the design of such systems.

KEYWORDS: Collaboration, artifacts, multi-context systems, to-do lists.

1. INTRODUCTION

Cooperation has impact on work environment of people cooperating. First, it requires certain organizational, technical, and economic circumstances, otherwise it cannot be established. At the same time, it creates certain constraints for team members. Besides the time pressure cooperative projects have, competition, expected quality and quantity of products or services, or dealing with complexity of technologies and processes are some issues, which need to get attention when a cooperative project is being set up. Several computer systems with specific software applications facilitate communication, coordination, and collaboration among people cooperating. Some of them are flexible enough to allow improvisations or ad hoc changes to predefined processes.

Coordination and collaboration between different communities of practice can only be established by exchanging artifacts created and modified within “object worlds” [7]. Object worlds influence the way of carrying out the work and the power relations between cooperating actors within and across the organizational boundaries. “They accommodate multiplicity and the need for uniformity at the same time.” To regulate what can be inscribed in which format and how and with whom it can be shared object worlds need to be designed and adapted by considering the circumstances under which interactions occur.

Artifacts play an important role in supporting cooperative settings. In the field of CSCW (Computer Supported Cooperative Work) several studies have been carried out, several notions are developed, and several design implications are derived from these findings [4]. Artifacts may be created by people cooperating, exchanged, modified, or removed. Artifacts evolve in the course of a project. Besides hosting content, changes made, debates carried out, questions asked, answers given, issues remained open and unclear, etc., artifacts inform us about ongoing processes and how they are connected to content they contain.

Artifacts can be composed or atomic, accessed simultaneously or asynchronously, owned by one or many, visual or textual, material or virtual, common or private. Some artifacts are shared and host several coordination-related data accessed by many. These artifacts enable communicative exchange between actors cooperating. They mediate the status of work-in-progress and make participants aware of others’ activities. They sometimes act as coordinators of work by being communication objects, by creating a common understanding of a task, by enabling talking about tasks, by reminding principles, approaches, and methods connected to a task, by keeping track of activities and materials, by hosting work plans, and so forth. So, artifacts can be used to initiate and establish coordination within a work group. They can be used to exchange data and deal with dependencies between activities. They can be used to exchange work-in-progress implicitly, to support articulation work, e.g., by representing work carried out, to point out possi-
ble and actual gaps in coordinating dependencies between tasks, to communicate the todos explicitly, to assign tasks to persons, to define and refine work to do, etc.

Besides knowing that artifacts are the main objects of exchange in collaborations, we have to consider the fact that there are boundaries between cooperating actors. Artifacts are boundary objects that can be efficiently used for team activities, especially in negotiating different collaboration issues. “Boundary objects, packaged and being turned into immutable to allow for sharing across contexts and different communities of practice” [1] support joining of different forms of knowledge, enable interpretative flexibility [2] and connections, which are accessible through fluent transitions, and help to relate different levels of knowledge and expertise. Different interests of participants in collaborations end up very often in negotiations. These can be about anything involved in the project, like economic, technical, organizational, personal, product-, resource- or management-related. Strategies and styles of negotiation can defer from team to team, but the interaction mechanisms needed for negotiations remain the same. Open issues are the core of negotiations, meetings are the main arenas to facilitate exchange between people, artifacts are mediators between negotiating parties. Boundaries between groups and single persons may be built and destroyed and rebuilt again depending on several impact factors caused by the cooperation itself.

As designers we have to understand what really happens in cooperative projects (which have been very extensively studied so far in the field of CSCW) and especially how we can support these with technologies and mechanisms combining electronic and physical tools and artifacts already established in such settings (which did unfortunately not get enough attention so far). In this paper we try to approach this problem. We introduce the notion of artifacts as multi-context systems and analyze current practices from this point of view (Section 4). To create a base for investigations we define different perspectives to work (Section 2). Then, we focus on a typical common artifact, the to-do list, we study in a real work environment (Section 3). We illustrate how we analyze the collaborative setting, in which we could observe crossing boundaries in a project. Finally, we try to derive implications for design of systems that support crossing boundaries in this sense (Section 4).

### 2. PERSPECTIVES TO COLLABORATIVE WORK

If we want to study and support a collaborative work setting by IT systems, we need to approach it from different perspectives. With a product perspective we focus on the product-in-development. Here we work on the product, we model it, we simulate it to find out the most appropriate parameters for it, we prototype first and customize if necessary before we start with its production. Several stakeholders are involved in this process, sometimes with conflicting goals. Mediating, bargaining, trading, or conflict resolution can be necessary and done by negotiations. The context is defined by the product, its properties and its relationship to other products or to its own versions and variants. To facilitate design and development of products and to provide collaboration support between actors involved, artifacts are established, which describe and illustrate static and dynamic properties of products. Certain tools or platforms are used to deal with these artifacts.

While the product perspective supports better understanding of the product created cooperatively, the process perspective focuses on individual or collaborative actions carried out in a group to achieve a common goal, which again can be design and development of a product. In this perspective, tasks, people and products are related to each other, which is complemented by a system forming the sequence of a set of task elements connected to roles and artifacts, and describing the business process for the specific project.

Finally, the interaction perspective is needed to support interaction with tools, artifacts, and people in a planned or situated context. In this perspective, by means of so called document centered collaboration coordination functionality of a collaborative system can be moved out of the application to documents themselves [3]. This approach has the goal to integrate content with coordination in such systems by giving documents more resources like operations on documents such as reading, writing, moving, updating to maintain application integrity. This type of exploitation of the document infrastructure implemented with a middleware layer applies active codes associated with the document. Besides documents being used as conventional electronic artifacts hosting content, computation is attached to documents, making them to active documents. A good integration of tools and applying active artifacts prevent that users have to translate artifacts from the context of one tool to the context of another tool. Improvisations are possible and the outcome depends on the capabilities of each participant.

There is a certain dynamic between these perspectives. The focus needs to be changed depending on the complexity of the product-to-design or service-to-maintain. More complex the product becomes, more attention is given to products naturally. In case of routine work people focus on processes and coordination issues to monitor, optimize, and maintain collaborative activities. How the transition is made between perspectives depends on work cultures, project ex-
3. A SCENARIO OF COLLABORATIVE WORK

We use ethnographic evidence to illustrate a setting in which crossing boundaries have been done by using to-do lists. We want to show the problems team members had both to protect their individual, normally insecure work environment and at the same time to maintain a space for collaborative work and mutual support in the project group. We present here a case study which has been carried out at Carpart in the scope of the research project MAPPER. Carpart is a company that produces car parts like gearshifts, head strains, and seat heating for automotive industry. It has several branches all over the world. The projects are multinational. The geographically distributed way of project organization made computer-supported communication and collaboration necessary. Meetings were arranged regularly to overcome the distance between distributed project members. We could observe several meetings and carry out in-depth interviews with some of the key actors during four visits between 2005 and 2008. In the following we describe one of the cooperation settings we could observe in 2005.

Regular and ad-hoc meetings were the main place to exchange information about work progress in projects. All project members from all sites participated these meetings by using teleconferencing facilities and sometimes screen sharing. Single open issues captured in projects’ to-do lists were discussed by asking the status quo of each item. Responsible persons explained the stage of the work progress when they were asked to. In some meetings, suppliers or customers were present too. The main common artifact in these meetings was a to-do list owned by the project manager, who was also in charge of moderating the meetings (Figure 1).

We observed a meeting in a project about distributed production of certain car parts. The collaboration was between Swedish and Polish branches of the company. The branch in Poland was supposed to use the old machines from Sweden. A to-do list was used in the meetings to discuss the work (Figure 2), in which all related activities were listed. The plan was first to introduce the old machines into the production and then use them in Poland. Nowadays, it was not easy to configure and control these machines. Additional knowhow was needed, which was not recruitable in the company any more. There were no written notes, manuals, tutorials, exact instructions of usage and repair, or how-to’s, to hand over to the Polish colleagues. The only possibility to find out how to use these machines in production was to ask the knowledge workers, who have been using these machines for a long period of time in production in Sweden. Unfortunately the most of these guys were retired.

Tellioglu and Wagner developed a layered terminology using the notion of space as a geographical and cultural category [9, p.252]. In their study in software development teams they found out that design spaces are regionalized and configuration management environments used in software design groups host practices that developers use for allocating, scheduling, aligning, coordinating, monitoring their individual and team work across organizational and social boundaries.

Besides making use of configuration management data, actors participating on interactions for clarification cope with breakdowns concerning interpretations of the conditions of satisfaction which are necessary for an action. An implicit shared background is required to interpret the conditions. “The sharing is partial and needs to be negotiated” [10, p.15]. Specific knowledge, interpersonal relations, and general attitudes build this shared background that is necessary to create a common understanding of work to be carried out cooperatively.

3.1 A SCENARIO OF COLLABORATIVE WORK

A shared understanding can be established if actors have access to common information in case of collaboration. This can happen in different ways. Some artifacts are created, updated, and exchanged between team workers for a limited period of time. These are intermediate as long as they are not final. They help exchange intermediary results in work processes, sometimes clarify things [10], communicate individual or cooperative actions, or create a shared understanding as a basis for future interpretations of interactions among team members. Additionally, meta-context can be retrieved, e.g., by investigating the change history of a common artifact, by consulting a buddy list, by looking at a contextualized user list showing persons who currently share a common focus. Team members are made aware of others’ availability and progress. They might also be able to trace work carried out by using certain tools like configuration management with explicit data about versions and user access history.

In the next section, we want to show that such requirements are originated in empirical evidence. We use one case (Carpart1) of several ethnographic studies we have been carried out for almost a decade in different work environments.

1The name of the company is changed. The project team consisted of Hilda Tellioglu, Gianni Jacucci, Ina Wagner, and Gianmarco Campagnolo.
and not available at the time of transfer from Sweden to Poland. There was only one person sitting in the meeting and trying to answer the questions of the Polish team. Presumably, there was no answer to all questions. The only competent person present in the meeting was not always able to answer the questions of the Polish colleagues, which made the desperate situation of the production more clear to all participating the meeting.

Besides the problems in knowledge recruiting and transfer to solve the problem of configuring and fine-tuning the old production machines in Poland, there were barriers of delegation and distribution of work. The Polish team was very angry getting old machines, which were useless for them. While the Swedish group was thinking that the Polish team should be happy to get these machines, even these are very old, because the machines used so far in Poland were much older and much more "useless" than the ones they get now from Sweden. This fact was not articulated explicitly, but was observable in the mimes and temperament shown by all participants, especially by the group managers of both sides. Being aware but not expressing this emotional level of the work, the to-do lists were applied to try to objectify the work-to-do, to manage the assignments, and to coordinate the assigned work. So, they helped to focus on certain issues by avoiding certain problematic discussions, which could end in unpleasantly for most of the participants. The hierarchy was hidden and all acted like they were equal from organizational, economic and technical point of view. The to-do list was linear, with no additional information to the single issue items. Names were put all on the same level, assignments were equally distributed, deadlines were there for everyone, priorities were given based on the type of work to be done and not on the person assigned to the issue.

There was a hierarchy defined between two work groups and there were power relations hidden in the issues composed to a to-do list. It was not clear why certain quality and quantity was expected by certain groups, considering the circumstances of production with old machines. For instance, in Poland the performance of the production was expected to be higher than in Sweden, even if they had the older machines and did not really know how to use them effectively. One of the important reasons to move the production to Poland was to produce cheaper and preferably faster, of course, without losing quality of products. These issues were not mentioned explicitly during the meeting, but only in the negotiation of alternatives and ways of doing things differently, in the argumentation why certain things could not be changed and must be done in a certain way.

One of the important problems we could observe was the degree of detail of the issue items in the to-do list used at Carpart. There were organizational, technical, cultural, and economic constraints connected to the single issue items. These were represented neither in the items nor in the to-do list as a whole. The background information about the creation, importance, and reasons of these issues and their properties were not visible in the list. Prohibiting awareness in this sense, these lists put the meeting participants into a challenging context: they had to protect their work processes by trying to be cooperative and willing to adapt and improvise. The role of the to-do list was to smooth the arena function of the meeting, in which discussions and negotiations can occur. Besides suppressing a lively debate between these two communities of interest, the to-do list documented what had to be done by whom until when. And that was all.

We could identify different problems at Carpart around the coordination of work: No information was exchanged between project members between two meetings. Single persons or distributed groups were not aware about tasks others were carrying out. Meetings were the only places where project managers tried to assess the progress of the project work, to clarify uncertainties in tasks and work flows, to define or redefine responsibilities, to set and reset deadlines, to negotiate objectives or the distribution of work, and to define new tasks if necessary. The to-do lists (Figure 2) were used to facilitate this function: As a project manager you are not anyones boss, you cannot give orders, to-dos are a way of giving indirect orders, setting responsibilities and deadlines, and of course by doing so a way of coordinating the project. Besides being meeting agendas, the to-do lists kept
Figure 2: The common to-do list used at Carpart, projected to the wall during meetings and shared by remote teams through desktop sharing facilities. It is the list of the project manager, including different to-dos to be carried out by different project members like CC or PE (shown in Resp. Person column).

as spreadsheets were then updated during the meeting and became the minutes of the meetings. Each line of a to-do list contained an (open) issue, the so called to-do, in the example above consisting of the project name, RFQ number, issue description, issue comments, target date, responsible person, and the status. We refer to this line of the list as structured data that we will explain later in the Section 4. Some projects had more than one issue listed. The single issues of a project could be assigned to different persons.

Project members were not informed about the content and changes made to the issue items before the meetings. They were not aware of changes done by others since the last meeting and not really prepared for the meeting considering the work progress of others in compare to their own work. Between the meetings, there were often times where some project members needed to exchange their problem, question, or suggestion for a solution with other colleagues, who are in charge of related issues they recalled from the last meeting. They also wanted to manage their own work individually, by organizing, documenting, revising, and articulating their individual work between two meetings, which was assigned to them. In some cases they had to communicate with other colleagues to answer questions. They did not want to be monitored in all their actions, but still they wanted to be coordinated and organized in the project group. We suggested a solution for this problem, by developing a prototype based on spreadsheets in which two spaces were provided for individual work and for common work. “The individual spaces had additionally room for discussion and exchange with others, one area dedicated for sharing with the project manager, and another one was a public space where everyone in the project group could access to communicate certain open issues.” [5, p.17].

4. MULTI-CONTEXT SYSTEMS

As illustrated in the case description above, to-do lists are mainly material. After being created by computer applications like spreadsheets in our case, they are usually printed out to document and to make them haptic for communication, visualization, and negotiation within the work group. A printed to-do list becomes then a common artifact for a project meeting. Normally, they are projected to the wall during a meeting or attached to coordinating common artifacts. Also written notes on a piece of paper by single project members are material and used in meetings.

In some cases, owners of printed out to-do lists, make notes on the list, mark areas and issues, strike through some list items. The lists get then multi-layered and cannot be thrown away easily, because they represent discussions carried out and decisions made. So, they host not only the content of the to-do item, they also represent the project context referring to the meeting context as meta-level information about the item.
To-do lists, as observed in Carpart, are composed of single issues, which can be finished, in progress, canceled or still open (Figure 2). They address different aspects of the same common issue in attention. Single issues can be atomic, including only the information related to the issue, like project title, RFQ number, issue description, comments, target company, responsible person, and status. This is then the only context that is created by such an atomic issue item of a to-do list. On the other hand, single issues can also include multi-layered context, like an annotation to the atomic part of the issue, a comment, a reminder, a link showing additional information in form of a web site or a document, which can be followed by just browsing.

A to-do list can contain nested issues related to each other and most likely depending on each other. This can be the result of an interdependency in work packages distributed in the team. A producer-consumer or task and subtask relationship can be mapped onto several issues listed together. If a to-do list is a nested one including multi-layered context as shown earlier, it represents more than one context. All these illustrations show that such a to-do list can contain context of different types, on content or meta-level. In such a multi-context system the main part is structured data enriched with attachments, like additional resources such as documents or web sites, and addons like annotations, tags, ranks, etc. linked to it. Considering that each issue has its owner (responsible person), such a list visualize additionally relationships between people around the project.

First of all, a multi-context system like a to-do list must be protectable by its owner, at least for a period of time which is defined by the owner. The possibility to share certain parts of such a list must be provided as well. Sharing can be done for reading and writing, which must be tailorable also by the owner. A easily accessible change history provided for each item, especially for the ones, which are accessed also by others, enables keeping track of updates, remarks of others as a meta-level exchange explicitly done between sharing actors, and also on a meta-level access to the item done by actors as an awareness mechanism with notifications to the owner.

Reasons for sharing can be of different kinds: When a content (here a issue item) is relevant for another content, it may make sense to link them to each other to complete the data needed and to clarify dependencies between these connected items as well as to consider these in work process. In these situations, boundaries need also be crossed. This happens when parties involved have to modify or adapt their own work depending on the work of others by just accessing the content of others. If it is a design and development of a product, parameters, properties, interfaces, etc. need to be defined, like in open planning in architecture by letting some parameters of design open for negotiation and mutual adjustment [8]. If it is a service with details in functions, features, organizational, and economic properties, these attributes need to be exchanged and modified when needed.

Taking responsibility of a work activity cooperatively is another reason for crossing boundaries, being open for exchange by providing information from a otherwise protected work area. Linking related items to each other enables sharing and creates a common view to all sharing it, especially for those who collectively are responsible for the overall result.
Another reason for sharing might be looking for help. Mutual support or collaborative problem solving can be provided by giving access to protected items. And, of course, when work is done and goals are achieved, this can be published to represent the work carried out.

So, linking, providing access or publishing are ways of sharing multi-context systems in a cooperative work environment. Systems supporting this must implement this functionality to facilitate user-defined protecting and sharing of sensible context in an enterprise. Since multi-context artifacts host all information relevant for a certain piece of work, they are the object of negotiation, exchange, sharing, and modification cooperatively. Such artifact based collaboration is normally be complemented with additional oral, direct, and explicit exchange between actors. The additional meta-context data improves the overview on responsibilities, work progress, and possible bottlenecks and problems occur, supports translation and merging among different parts of the task or product, and supports even participatory management by engaging all involved into the project [9]. Of course, the complexity of articulation work is reduced and the design can be assembled.

It cannot be avoided to think about regionalization [9]. Due to the complexity of a project work, its content is usually separated into several specialization areas and assigned hopefully to according stakeholders. This makes the definition of insiders versus outsiders, and consequently the protection from outsiders necessary. Protection might be very relevant for those who want to protect an area of work or expertise, a responsibility and a position, or an idea. Protection and sharing go hand in hand. If common data cannot be shared in a work group, then it is very difficult and almost not possible to achieve the common goal of the group. At the same time, protecting and crossing boundaries must be possible, not only organizationally, but also technically and practically.

5. CONCLUSIONS

In this paper, we showed that work practices can be observed and studied from product, process, and interaction perspectives. Considering the dynamics of these perspectives and different reasons for protecting and sharing of one’s work artifacts, it is necessary that collaborating parties need to have a common understanding about their own and each others’ work as well as interfaces and dependencies between all components. Multi-context systems are introduced as a new notion, which helps define and analyze the different levels of data used and exchanged in a work group. A real multi-context system, a to-do list, is used to illustrate the practice around such an artifact to underline the importance of such a system. The analysis of to-do lists ended up in a model of a normal and nested multi-context system, which needs more elaboration and investigation to develop further to a computer system implementing the model to support cooperative work from all perspectives mentioned in this paper.

REFERENCES


