Use of Multi-Context Systems for Crossing Boundaries

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POSTER PAPER

ABSTRACT

This paper is about the introduction of multi-context systems as a framework. Multi-context systems consist of structured data enriched with attachments as additional resources like documents or web sites, and with add-ons like annotations, tags, ranks, etc. linked to it. Attachments and annotations are connected by hyperlinks to the structured data. Multi-context systems help define, capture, 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 systems. The analysis of to-do lists ended up first in a model and then in a prototype, which was implemented and evaluated. The prototype shows how multi-context systems are useful to overcome problems of boundary crossings between teams.

KEYWORDS: Collaboration, boundaries, multi-context systems, to-do lists, case study.

1. INTRODUCTION

A cooperation requires certain organizational, technical, and economic circumstances. Teams need to be built, decision making must be organized, a common technical infrastructure must be established, financial resources must be provided. On the other hand, cooperation creates certain constraints for team members. Time pressure, competition, expected quality and quantity of products or services in development, or the complexity of technologies and processes are some issues to mention briefly. To overcome these constraints and create a common understanding of these, companies establish certain IT systems to facilitate communication, coordination, and collaboration among people, with more or less success.

There are several CSCW systems established to support cooperative work. Some companies can organize themselves by simple email exchange, some need more communication channels and introduce instance messaging, others work on common artifacts by using a common information space. In most cases, simultaneous access of multiple users are provided. Companies like CISCO, IBM, or SAP offer already hybrid systems and knowhow to setup and consult cooperating enterprises.

Even if appropriate technologies are established in cooperations, boundaries might exist between participants for several reasons. Boundaries might be originated by competition, knowledge and work distribution, power structures, economic or technical (inter)dependencies between collaborating partners, lack of expected effort, etc. Tellioglu and Wagner developed a layered terminology using the notion of space as a geographical and cultural category [6, p.252]. In their study 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” [7, p.15]. Specific knowledge, interpersonal rela-

tions, and general attitudes build this shared background that is necessary to create a common understanding of work to be carried out cooperatively.

As thoroughly studied so far, artifacts of different kinds are identified as main boundary objects in collaborations. They build the bridge for boundary crossings between cooperating parties. "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 for exchange, 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.

Artifacts bridging boundaries 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 possible 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.

Several ethnographic studies in CSCW showed that boundary crossing can be a big deal for projects [1] [3] [4] [6]. If people do not share and keep their boundaries no matter what happens in a cooperative project, big damage can be caused. So, this is an important organizational and technical issue for enterprises, because the success of a project depends on it.

Is it possible to guarantee exchange between cooperating partners and a common understanding about knowledge and openness in a collaboration? 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 [7], 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.

Further questions are: What type of cooperation mechanisms and technologies are useful to support boundary crossing? What are crucial attention points if a collaborative project sets up the IT environment for the cooperation? Which approach can help to find out the most appropriate collaborative work environment for a very specific project? This paper tries to answer these questions, first by studying a collaboration project and analyzing coordination activities around a common artifact (the to-do list) (Section 2), then by introducing the concept of multi-context systems (Section 3) and showing its implementation and application as a prototype (Section 4) before discussing and concluding the paper (Section 5).

2. 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[1] in the scope of the research project MAPPER[2]. 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 item by item. Responsible persons explained the status of the work progress when they were asked for. 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 (Figure 2).

Figure 1. A regular project meeting desk at Carpart full of artifacts and the current agenda based on the common to-do list was projected on the wall.

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. 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 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 not always an answer to all questions.

Besides the problems in knowledge recruiting and transfer to Poland, there were barriers of delegation and distribution of work. The Polish team was very angry getting the old machines, which were almost 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 mimics 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. 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 (Figure 2). 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 this 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 produc-

[1]The name of the company is changed. This study has been carried out by a team consisted of Hilda Tellioğlu, Gianni Jacucci, Ina Wagner, and Gianmarco Campagnolo.

[2]http://mapper.eu.org/

ISSUE LIST (Project Manager)

Meeting date	21. Oct 2005
Venue	Conference room 7
Attendees	JA, PE, JC, CC, AF, MS, SH
Apologies	

Structured data

Project	RFQ No:	Issue	Comments	Target Comp.	Resp. Person	GYR Status
Nissan P32L		CER	Signatures from Poland	7 Oct 2005	CC	N
		Seat Foam samples	advise Lear of delay	7 Oct 2005	PE	N
		Housing refer ...	... through Lear	9th Sept	PE	Y
		SLOT Samples	fiber requested	COMPLETE	PE	G
		Varranty agreement & ...	... KA & Lear to be	7 Oct 2005	JA	G
323VL-328-JCL L322		L313 A1 harness change	... date with JCI	21 Oct 2005	CC	G
		20133326	JCI sign off	13 Sep 2005	CC	G
		L319 Cost breakdown required for ...	submission arrange with		JA	Y
L384		Timing plan		9th Sept	CC	G
		JCI to false order	... order from JCI		CC	G

Figure 2. A fragment of a common to-do list used at Carpart, projected to the wall during meetings we observed 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.

tion 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 loosing 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, or 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. 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 and of course conflicts could 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 among 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. Besides being meeting agendas, the to-do lists kept 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. 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

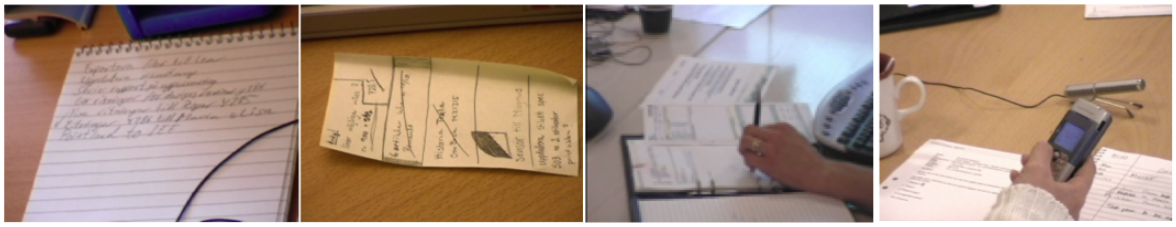


Figure 3. Organizing meetings at Carpart: Individual lists, notes, post-its, personal data or text messages on mobile devices.

their problems, questions, or suggestions 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.

3. MULTI-CONTEXT SYSTEMS

As illustrated in this case description, to-do lists are central for coordinated cooperations. They are created and updated by using computers. Regularly they become meeting agendas and are sent to participants of the meeting beforehand. Participants print out the agenda and use it during meetings as documents to keep track of activities in the meeting. The meeting agenda makes participants aware of the order of issues discussed. They can be prepared for raising their voice if they feel involved or they are asked for. This way to-do lists help arrange and moderate meetings. Project managers can use them to ask unpleasant questions to project members in a more formal way, without being hesitant to cross boundaries. For instance, they can ask, why certain tasks are not completed yet, if there is an open issue on the list with a deadline set but not finished yet. Project managers see the to-do lists as instruments for management: "As a project manager you are not anyone's boss, you cannot give orders, to-do's are a way of giving indirect orders, setting responsibilities and deadlines".

In meetings people make notes on their copy of the list, mark areas and issues, strike through some list items. The lists get 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 on a meta level. They refer to the articulation of work happened during meetings.

To-do lists, as observed at Carpart, are composed of single issues, which can be finished (G, green), in progress (Y, yellow), or still open (N, red) (Figure 2). Single issues can be atomic, including only the information related to the issue, like project title, RFQ number, issue description, comments, target completion date, responsible person, and status. This data is structured and captured in a list.

To-do lists are not the only artifacts used during meetings at Carpart (Figure 2). Physical artifacts representing or being the product or a part of the product, material artifacts used in production, folders with different types of documents, personal calendars, notebooks, printouts of presentation slides, post-its or just pieces of papers relevant for the meeting, etc. are present on the meeting desk. If it is needed, actors search in folders they brought to the meeting for certain information and relate them to the current issues discussed. Meeting participants are in charge of making sense of data available but not linked to each other so far (Figure 3).

A to-do list can contain issues, which are related to each other or most likely depending on each other. This can be the result of an interdependency between work packages distributed in the project team. A producer-consumer or task and subtask relationship can be mapped onto several issues listed together. Such to-do lists can contain context of different types. This can be on content level or on meta-level. The main part of such *multi-context systems* (Figure 3) consists of structured data enriched with attachments as additional resources like documents or web sites, and with add-ons like annotations, tags, ranks, etc. linked to it. Attachments and annotations are con-

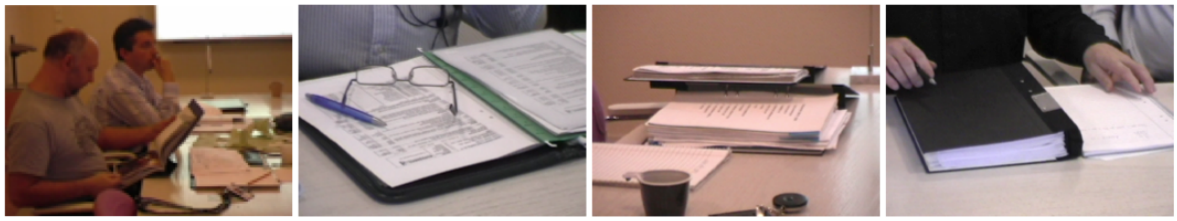


Figure 4. Folders as physical document repositories used during meetings at Carpart.

nected by hyperlinks to the structured data. Considering that each issue has its owner (responsible person), such a list visualize additionally relationships between people within the project.

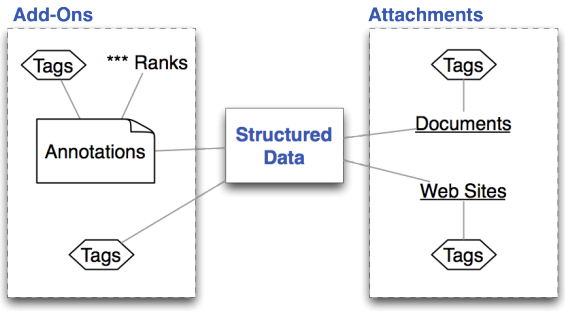
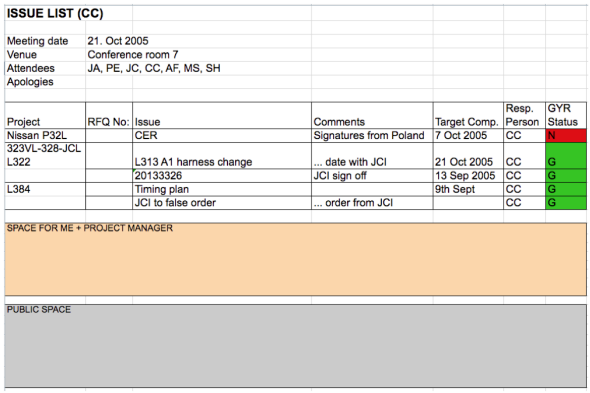


Figure 5. The model of multi-context systems based on to-do lists.

4. THE MCS PROTOTYPE

Based on the definition of multi-context systems, we developed a prototype to evaluate our approach. In the research project MAPPER we had an early list-based prototype [5] based on three spaces: an individual to-do list, a private space shared with the project manager, and a public space shared with all in the project (Figure 4). In shared spaces comments can be added and modified. We evaluated this prototype with users from Carpart by means of focus groups and interviews with single key actors. The prototype was found very useful for communication within the group and coordination of work. They mentioned among others, that a lot of double work can be avoided by providing this kind of openness into cooperation projects, that questions can be asked easily and more often without waiting for regular project meetings, that group awareness can be improved by such mechanisms, that implicit communication provided this way helps articulation work in projects and reduces communication and clarification overhead in projects.



ISSUE LIST (CC)

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L384		Timing plan		9th Sept	CC	G
		JCI to false order	... order from JCI		CC	G

SPACE FOR ME + PROJECT MANAGER

PUBLIC SPACE

Figure 6. The early prototype *myToDoList* implemented for each project member [5].

We continued with the prototyping since then. In this paper we present a new version of it, which is very different than the first one (Figure 4). In this new version we considered multi-context systems as the base conceptual framework. The new prototype, called MCS, is hypertext-based. Its administration client is currently implemented in Microsoft Excel, which is the main office application Carpart used for the management of projects. It uses links to compose project context by relating different type of data created and modified by different users. It makes the system more flexible and scaleable. At the same time, it allows multi-user access without disturbing data of others by overwriting. Users can enter their tags, comments, ranks, or links by using the context menu.

The MCS data can be accessed by a web-based client ap-

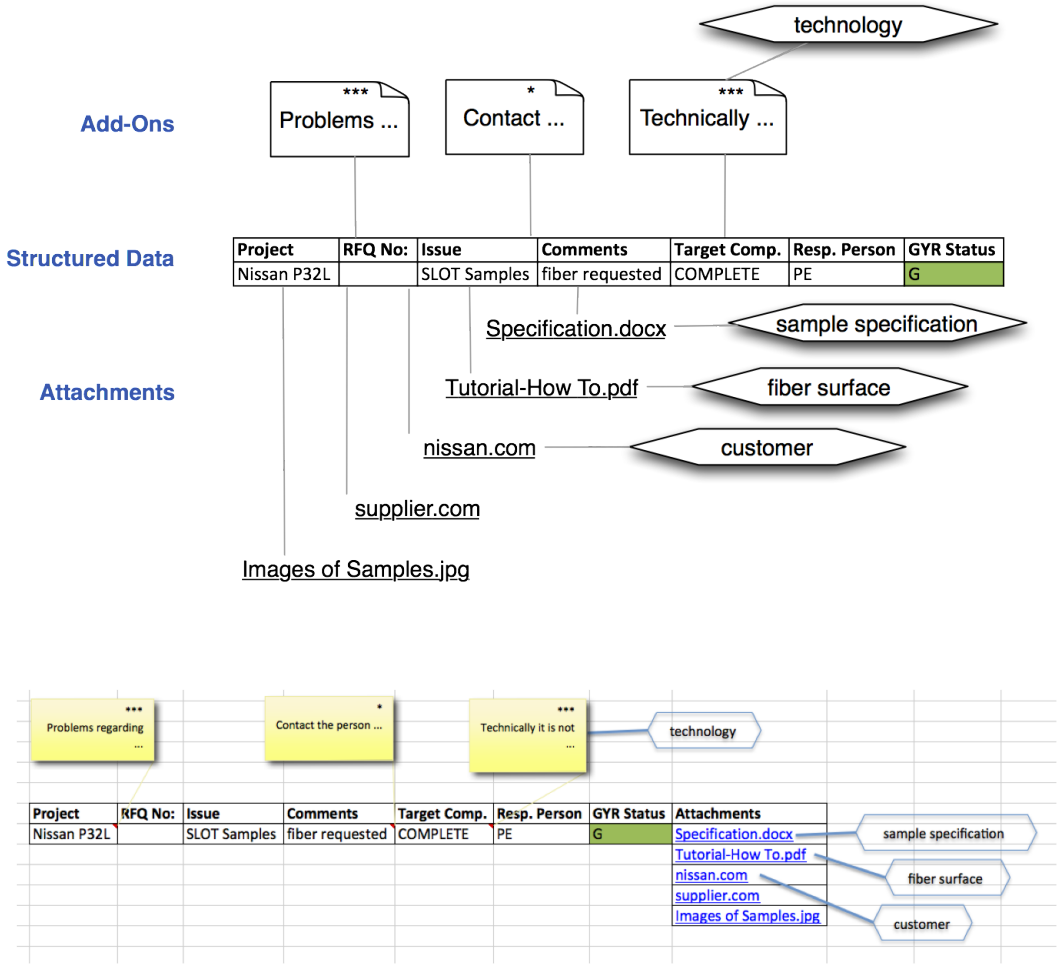

Figure 7. A view of the prototype MCS applied at Carpart (top) and a screenshot of the MCS prototype implemented in Microsoft Excel (bottom).

plication. A single search text is used in this prototype to look for data matching the text. The search is done in issues (considering all fields of an issue), in tags, in annotations. The result lists are structured by issues, tags which can be followed to see the attachments or issues, and annotations. The client application is currently under evaluation.

5. DISCUSSION AND CONCLUSIONS

What is the role of multi-context artifacts like to-do lists in crossing boundaries? What happens when cooperating actors want to protect their own work domain, but at the same time be flexible and autonomous enough to open it up to let others help and interact? What are the requirements to such systems?

First of all, a multi-context system 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. A change history provided for each item, especially for the ones, which are accessed also by others, enables keeping track of updates. 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 and to clarify dependencies between these. In these situations, boundaries need to be crossed. This happens when parties involved have to modify or adapt their own work depend-

ing on the work of others by just accessing the content of others. Being cooperatively responsible for a work activity is another reason for crossing boundaries. Linking related items to each other enables sharing and creates a common view. 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.

In this paper, we showed that it is necessary that collaborating parties need to have a common understanding about their own and each others' work. Multi-context systems are introduced as a new framework, which helps define, capture, 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 systems. The analysis of to-do lists ended up first in a model and then in a prototype, which was implemented and evaluated. The prototype shows how multi-context systems are useful to overcome problems of boundary crossings between teams. It provides shared access to project member, without letting them to disturb each others' data. The transparency is possible, tailorable, and harmless. Sharing of knowledge is made easy. Annotations and attachments can be added by others, comments can be ranked to show one's opinion about the input of others. A search client provides easy access to the huge amount of data gathered easily in a project context. Project members communicate implicitly. Awareness about the group and work progress is implemented by showing others remarks, reactions to common multi-context systems.

There are some issues in the MCS prototype that need to be developed further. With a zoom in and zoom out functionality, the problem of loosing overview can be avoided. This feature is not implemented yet and is an issue for future work. It is still an open question, whether it is necessary to show the initials or names of the contributors of annotations and add-ons in MCS. It is very useful to have this data in the client application, but not necessarily in the administration client. Also in the conceptual part of this research, we identified interesting questions: How can completeness and accessibility of annotations and add-ons in a multi-context system be maintained if the main artifact is mainly used as a print out? How can interactivity with the data contained in multi-context systems be provided? Are technologies like RFID, 2D barcodes and imaging systems, Tangible User Interfaces, etc. more suitable to design such systems to create mixed reality environments? In our future work, we plan to investigate these question in a more sophisticated prototype and evaluate it with real users.

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