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Experimenting Crisis Response Coordination

Jörn Franke[1], Karim Dahman[2], Francois Charoy[3]
[1] SAP Research Sophia Antipolis, Antibes, France, [2,3] Nancy Université, France
hwilensk@uci.edu

Abstract. Coordination within and between organizations in dynamic situations, such as a crisis response, is still an important problem in CSCW research. Recent examples, such as the response to Hurricane Katrina, show typical coordination problems arising in this context. They lead to no efforts, double efforts and conflicting efforts. This means that the responders cannot help the people as much as possible. We assume that some of these coordination problems are related to the tools used for coordination. Modeling coordination explicitly can help to overcome the problems with current tools, such as telephone, fax or e-mail. We present our implemented concepts for modeling coordination in dynamic situations explicitly and explain challenges with respect to their evaluation in form of interviews and experiments.

Introduction

Developing and evaluating information system supporting coordination of a crisis response is a challenging topic. Moreover, the situation becomes even more difficult if we consider the inter-organizational dimension of this problem. However, recent disaster examples, such as Hurricane Katrina have shown that there is a need for designing and evaluating information systems addressing this problem [10]. There, we find typical coordination problems. For example, people were rescued from an area and left on highways without anyone taking care of them or providing shelter. Some areas were searched several times, but others not at all. Coordination problems lead to no efforts, double efforts or conflicting efforts. The result of them is that people cannot be helped as much as possible. Based on our interviews in the SoKNOS project [4], we assume that some of these coordination problems are related to the tools used for coordination in a disaster response. Examples for these tools are telephone, fax, e-mail, notes, Whiteboards or radio. While they allow ad-hoc coordination in nearly every situation, they only enable the users to coordinate in a very unstructured way. According to Malone and Crowston, coordination is about “managing the dependencies between activities” [8]. However, when using current tools, the dependencies between activities are not made explicit. They may exist in the head of people or are hidden in unrelated messages. Thus, we propose to model them explicitly with information system support.

We describe in the next section our framework for explicit modeling of coordination in dynamic situations. The disaster response is critical example for this. Afterwards, we present how the framework can be extended to the inter-organizational level. Finally, we discuss our efforts to evaluate our concepts implemented in a distributed collaboration service. We explain challenges with respect to interviews and experiments with students.

Modeling Coordination explicitly in dynamic Situations

Modeling coordination explicitly has been subject to intensive research in the CSCW community. There, many different types of workflow systems have been proposed (cf. [4] for a more detailed overview). These systems allow modeling coordination explicitly by describing graphically the activities and dependencies between them. This has several benefits. It is clear for the user, what has been done, what is currently going on and what are the next steps. The models can be evaluated according to certain correctness criteria, e.g. freedom of deadlocks. Furthermore, their execution can be tracked by a system and the users are aware of the status of the activities. Hence, we find already several proposals to extend these system for dynamic crisis response management (e.g. [7, 5, 2, 6]). Nevertheless, only recent work explores the problems of these systems in the crisis response in more detail [4]. Given the limitations of the existing approaches, we designed our own approach based on user interviews in the SoKNOS project. For instance, we identified the problem of shifting goals in a dynamic situation. Shifting goals imply that the current set of activities needs to be reassessed. This includes also their dependencies. For example, let us assume a disaster response to a flood (cf. SoKNOS use case [4]). The military fills and transport sandbags for the fire brigade. The fire brigade uses this sandbags to build a dam. However, the flood gets worse and the goals shift towards evacuating a residential area. This means building a dam is canceled and evacuation is initiated. However, the organizations need also to take into account that filling and transporting of sandbags need to be cancelled, otherwise conflicting efforts take place (i.e. typical coordination problem). Clearly, this is a simplified example, but in reality there are more dependencies and activities. Thus we think information system support is necessary. We describe in the subsequent sections how such information system support can be designed and evaluated. These concepts have also been implemented in a distributed collaboration service.

A Framework for explicit Modeling of temporal Coordination

Our framework allows modeling of activities and temporal dependencies between them. Examples for temporal dependencies are that activities have to start at the same time, can overlap or have to finish at the same time (cf. for a complete list [4]). It is not obligatory to model dependencies and only the ones perceived as important by the user need to be defined. It is also not necessary to provide concrete quantitative points in time (e.g. they start at 12:02), because we assume this is very difficult to define in a dynamic situation. The model can be verified for correctness to make sure that the activities can also be executed given the temporal dependencies. Furthermore, it is possible to keep track of the execution of activities (i.e. their state changes). This allows also detecting deviations between the model and how activities have been executed. Shifting goals leading to a reassessment not taking into account all dependencies can thus be detected and highlighted to the user. We provide now an illustrative example how this framework works in Figure 1.

We see there the evolution of the model for a response to a flood disaster in four stages. In the first phase, the fire chief has modeled the activities “Protect Area from Flood” and “Build Dam”. A dependency is established between them. This dependency says that the activity “Build Dam” should only be executed if the activity “Protect Area from Flood” is executed. The verification procedure does not return any errors in the model. At the moment, both activities are in state “Execute”.

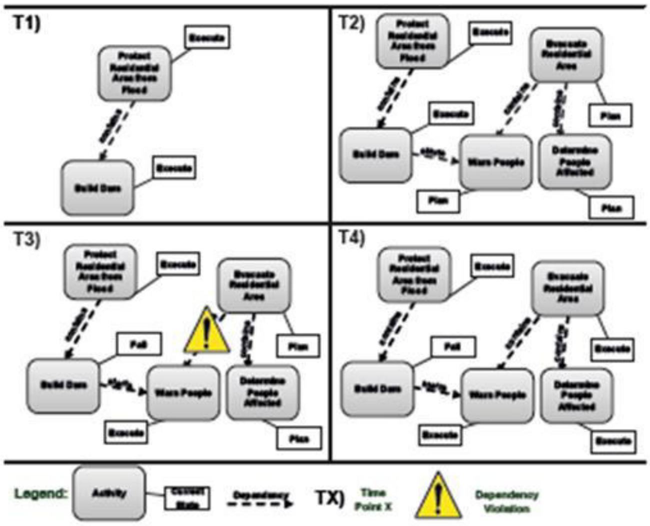

Figure 1. Example Model of our Framework

In the second phase, further activities are modeled: “Evacuate Residential Area”, “Warn People” and “Determine People Affected”. These activities are in state “Plan”. Further, dependencies are modeled between them. The verification procedure confirms the correctness of the model. In the third phase, the activity “Build Dam” is changed to state “Fail” and the user changes the activity “Warn People” to “Execute”, because the goal shifts from protecting the residential area to evacuating it. This leads to a violation of the dependency between the activities “Warn People” and “Evacuate Residential Area”, because the latter is still in state “Plan”.

The user resolves this in the fourth phase by executing the activity “Evacuate Residential Area”.

Extension of the Framework to the Interorganization Level

Given our interview results (cf. [4]), we came to the conclusion that our framework would be most useful when using it on the inter-organizational level to facilitate coordination between organizations. Hence, we developed a concept to enable inter-organizational coordination with our framework. Here, we need to consider that privacy, regulatory, strategic or other reasons prevent that everything can be shared between everybody. For example, the military cannot share everything what they do with the fire brigade.

The basic idea of our concept for the inter-organizational level is illustrated in Figure 2. Each organization has its own workspace, where it models activities and dependencies. Selected activities can be shared between people of different organizations. This means that they are replicated in the different workspaces of the organizations and that updates, such as state changes, are also replicated when they occur. Dependencies can be established between shared and internal non-shared activities. In the example in Figure 2, the military has shared the activity “Transport Sandbags” with the fire brigade. It is replicated in both workspaces. They fire brigade has established a dependency from the shared activity to the activity “Protect Residential Area from Flood”. The shared activity is changed to state “Execute” by the military and this state change is propagated to the workspace of the fire brigade.

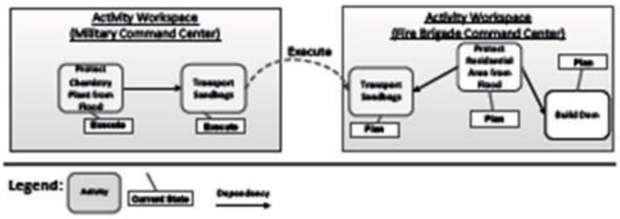

Figure 2. Example for Sharing Activities Between Different Organizations

Of course, replication means that there can be conflicts. These conflicts may lead to a diverging view on activities or dependencies in different workspaces. However, we argue that there is a need for a converging view in order to avoid coordination problems. Contemporary tools do not address this. For instance, in [4] we identified conflicting state changes of one shared activity (e.g. it is changed into “Fail” in one workspace and into “Cancel” in another) or different causal order of state changes leading to a different view with respect to the violation of dependencies. We also described how these conflicts can be detected and handled automatically to ensure eventually a converging view.

The Challenge of Evaluation

Evaluating crisis management software is not an easy task. There are several possibilities. We investigate in this section three different methods for evaluation: Expert interviews, disaster exercises and experiments. Afterwards, in the next section, we describe the design of our own experiment to evaluate the concepts implemented in a prototype mentioned before.

Expert interviews can be used to gain a consensus about advantages and disadvantages. Based on our own experience [4], this can provide useful hints. However, we noticed also cultural differences with respect to risk attitude towards using new software. Some experts were more reluctant to accept new technologies as part of their work.

Disaster exercises are probably as close as possible to a disaster response. However, their goal is usually not evaluating tool support. Thus many complex factors come into play that makes it difficult to assess the contribution of a tool with respect to coordination. Furthermore, they are usually costly and difficult to repeat. This is particularly true for inter-organizational exercises.

We think experimental results are complementary to evaluations in disaster exercises. They require fewer resources and can be repeated more often. Additionally, they can focus on the tool to be evaluated. However, results from experiments cannot be transferred to conclusions with respect to the tool support in a disaster response. Nevertheless, they are useful to interpret the results obtained in a disaster exercise or expert interviews. Experiments have been already described for evaluating tools and concepts in the area of information systems for crisis response (e.g. [9]).

Design of an Experiment

Although experimental research is important, there are not many experiments described with respect to interorganizational coordination in dynamic situations. We find some experiments about dynamic process management in the literature, but they do not address the inter-organizational dimension. Thus, we designed an experiment to assess and compare different tools for this purpose. In order for the experiment to be successful, it must demonstrate the typical coordination problems, as described before, can be reproduced. We conducted the experiment successfully three times to confirm its design. Further experiments are currently conducted to assess and compare different tools including our own prototype.

Details

Our experiment design is inspired from the LEGO serious play™ experiments in management science [1]. There, LEGO®[1] has been used as a tool to describe and evaluate business strategies. Contrary to existing work, our experiment requires to coordinate actions in the real world and not coordinating work on a digital artifact. We expect that this would lead to a higher probability that coordination problems will occur and think it is more closely to the disaster exercise case.

During the experiment, five student teams had to coordinate the construction of a LEGO® object: architect, builder, assembler, transporter and engineer. Each team

1 LEGO® is a trademark of the LEGO Group of companies which does not sponsor, authorize or endorse this publication (see http://aboutus.lego.com/corporate/fairplay.aspx)

was located at a different site and could not see what the other team was doing. They had to coordinate through an assigned tool (e.g. chat tool). A LEGO® object consisted of LEGO® components, which consisted of standard LEGO® bricks. The architect team had the specification of the LEGO® object. It instructed the builder team to construct components and the transport team to transport them from the building site to the assembly site.

There, the architect instructed the assembler how to create an LEGO® object out of the components. The builder team had only the specification of the LEGO® components. The engineer team had to construct another LEGO® object, which was related to the object of the architect team. It requested LEGO® components from the builder team and assembled them itself. Since not every team knew what the other team was doing or their specifications, we expected that typical coordination problems would occur. Shifting goals can be simulated in various ways, for example, by change of specification or change of teams.

Outcomes

In order to assess the experiment design, we generated three different outcomes of the experiment. The first outcome was a survey conducted before and after the experiment. The survey conducted before the experiment assessed the expertise of the participants. Dörner showed that experienced managers have better skills to solve problems in experiments than students [3]. However, valid conclusion can be still derived from student experiments. The survey after the experiment tried to assess which coordination problems could be related to the tools used and which ones had other reasons. For instance, we asked each team what were the main problems and what were the problems faced with each team. They had also to provide input on advantages and disadvantages they faced with their tools. We found out in the surveys that indeed problems occurred due to the tool used, but other problems had their cause in misunderstandings.

The second outcome was the data gathered from the tools used for coordination. We show in Figure 3 an example for a coordination problem caused by the chat tool used. The architect team got confused, because the builder team confirms twice that the same blue component has been completed, but it never receives information about the white component. This led to further confusion. Further conflicts have been identified in the data gathered from the tools.


me: Build Piece (C,1)
4* Build Piece (C,1,White)
4* Build Piece (C,1,Blue)
Builder: finish(4* Build Piece (C,1,Blue))
me: Blue?
Builder: sorry
me: i asked you first the white ones :p
Builder: that's done
me: Build Piece (B,2,Grey/Red)
Builder: finished(4* Build Piece (C,1,Blue))
me: i asked you something
how is the work?
stop building
unbuild Piece (B,2,Grey/Red)
tell me when it is done
the unbuild

Figure 3. Example for a coordination problem when using the chat tool

The third outcome was the objects constructed by the efforts of different teams. It turns out that the objects were very close to the specification, but did not fit exactly. For instance, in one case one part of the object has to be hold by the assembler team so that it does not collapse. We could not exactly identify the root cause for this, because it could have been also a misunderstanding between architect and assembler team. Further interviews with each team member could have identified the root cause.

Summary

We described in this section the design of an experiment to evaluate tool support for inter-organizational coordination in dynamic situations. We demonstrated that the experiment can reproduce typical coordination problems. Furthermore, we explained how it is possible to determine if the root cause for these problems is the tool or something else. Thus, we validated the experiment design. Further experiments will allow us to assess and compare different tools for inter-organizational coordination in dynamic situations.

Conclusion

We presented in this paper the problem of inter-organizational coordination in dynamic situations. Dynamic situations have been characterized by shifting goals of different organizations that lead to coordination problems. We argued that adequate information system support can avoid some typical coordination problems in this setting. Afterwards, we explained our own concepts for addressing these problems. They have been implemented in a distributed collaboration service [4]. Finally, we addressed the problems of evaluating these kinds of systems. We described in more detail the design of an experiment to assess tool support for inter-organizational coordination in dynamic situations. We confirmed the validity of the experiment by conducting it three times. Further executions allow assessing different tools. Future versions of the experiment can enable us to assess different aspects of our concepts, such as the synchronization mechanisms on the inter-organizational level. The challenge here is to produce synchronization conflicts without forcing the user to create them consciously.

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