AN OBJECT-ORIENTED METHOD AND TOOL FOR STUDYING COLLABORATIVE ACTIVITIES

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ABSTRACT

This paper provides an overview of a method and tool that have been used for studying interaction in the frame of synchronous collaborative problem solving activities. This method is based on the "Object-oriented Collaboration Analysis Framework (OCAF)", a framework that puts emphasis on the abstract and tangible objects that appear on the mediating computer screen during problem solving. The notions of the "objects' histories and ownership" are introduced in this analytical framework. In the paper we put special emphasis on a tool that has been recently developed to support this framework, together with extracts of studies that have been undertaken, during which OCAF has been effectively used.

Keywords

Groupware, computer mediated collaborative problem solving, collaboration study.

1. INTRODUCTION

Analysis of activities of groups of people engaged in problem solving- at a distance- is important for gaining an insight in the problem solving process and understanding of collaborative interactions. Socially inspired theories, supported by the growing development of network and CSCW technology, have increased research on technology-based collaborative problem solving environments. The methodological issues of collaboration analysis are of prime importance, given that they are directly related to the development of this research and technology area. This is a methodological strand of particular importance in the context of human-computer interaction studies, given the widespread use of computing equipment for supporting groups of collaborating actors.

In this paper we outline a method for analysis of collaborative problem solving activities, inspired by key aspects of Activity Theory [12]. Activity-Theory-based methods, supporting information technology design, have been proposed recently, e.g. Activity Checklist [9], AODM [14], ActAD [11], however these techniques do not include explicit models and tools for the evaluation phase.

This method has been used for conceptualisation of the situation of groups of individuals, engaged in exploratory and design problem solving activities, and for evaluation of the effectiveness of IT design. The method called "Object-oriented Collaboration Analysis Framework (OCAF)" was originally proposed in [4]. Recently, analysis tools have been built to support this framework, while OCAF has been used in a number of field studies investigating various aspects of collaborative problem solving (e.g. [2,3,8,10]).

OCAF studies the activity through the objects of the solution. I.e. the objects that exist in the problem-solving context become the centre of attention and are studied as entities that carry their own history and are "acted upon" by their owners. This perspective produces a new view of the process, according to which the solution is made up of structural components that are "owned" by actors who have contributed in various degrees to their existence. This view of the world can be useful, as it reveals the contribution of the various actors in parts of the solution, and the relevant focus shifts [5,6], identifies areas of intense collaboration in relation to the final solution and can relate easily to other analysis frameworks like interaction analysis.

In this paper, an outline of the OCAF method is included together with presentation of the functionality of the *Synergo* tool that has been proposed to support the method. This tool is associated to a synchronous collaboration-support environment, which permits direct communication and problem solving activity of a group of distant users, manipulating a shared diagrammatic representation. Through the Synergo analysis tool, the researcher can playback the activity off-line and annotate the activity and the produced solution using an annotation scheme which can be defined and adapted according to the specific objectives of the study.

2. MODELLING COLLABORATION

In this section we describe the key parameters through which we can model collaborative problem solving activity. We suppose that the activity involves a group of subjects (actors) who are engaged in collaborative problem solving mediated by computing technology. Problem solving activity is usually considered as a process of refinement of abstract ideas ("abstract objects") and externalisation of these ideas in the form of parts of the solution to the given problem. Collaborative activity is based on communication, which takes the form of either direct communication acts or by observing operations in the shared activity space (feed-through communication [7]). Operations of the group members are defined as events that are either changes of the state of the activity space or communication messages.

The activity is defined according to the following four dimensions:

The time dimension:

The actors' dimension: All actors, $A = \{A_1, A_2, ..., A_k\}$.

The objects' dimension: $O = \{O_1, O_2, ..., O_\ell\}$. In the frame of the Synergo tool discussed later, a solution is considered as made of components (objects that compose the final solution), rejected components and abstract components

The typology of event dimension: This is a dimension through which interpretation of the activity can take place. We assume that there is an existing analytical framework, which defines this typology. If *r* is the finite number of expected event types, then we define a set $T = \{T_1, T_2, ..., T_r\}$ as the analytical framework of the study. While in the original OCAF proposal [4] we have included such a closed set *T*, in this current version we consider the method as independent of a specific analytical framework, so set *T* can be defined by the framework user.

Using the above four dimensions we can describe any given activity as a set of discrete non-trivial events produced by the actors. These define an ordered set of *m* events $E = \{E_1, E_2, ..., E_m\}$. Each one of these events is related to meaningful operations of the actors who interact with objects of the set *O*. Each event is defined as a tuple $E_{i_{tAOT}} = (t_t, A_A, [O_O], [T_T])_i$ where $i \in [1, m]$, *t* the event timestamp, *A* the actor who performed the operation of the specific event, *O* an optional parameter referring to the object of the specific operation and *T* an optional parameter which interprets the event according to the analysis framework T.

This is a useful model for ethnographic studies. Every time an event is produced by the actors, this is recorded and a history of such events, i.e. an ordered list of *Es* can be produced, as a result of such an activity. No mental or cognitive operators are defined, as these can be generated later as interpretations of the recorded activity. This model permits further analysis and interpretation of the activity, while quantitative indices of the activity can be easily produced or visualizations can be generated [13].

The mediating computer tool may adhere to a typology of generated events, thus automating the task of categorization of observed events, so for instance if a software tool is used that permits a number of operations, every time such an operation is recorded this is automatically categorized according to a scheme of analysis.

OCAF interprets exchanged messages (written dialogues during collaboration by distance), or oral utterances (during face to face collaboration), in relation to operations towards "objects" of the activity space. A language for action approach [17,15], defining a unifying framework for analysis of the activity is used in this case.

3. VIEWS OF COLLABORATION

Various analytical views of quantitative or qualitative nature can be generated using this model and visualized through the Synergo tool, as in the example shown in fig.1.

Some of them are related to quantitative measures of collaboration, like *density of activity*, if a time quantum is defined of t_q length.

An alternative index that often needs to be defined during collaborative problem solving activities is that of *balance of activity* between the partners. A specific example of definition of an index of balance of activity (Collaboration Factor) has been proposed in [13], related to activity that produces diagrammatic representation of a solution made of a set of interrelated objects *O*.

In addition, a *spatial representation* of the activity can be generated by mapping the events to the produced final solution. This is a form of a spatial representation, as the components of the solution can include the sequences of the events that lead to their creation, i.e for each object O of the solution, we can associate the sequence of events E_i for which O_i is of a specific object O. This is defined as the *object history*. Such a view can be seen in fig.2.

Additional secondary indices may be associated to these objects, like the *diversity of actors A* that appear in such set of events, the length of this history, i.e. the number of events associated to a specific object, etc. Also measures of *focus* of activity and *focus shifts* can be generated through this view.

The views created by the OCAF model are useful for the analysis and evaluation of problem solving, providing a perceptual view on these parameters. This view can be directly related to the produced solution, associating the history of interaction to the items involved. Also items discussed but not included in the solution appear in this view. One can consider the generated views as an attempt to relate the time dimension (predominant in interaction analysis) to the space dimension (predominant in diagrammatic solution representation). Various transformations of this view can make it suitable for different users. For instance, by adequate colour-coding of the participants and their roles, the association of ownership to solution items could become vivid, supporting reflection of problem solvers in a metacognitive level. So this tool offers the opportunity for the computer to be subsumed into the gestalt, to take the role of scribe and historian in a group dynamic. These roles are vital to group success, and, especially in distributed teams working in virtual spaces across, where group dynamics are difficult to maintain.

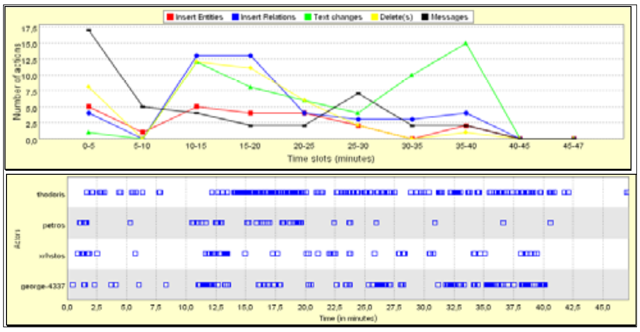

Figure 1. Views of the activity produced by Synergo: (a) density of activity per type of event, (b) activity per actor.

4. AN EXAMPLE OF COLLABORATION STUDY

In a typical synchronous collaborative problem-solving situation, two or more actors, supported by networked equipment, collaborate at a distance by communicating directly and by acting in a shared activity board. A digital representation of a solution to a given problem may appear in this shared board. This activity is typically monitored through logging of the main events, recording the activity of the actors in the shared activity board and of the dialogue events, if they are in text form. In addition the dialogue can be captured, through video and audio recording, if videoconferencing technology has been implemented, while additional information of the activity and the context within which this has taken place, may be captured in other forms. The collaboration-support tool used in recent studies has been Synergo, a tool that permits collaborative building of diagrammatic solutions to problems in the form of flow charts, concept maps or other graphical representations [16]. This environment has been built using the *Abstract Collaborative Application Building Framework* developed in the frame of the ModellingSpace project [1]. Synergo supports annotation of the solution according to the OCAF approach and visualization of a number of indices of the process. The analysis methodology involves two phases supported by the tool, as discussed in the following.

During phase (A) we define an interpretative scheme of the expected operations during the problem solving activity. This scheme defines a closed set of event types *T*. In the provided analysis tool, the user can define such a set and associate typical events included in the log file to them. *Proposal, Contestation, Rejection and Acknowledgement* were the events that were related to dialogue acts and *Insert, Modify, Connect* were related to events on the activity space of our example study.

During phase (B) the Synergo analysis tool is used for presentation and processing mainly of the logfiles, produced during collaborative problem solving activities. These logfiles contain time-stamped events, which concern actions and exchanged text messages of partners engaged in the activity, in sequential order. The logfile events are produced by exchanged control and textual dialogue messages and need to adhere to a defined XML syntax. These events can be viewed, commended and annotated by the tool discussed here. The activity can be reproduced using the Playback tool of Synergo that reconstructs the group problem solving activity on the actors' workstations desktop step by step, through a single view. Annotation of the events is done, according to the specific analysis typology defined in phase A, that permit building of an abstract view of the activity.

In the example of fig.2 one can see the graphic representation of this history and annotation of the solution in the shared activity board. Each item of the diagrammatic solution of a problem (a concept map representing a web service in this case) is associated to the sequence of events that lead to its existence. So the sequence *(I),(C),(M),(R),* shown in figure 2, represents the following events: *(I)nsertion* of this object by actor A, *(C)ontestation* of this insertion by Actor B, *(M)odification* of the object by Actor A and *(R)ejection* of the modification of Actor B. This view of the activity depicts the intensity of collaboration in relation to specific parts of the diagram and identifies the

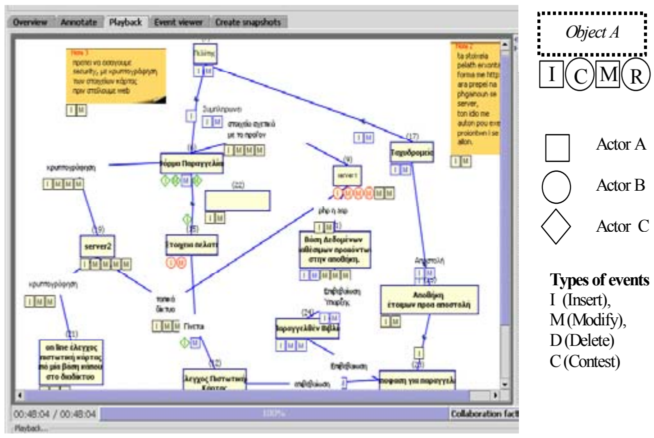

Figure 2. An annotated solution

collaboration patterns of the activity.

Generation of the annotated view by interpreting one by one the logfile events is a tedious process; the Synergo environment facilitates this process, by allowing association of the events, automatically generated by the software, to classes of annotations. So for instance, all the events of type "Modification of concept text" in a concept-mapping tool are associated to the "*Modification*" type of event of the OCAF scheme.

Not all events however can be automatically annotated in this way. For instance, textual dialogue messages need to be interpreted by the analyst and after establishing their meaning and intention of the interlocutor, to be annotated accordingly. So for instance, a suggestion of a student on modification of part of the solution can be done either through verbal interaction or through direct manipulation of the objects concerned in the shared activity board.

This process often necessitates definition of new objects that do not appear in the activity space. These are the "abstract objects". In our case the actors negotiated during the initial phase the characteristics of the model to be built, so the concept "model" was an object of negotiation and was defined and accordingly annotated at this stage. The annotated solution can be visualized, like in fig.1 or through the graph the Collaboration Factor (CF) [13].

5. CONCLUSIONS

The OCAF method supports analysis of data collected during ethnographic studies of various forms through which interpretation of the activity can take place. It has been used effectively for evaluation of collaboration-support groupware.

New innovative concepts of the OCAF method are the *history* and *ownership* of the objects, the various *views* over the activity, supported by the tool that has been developed. A key concept is the unification of dialogue and action and the object oriented character of both, through the event analysis scheme. In the original OCAF method proposal, such a scheme was included, while since then other researchers have applied different analytical frameworks using the same method effectively, (e.g. [16]). A number of quantitative indices have been generated from the proposed OCAF model, like the collaboration factor, which produce a visual effect of the activity at run time, or can be used for analysis later on.

The contribution of the OCAF tool to interpretation of the activity using various views and levels of abstraction is substantial, since the tools are capable of reproducing the activity, using the logfile of annotated events.

6. ACKNOWLEDGEMENT

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