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TOWARDS AN XML-BASED REPRESENTATION OF COLLABORATIVE ACTION

Abstract. Interaction analysis is a core function for the support of coaching and evaluation in CSCL. It relies on information captured from the actions performed by the participants during the collaborative process. This information includes data of distinct nature and format, which demands a *flexible* and *standardised* data representation, *adaptable* to different analytical perspectives and collaborative situations. Besides this, it is known that the correct interpretation of human action needs to take context into account. We propose in this paper our approach towards the definition of an XML-based representation of source data, which includes a description of the context of collaboration, and offers a common representation for data of different origin and nature. It is extensible, and independent of the subsequent data analysis methods to which it might be applied. The paper also discusses the possibilities and limitations of XML as a representation language.

1. INTRODUCTION

Analysis of interactions has been recognised as the basic instrument for the understanding of collaborative learning (Dillenbourg, 1999), and it is at the core of evaluation and coaching in CSCL. Recently, Jerman, Soller and Mühlenbrock, (2001) have proposed the *collaboration management cycle* as a model of the functions needed to support interaction analysis in CSCL environments. A central element of this cycle is a *representation of the data sources* suitable for further processing by the analysis systems.

Our interest in the representation of collaborative interaction is motivated by our current work regarding computational support of formative evaluations in CSCL. It is part of a more general research project oriented to the refinement of the DELFOS framework for the design of collaborative learning situations (Osuna, Dimitriadis and Martínez, 2001). For it, we have taken a *situated learning* perspective (Wilson and Myers, 2000), which has led us to the definition of a mixed method for formative evaluation (Martínez, Dimitriadis, Rubia, Gómez, and de la Fuente, 2003). It relies on an interaction analysis cycle inspired in the one defined by Jermann et al. (2001), where data collected from the collaborative activities supports the overall evaluation process. These data need to be represented in a *format* that meets the following criteria: it has to be *generic* to be able to integrate the different sources, *flexible* so that it can be adapted to different analytical perspectives, and represented at an appropriate *level of abstraction*, so that it can be processed either manually or computationally. Finally, it has to be expressed explicitly in a standard language in order to promote *interoperability*.

Unfortunately, existing proposals for interaction modelling do not meet these requirements. Either they are constrained to a single source of data, or they do not make explicit the representation format they use. Some systems rely on dialog analysis, usually based on some form of pre-codification performed by the participants, like EPSILON (Soller, 2000). Others base the analysis on actions performed on structured shared workspaces, like Mühlenbrock (2001), and OCAF (Avouris, Dimitracopoulou, Komis, and Fidas, 2002). None of these proposals offer an interoperable solution based on an explicit and standard representation of the interactions.

Therefore, CSCL still lacks an explicit definition of the information that systems should provide for supporting interaction analysis procedures. We propose in this paper an XML-based definition of collaborative interactions, independent of any analytical approach, adaptable to different scenarios, and suitable for the representation of data coming from diverse sources, including field work as well as automatically collected data. We have chosen XML (Bray, Paoli, Sperberg-McQueen and Maler, 2000) as it is an accepted standard that provides a common and understandable representation of the vocabulary, and can help to improve reusability, modularity and interoperability of the applications.

The rest of this paper is structured as follows. Next section introduces the main characteristics of the proposal, including a generic definition for collaborative action, and the ideas for the representation of context and of different types of action. Then, we present the steps performed for the validation of the model and the results obtained from it. The paper finishes with a brief discussion that includes the benefits and limitations of the use of XML as a representation language and our ideas of further work.

2. COMPUTATIONAL REPRESENTATION OF COLLABORATIVE ACTION

We start introducing the *concept* of collaborative action in which we base the rest of the proposal. Then we present our approach to the representation of collaborative actions.

2.1. Concept of Collaborative Action

The concept of collaborative action is not easy to define. Although it has been extensively used in the literature, either its meaning has been taken for granted or it has been defined specifically within the context of each approach. We need a definition able to deal both with actions and discourse, covering cognitive and social aspects of interaction, simple to process and able to deal with known problems, such as silence and inactivity (Littleton and Light, 1999, p. 182). Taking these issues into account, we propose the following definition for interaction as "*an action that affects or can affect the collaborative process. The main requirement for an action to be considered a possible interaction is that the action itself or its effect can be perceived by at least a member of the group distinct of the one that performed the action*". This definition provides a generic view of interaction, without restricting it to a particular source of data or analytical perspective, and gives an operational criterion to select appropriate input for interaction analysis.

2.2. Description of the Model and its XML Representation

This section introduces the main ideas of our proposal towards the definition of a model of collaborative action and its representation in XML, which has been defined by means of a DTD (Data Type Definition), whose main elements are depicted in figure 1.

The DTD represents the context of the collaborative actions adopting some elements from the DELFOS framework which was specifically defined for the design of CSCL applications. It proposes the concept of situation to model the general features of a learning environment, including learning objectives, number of expected participants, metaphors, etc. According to these ideas, we propose the element SITUATION as the one that represents the context of the learning activities in the model and in the DTD. A situation is defined by a set of generic attributes (id, name, desc), and by the optional textual element SIT.DESC. A situation is constituted by a set of sub-elements: ROLES, USERS, GROUPS and OBJECTS.

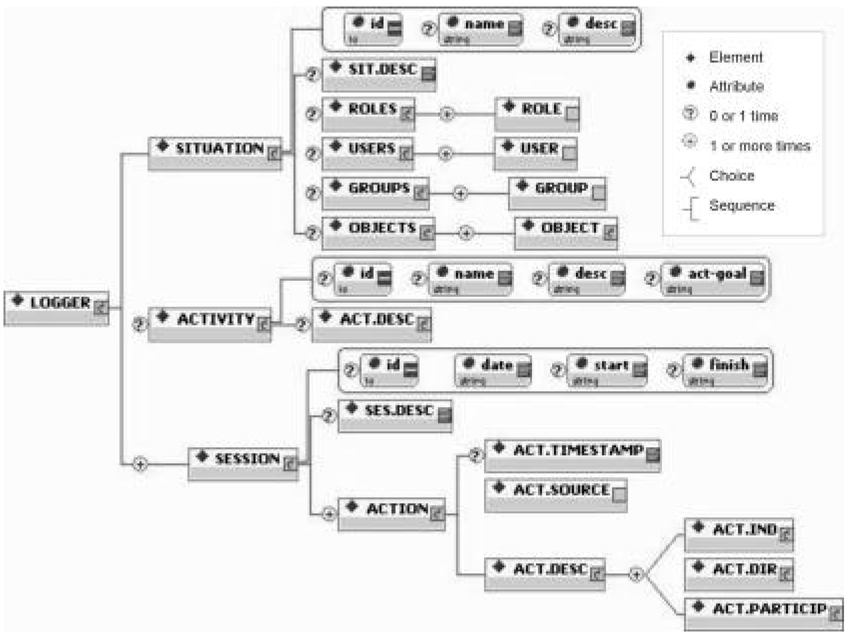

Figure 1. Overview of the DTD proposed. It shows the top-level elements with their attributes

The second aspect we face in our proposal is to provide an operational taxonomy for the representation of collaborative action. We aim at integrating dialog and action, as well as data collected manually as well as automatically in a common structure, by means of a classification that focuses on the agents that take part in interactions. This way, the proposal distinguishes between *direct interactions* with a source and one or more receivers (ACT.DIR), *indirect interactions*, mediated by a shared object (ACT.IND) and finally, *participation-oriented interactions*, that allow to annotate participations of an actor in situations where no receptor has been identified (ACT.PART). The main advantage of this bottom-up approach is that it easily accommodates to the data collected by the system for each type of interaction.

An important challenge that appears when trying to provide a representation that is both *generic* and *operational* is how to combine flexibility with structure. We have followed several design criteria so that the DTD can represent a wide range of collaborative interactions, and does so providing appropriate detail for a number of collaboration analysis purposes. Namely, we have looked for *modularity*, by including parameter entities, optional fragments, and external DTDs (Bray et al., 2000), as well as for *flexibility*, by constraining the obligatory elements or attributes to those indispensable for analysis, with a set of optional elements for those systems that perform finer studies. Furthermore, the DTD is *extensible* in that it can be adapted to new situations, maintaining backwards compatibility.

3. DISCUSSION AND FUTURE WORK

As mentioned beforehand, the main purpose of the definition of the DTD was to provide a common representation for data sources for the analysis of interactions in CSCL systems. It has been applied to a mixed-method evaluation we have been working on along the last three years (Martínez et al. 2002), whose main characteristics are the use of several sources of data of different nature, and the integration of various analytical approaches. The DTD has supported evaluations performed on different settings, including a semi-presential course at a traditional university, a pure distance course at an open university and a problem-based setting (Martínez, 2003). These experiences have shown that the model is expressive enough for representing a wide range of types of interaction, namely: face to face interactions obtained from field observations; indirect interactions mediated by the computer obtained from log files; and social relationships obtained from questionnaires. The DTD has been also able to support different analysis procedures, and it is a powerful tool for the integration of these data and analysis methods, which allows to increase efficiency in mixed evaluation processes.

We have faced the trade-off between flexibility and structure in the definition of the DTD. As a conclusion to this issue, we state that although it is not possible to provide a unique model suitable for all collaborative situations, XML provides mechanisms to fix a minimal structure and add optional features to be configured by each researcher at convenience. However, further work should be done in the application of the proposal to new situations in order to refine and enrich it.

A central aspect of our proposal is the use of XML as a representation language. Drawing on our experience, we can comment on its benefits and limitations. First of all, we have taken advantage from available technologies related to the standard, such as programming libraries, and XML-browsers when developing our tools. The most important feature, however, is the fact that the model can be readily used and judged by other researchers, which might be the starting point of a consensus in the structure of log files for analysis of collaboration in CSCL. However, XML is limited in that it does not provide a semantic level. Our plans of future work aim at studying how ongoing developments of the XML project, such as the work on XML Schemas and semantic extensions can help to enrich the model without loosing its current interoperability and flexibility.

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REFERENCES

Avouris, N., Dimitracopoulou, A., Komis, V., and Fidas, C. (2002). OCAF: An object-oriented model of analysis of collaborative problem solving. In *Proceedings of CSCL 2002, Boulder, CO* (p. 92-101).

Barros, B., Verdejo, M., Read, T., and Mizoguchi, R. (2002). Applications of a collaborative learning ontology. In *Second Mexican International Conference on Artificial Intelligence, MICAI 2002, Mérida* (Vol. 2313, p. 301-310).

Bray, T., Paoli, J., Sperberg-McQueen, C. M., and Maler, E. (2000). *Extensible markup language (XML) 1.0 (second ed.) W3C Recommendation.* Available on line at: http://www.w3.org/TR/REC-xml.

Dillenbourg, P. (1999). Introduction; What do you mean by "Collaborative Learning"? In P. Dillenbourg (Ed.), *Collaborative learning. Cognitive and computational approaches* (p. 1-19). Oxford: Elsevier Science.

Jermann, P., Soller, A., and Mühlenbrock, M. (2001). From mirroring to guiding: a review of the state of the art technology for supporting collaborative learning. In *Proceedings of EuroCSCL, Maastricht* (p. 324-331).

Littleton, K., and Light, P. (Eds.). (1999). *Learning with computers: Analysing productive interaction*. London: Routeledge.

Martínez, A., Dimitriadis, Y., Rubia, B., Gómez, E., and de la Fuente, P. (2003). Combining qualitative evaluation and social network analysis for the study of classroom social interactions. Accepted in *Computers and Education*, *special issue on Documenting Collaborative Interactions,* summer 2003.

Martínez, A. (2003). A model and a method for computational support for CSCL evaluation (in Spanish). *Unpublished PhD thesis*. University of Valladolid, Valladolid.

Mühlenbrock, M. (2001). *Action-based collaboration analysis for group learning*. Amsterdam: IOS Press.

Osuna, C., Dimitriadis, Y., and Martínez, A. (2001). Using a theoretical framework for the development of educational collaborative applications based on social constructivism. In *Proceedings of EuroCSCL* (pp. 577 - 584).

Soller, A. (2001). Supporting social interaction in an intelligent collaborative learning system. *International Journal of Artificial Intelligence in Education*, 12, 40-62.

Wilson, B., and Myers, K. (2000). Situated Cognition in Theoretical and Practical Context. In D. Jonassen and S. Land (Eds.), *Theoretical foundations of learning environments* (pp. 57-88). Mahwah, N.J.: Lawrence Erlbaum Associates.

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