

# An Ontology-Based Approach to Supporting Didactics in E-Learning Systems

Denis Helic

*Institute for Information Systems and Computer Media  
Faculty of Computer Science, Graz University of Technology  
dhelic@iicm.edu*

## Abstract

*Recent developments in E-Learning systems aim at providing a better support for didactics-aware learning scenarios. Typically, in order to provide that support the number and complexity of the system features must be increased. Consequently, maintaining or configuring of such systems becomes increasingly difficult. In this paper an ontology-based solution for automatic configuration of the system features according to didactically sound descriptions of learning scenarios is proposed. Additionally, a possible application of the proposed solution in a collaborative E-Learning system called WBT-Master is presented.*

## 1. Introduction

In past years, E-Learning efforts focused mainly on enabling efficient Web-based delivery of the educational content. Didactically, such an approach to E-Learning is very elementary because learners are only involved in simple Web-based reading of the content previously prepared by teachers. Consequently, many E-Learning projects have failed because of poor cost-benefit ratios or unsatisfactory learning effectiveness [3, 4].

In the scope of the CORONET project, which focused on training of the workforce in the software industry, we implemented a didactics-aware E-Learning system called WBT-Master. The system supports activity-based collaborative learning scenarios. The WBT-Master system has been used in a number of software companies for training of the workforce. The evaluation results exhibit improvements in the cost-benefit ratio and the learning effectiveness when compared with the simple E-Learning solutions [5].

However, these results could be achieved only by an enormous effort on the part of the system

developers and the teachers. There are several reasons for this situation. First of all, highly sophisticated and complex system functionality is needed to support the required learning scenarios. From the teachers' point of view, it becomes increasingly difficult to configure the system in an appropriate way in order to realize a particular learning scenario. Typically, such tasks can be only accomplished with support from the system developers. Similarly, the system developers also experience difficulties. For example, they have problems in properly understanding the advanced didactical aspects of the system.

Therefore, the whole process of providing the system support for different learning scenarios requires a lot of discussion between the teachers and the system developers and an iterative system configuration work carried out by the developers.

In this paper a solution that bridges the gap between the didactical and the functionality aspects of the system is proposed. By introducing a sophisticated ontology-based mapping mechanism between these two system levels this solution allows the teachers to deal solely with the didactics and the system developers with the functionality of the system.

## 2. Didactics in WBT-Master

The model of the didactics in WBT-Master follows activity-based didactics theory. This didactics model works with so-called learning scenarios. A particular learning scenario includes:

- A sequence of activities that need to be carried out to accomplish a particular learning goal.
- The user roles involved in the scenario.
- The system tools, features and services needed to support the activities.
- The educational content relevant to the learning goal.

Formally, an XML schema with XML elements for describing learning scenario components has been developed. A valid XML instance of this XML schema constitutes a system configuration file used to instantiate a generic integrated learning environment that supports the desired learning scenario.

Using this formalism a number of collaborative learning scenarios have been developed. These scenarios include Web-based tutoring, knowledge profiling, knowledge mining, project-oriented learning and collaborative writing.

The main problem related to the scenario development is the conceptual gap between the didactic and functionality aspects of the system. To achieve optimal results in realization of the scenarios the teachers need to get acquainted with the system functionality and the system developers need to understand the didactic aspects. This, of course, requires a lot of hard work on both sides to bridge the gap. Eventually, problems such as sub-optimal system solutions, increased costs or user frustration arise.

### 3. An Ontology-Based Model of Didactics

The main component of a learning scenario in WBT-Master is the activity sequence. The sequence prescribes all activities and how and when these activities should be carried out by users. For example, in a typical collaborative writing scenario the learners write and comment on a series of documents. The teacher provides a feedback on the documents and both the learners and the teacher discuss the provided feedback. Finally, the learners work on improving the documents.

The enclosing learning scenario provides a particular context for the sequence, i.e., the scenario binds activities to the system features and the content so that a coherent and didactically sound learning environment is obtained. Thus, the described relations between activities are *local* to the learning scenario.

However, apart from the *local* relations, activities can be related by means of *global* relations that are not specific to a particular scenario but hold for all scenarios.

First of all, such *global* relations between activities can be *temporal*. For example, *whenever* the teacher provides a feedback the learners want to discuss their results. Obviously, this is always the case, i.e., it is independent of a scenario.

Further, activities can be involved in *structural* relations. These relations describe activities, which are composed from a number of other activities. For example, we can model the collaborative writing

scenario as a composite activity that includes writing, commenting and providing feedback exactly in that order. Additionally, the above introduced *global temporal* relation between providing feedback and discussion (i.e. discussion of the results *after* the feedback) is also present.

The structural relations represent a very powerful modeling mechanism because a composite activity is just another kind of activity (i.e., they support component-based modeling) [1]. For example, in a typical problem-solving scenario the learners first read about the problem statement. At the next step they need to brainstorm a solution to the problem. Finally, they are involved in collaborative writing (the composite activity) to write down their solution.

Last but not least, an activity can be a *specialization* of another more general activity. For example, the evaluation of the learners' work is a special kind of feedback where the teacher grades the learner's work using a grading schema.

A very important principle related to the specialization relation is inheritance, i.e., the special activity inherits all relations from its general activity. For example, the above described global temporal relation between providing feedback and discussion is inherited by the evaluation activity. Thus, *whenever* the teacher evaluates the learner's work by grading it the learners and the teacher discuss the grades.

To formalize such a model we use ontology formalism and define a top-level didactics ontology that specifies the basic *activity* concept and possible relations between activities. The relations are *is-preceded-by*, *is-followed-by* (global temporal), *part-of* (structural) and *kind-of* (specialization) relation.

The use of the didactics ontology guarantees separation of concerns between the didactics and the system related issues, i.e., the teachers can concentrate their efforts solely on the didactics. Additionally, component-oriented modeling and inheritance mechanism encourage reuse of activities and support the teachers in rapid development of new learning scenarios.

### 4. Binding Activities to System Features

The developed didactics ontology does not yet address the problem of mapping of the activities onto the available system features. However, it provides the basic means (e.g., the set of the related activities, inheritance and composition) to develop such a mapping mechanism.

The main idea of such a mechanism is to develop semantic descriptions of the available system features

by relating them to the identified activities. One basic relation that can be used is the *supports* relation to express the fact that a certain system feature *supports* a particular activity. Now, when a particular activity is included into a learning scenario the system searches in the available semantic descriptions of the system features for a system feature that *supports* that activity. The system finds the related feature and adds it to the learning scenario automatically.

Let us illustrate this with an example. Obviously, the discussion forum tool *supports* the discussion activity. Whenever a learning scenario includes the discussion activity the system finds the discussion forum tool and includes it automatically into the learning scenario.

Further, the mapping mechanism can make use of the relations between the activities. For instance, the above mentioned collaborative writing activity is composed of writing, commenting and evaluation. Because evaluation is a *kind-of* feedback, and feedback is *followed-by* discussion the collaborative writing activity dereferences to writing, commenting, evaluation and discussion. Thus, the system automatically infers the system features that *support* these four activities (i.e. the document editor for writing, the annotation tool for commenting, the grading tool for evaluation and the discussion forum tool for discussion) and includes them into the learning scenario.

In addition to their relations with the activities, the system features can be related with each other. For example, the document editor tool that supports the writing part of the collaborative writing needs to deal with different versions of the documents. Typically, the editor communicates with an external version control tool to manage the document versions. Thus, we can say that the document editor tool *depends on* the version control tool. Therefore, the mapping mechanism needs to take this relation into account and add automatically the version control tool to a particular learning scenario.

To capture the relations between the system features another top-level ontology should be developed. This ontology defines the basic *system feature* concept and possible relations between features. Currently, the relations that are included into the ontology are the *depends-on* relation and the *part-of* relation to describe composite features.

## 5. Conclusion and Future Work

In this paper a possible approach to bridging the gap between modeling of didactically sound learning

scenarios and their actual realization in E-Learning system has been presented. Currently, the presented ontology-based approach is still under development. The future work will include:

- Testing of the presented approach within a number of software companies in the scope of an industry-related project.
- Refinement and further development of the approach as the result of the testing. For example, new relation types might be needed in the system features ontology and to improve the mapping mechanism.

Another important aspect that the future work will include is the compatibility with the recent standards. The basic concept of activity-based learning scenarios in WBT-Master has been developed prior to the recent standardization efforts such as IMS Learning Design (IMS-LD) [2]. The IMS-LD models the didactics through so called Units-of-Learning, which encapsulate a particular learning scenario as a sequence of recursively structured activities. Each activity is associated with user roles that take part in that activity and an environment which relates the activity with the content and a supporting system service.

Thus, the basic WBT-Master model is very similar to the IMS-LD on the conceptual level (i.e., they both relate activities with user roles, the content and the system features or services) and mapping between two models should be straightforward. Such a mapping can have a number of advantages. For example, the WBT-Master model becomes standard compatible and can make use of the recently developed IMS-LD tools such as IMS-LD players. Further, the advantages of the ontological approach such as separation of concerns, component-based modeling, reuse and simplicity of authoring become immediately available for the IMS-LD.

## 6. References

- [1] Dimitriadis et al., Component-Based Software Engineering and CSCL in the Field of e-Learning, *Upgrade*, 4(5), 2003.
- [2] Koper R., Olivier B., and Anderson T. (Editors), IMS Learning Design Information Model, IMS Global Learning Consortium, 2003.
- [3] Mioduser D., Nachmias R., Lahav O., and Oren A., Web-based learning environments: Current pedagogical and technological state, *Journal of Research on Technology in Education*, 33(1), 2000.
- [4] Oliver R. et al., Learning management systems: One size fits all?, *In Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications*, pages 1498–1499, AACE, Norfolk, USA, 2002.

[5] Trapp S., Coronet project - final report, Technical Report IST-1999-11634, Fraunhofer IESE, 2002.