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Integrating Ontologies into the Collaborative Authoring of Learning Objects

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Abstract: Authoring learning material is a multi-disciplinary undertaking where different people can play their role. Any support that can be provided for the collaboration of instructional designers, pedagogues, media designers, and students, among others, is welcome. In particular, metadata annotation of learning objects is an important task within the whole authoring process. This work presents the first resulting products and approaches from the MD2 project, consisting of a service-oriented framework and a tool to support the integrated, ontology-based collaborative annotation of learning objects.

Keywords: Learning objects, metadata, ontologies, collaborative annotation
Categories: K.3.1, K.3.2

1 Introduction

Our current Society is constantly involved in a permanent evolution of knowledge and new educational models aim to provide solutions to its challenges. The constructivist visions of education [Jonassen, 1999] claim a participative role for the learner. Learning Management Systems (LMS) are key tools to support new educational models. But traditional LMS lack the required flexibility and adaptability to implement constructivist educational models. Any constructivist approach implies involving learners further in the instructional process. In particular, many different roles can participate in the creation of learning material [Polsani, 2003], including instructional designers, pedagogues, instructors, media designers and students. For this reason and due to its multidisciplinary nature, any support for collaborative participation is welcome.

The authoring of learning objects [Milligan, 2003] and annotation tools [Magee et al., 2002] provide scant support for collaborative authoring, annotation, or edition. They bind users to editing content isolated from the rest of the team and, in the best cases, provide a basic version control mechanism. However, versioning usually works at the package or file level, but not at the content level. Collaborative authoring at the content level can be supported by complementary discussion forums, but the results of discussions may not necessarily be easily committed as changes into the final contents.

The goal of this work is to provide an integrated solution to collaborative authoring for the creation of learning material. In this way, the MD2 project aims to provide a framework, method, and a set of tools that can help authors carry out several collaborative tasks involved in the creation of reusable learning material. Among others these tasks are: editing changes, proposing annotations, sending and discussing proposals, providing assessments, conciliating different proposals and carrying the final decision to the learning object. Of course, the development of a general-purpose collaborative authoring facility for learning objects is a fairly ambitious goal. Therefore, firstly we have limited the approach to providing support for metadata annotations. Nevertheless, the overall architecture and software tools have been designed to provide a general-purpose collaborative authoring system.

In order to improve reusability of learning objects, metadata annotation is an essential task. If we consider automatic and dynamic composition of learning objects with a pedagogical purpose, it becomes clear that the computer should have access to information regarding the design of instructional material [Wiley, 2002]. Metadata annotations are the vehicle that transports this kind of information, and they should be considered as an essential authoring task. In a broad sense, annotation is considered as the act of adding extra information associated with a particular point in a document. Nevertheless, we restrict annotations to a non-linguistic form, and they must be made to a learning object (e.g. learning object metadata [Thropp and McKell, 2001], or other structured descriptive information models, like IMS Learning Design [Koper et al., 2003]).

However, metadata annotation is usually an arduous and not often a successfully completed task, despite the fact that metadata specifications are mostly mature and a number of tools are readily available. To alleviate this, a collaborative annotation approach is taken to share metadata annotation tasks among a group of asynchronous and distributed authors. On the other hand, current specifications for learning object metadata (LOM) are not fully prepared to semantically represent rich information about the design process of instructional material. LOM and related specifications cannot be readily used to annotate a learning resource to express a design restriction, or a rationale occurring during its design. The common approach here is to extend metadata with the richer semantic support provided by ontologies [Sicilia, 2004].

The rest of the paper is structured as follows: Section 2 describes the main goals of the work and the overall architecture of our solution; Section 3 focuses on the collaborative annotation module and its role within the software platform; Section 4 describes the issues that arise when external ontologies are integrated to augment the base of annotations; and finally Section 5 states some conclusions and future lines of work.

2 MD2: An Integrated Approach to the Collaborative Authoring of Learning Objects

The purpose of the MD2 project is to provide solutions to major issues that arise during the creation of learning material. The main objectives of the project are the following:

- The development of a method and a set of tools for the collaborative authoring of learning contents that can offer a framework for constructive learning and creation of knowledge with a view to improve efficiency and reduce the efforts of coordination.
- The extension of current learning objects specifications to improve reusability through metadata cohesion by means of shared and agreed on ontologies.

The sought-after authoring facilities of MD2 are provided by CARLOS[1], a collaborative and integrated development environment (IDE) used to author reusable learning objects. Figure 1 depicts the context of CARLOS authoring tools. Such IDE can be integrated with any IMS-compliant LMS that provides required external services, such as a learning object run-time engine, an index and search service, or any user modelling and profiling database.

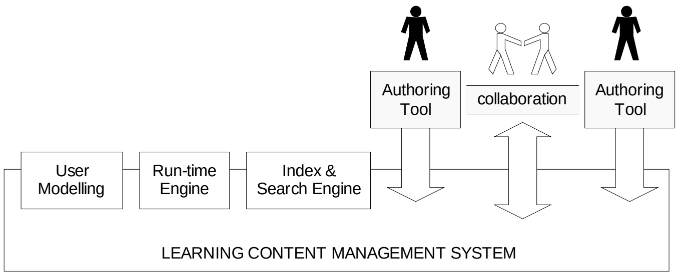

Figure 1: Context of the collaborative authoring environment

The overall architecture of the CARLOS software platform is portrayed in Fig. 2. Next, a brief description of its modules and functionalities are presented.

- *Edition + Annotation*: these modules provide the basic functionalities for editing and annotating learning objects. Both are integrated into a unique tool, but enhanced with capability extensions to consider transversal aspects served by other modules, like ontology import and collaboration support.
- *D-Ontology Import*: this module allows for the extension of the annotation vocabulary by using RDF(S) domain ontologies.

[1] CARLOS stands for Collaborative Authoring of Reusable Learning Objects System

- *Collaboration*: this module supports the collaboration protocols and mechanisms during the development of the learning object [Dodero et al, 2002].
- *Assessment*: this module provides the means to perform quality tests for the learning object in-development [Sarasa and Dodero, 2004]. It is tightly integrated with the collaboration module.
- *Performance Analysis*: this process carries out an analysis of the behavior of learning objects users during the didactic process in order to evaluate their performance in a given learning context. It takes into account the user model and the LMS run-time engine. The results of user performance is reverted into proposals for further refinement to the learning object.
- *Refactoring Observer*: this asynchronous system takes the values and annotations generated by the performance analyzer as input, and generates proposals to re-design the learning object (i.e., further annotations, refinement of objectives and/or requisites, recommendations for new examples, splitting or merging contents, etc.).

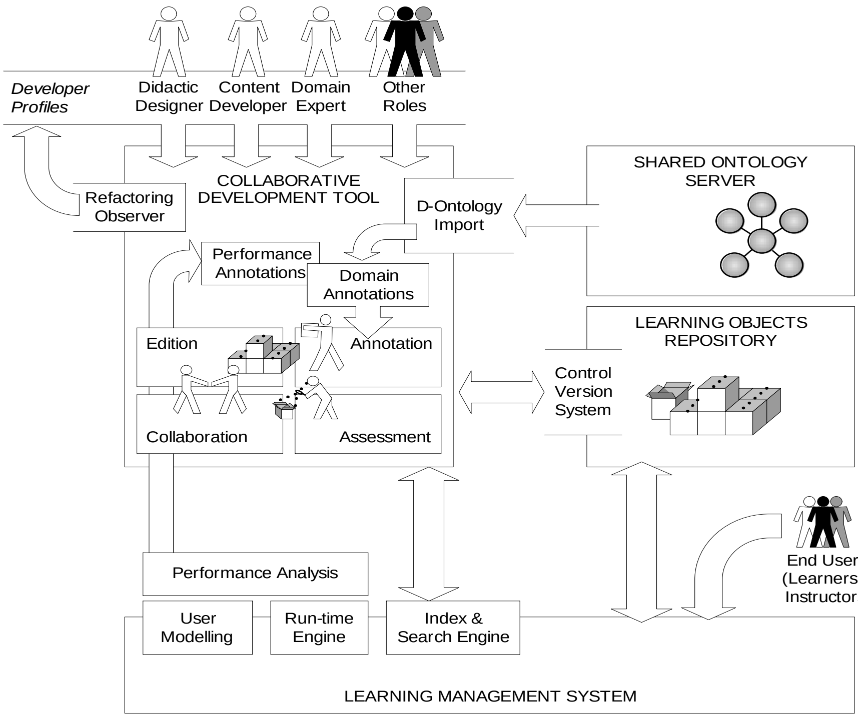

Figure 2: General architecture of the CARLOS platform

The remaining architectural components of Fig. 2 (i.e. LMS, learning object repository and shared ontology server) are external subsystems that must be adapted to the development platform in order to take advantage of their services. Web services are used to accomplish the integration of such components and systems in an integrated architecture [Padrón et al., 2004].

We have first developed a collaborative annotation tool to take advantage of the main modules, i.e. annotation, ontology import, collaboration, and assessment. The annotation tool operates over the available web service infrastructure. The tool was conceived as a general-purpose collaborative authoring system to develop XML documents, according to any predefined schema. Its pattern-based design [Gamma et al., 1995] reduces the possible dependencies that learning objects specification schemata might impose, and also allows collaboration protocols and evaluation strategies to be dynamically plugged-in and out.

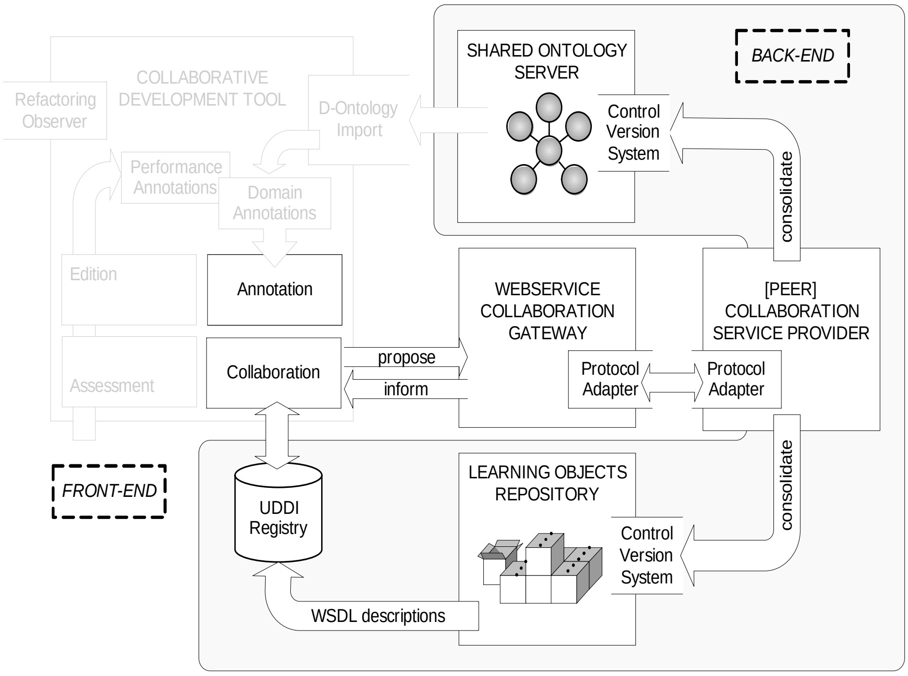

Figure 3: Role of the collaborative annotation server in CARLOS

3 A Service-Oriented Architecture for Collaborative Annotation

The collaborative annotation facility relies on a web service collaboration gateway and a collaboration service provider, which are depicted in Fig. 3. The front-end translates proposals and notifications of change to the adequate web service primitives by using WSDL descriptions. On the other hand, the back-end server works as the collaboration provider. Although it has been implemented as a centralized server, it is also feasible to integrate its services into the front-end part. This way, a peer-to-peer collaboration infrastructure can be built without any loss of functionality.

3.1 Annotation tool

The front-end annotation tool provides the interface to annotate any learning object selected from the repository. The front-end is developed and deployed independently from the back-end collaboration server. It must only consider the WSDL published interface and interact with the appropriate web services. In this way, different front-end tools can be developed to profit from the collaboration server.

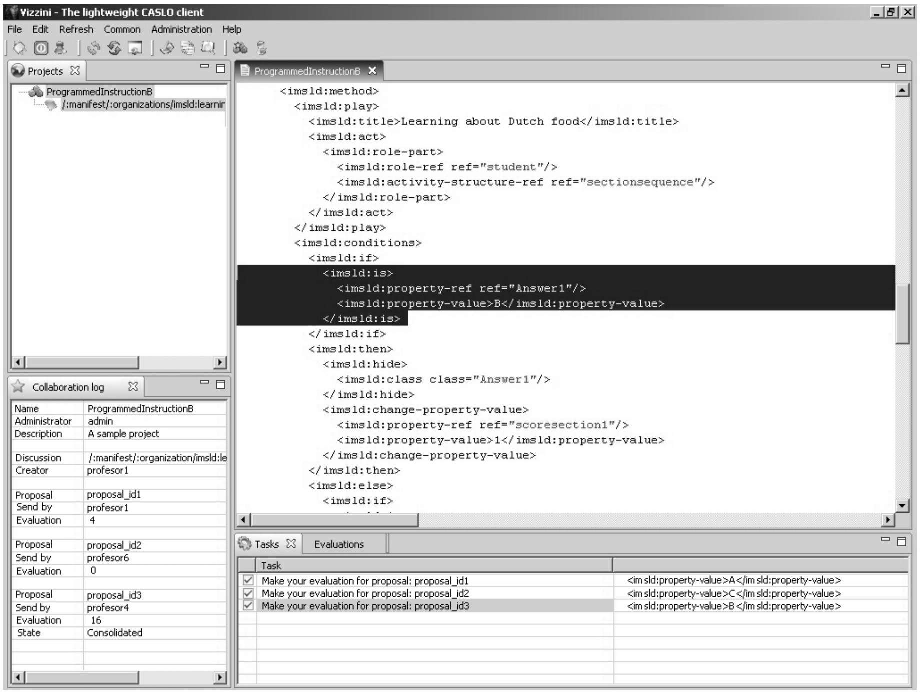

Figure 4: Operation of Vizzini *thin-client on a learning object*

Currently, a thin-client application nicknamed *Vizzini* is available for the front-end, giving access to all the functions of the collaboration services. Every annotation is carried through the collaboration server before being applied to the learning object manifest that is being edited (see Fig. 4). The upper right panel shows the current state of the manifest file with the selected annotation, the upper left panel shows a tree-structured collection of annotations, the lower left panel depicts the collaborative activity log, and the lower right panel contains the pending and fulfilled tasks and assessments for the selected annotation. However, our thin client does not provide a complete authoring environment for learning objects. For that aim, a plugged-in extension to *Reload* editor [Milligan, 2003] is being developed.

3.2 Collaboration services

The collaboration back-end allows users to annotate a learning object after negotiating and evaluating annotation proposals. Two web services have been provided for this:

- The main collaboration web service accepts the collaboration protocol messages and also deals with issues that are related to the management of users, projects, and negotiations.
- The second web service monitors the pending tasks, which are mainly assessments for negotiations in which users take part.

Every interaction is automatically negotiated and the result is included in the appropriate section of the manifest file. As a side achievement, the whole collaboration process is logged and registered in a version control system, making it possible to trace the annotations that have been carried out.

4 Integration of Ontologies in Annotation

The second goal of MD2 is to extend current learning object metadata potential to improve reusability by means of shared and agreed ontologies. In this sense, deriving meaning from contemporary web and learning resources is nearly impossible without a common metadata framework for describing such resources —that is the rationale behind the semantic web [Berners-Lee et al., 2001]—. Metadata are used to describe, certify, annotate, extend or keep an updated history of a given learning object, and represent an interpretation of resources for a machine-understandable layer (e.g. software agents, sophisticated search engines, or web services) that can facilitate their automated processing. Ontologies aim at capturing and providing a commonly agreed understanding of a given domain and play an important role as a shared source of formally defined concepts for communication. Thus, ontology annotations are commonly used to access learning objects and services from distributed repositories and present them to the users according to the learning context.

Metadata annotations are usually made according to LOM, which distinguishes different categories (i.e. general, technical, educational, classification, etc.) to describe a learning object. The *classification* category is used particularly to accommodate annotations related to a given classification scheme (e.g. the Dewey decimal classification system [Dewey, 1983] or any other taxonomy). In our work, the elements *taxon* and *taxonpath* from the classification category are chosen for cataloguing resources with domain-specific information. It must be noted that this is a limited solution, since current LOM specifications are not prepared for full-fledged ontologies that can be represented by description logics [McGuiness and Van Harmelen, 2004].

Considering that the purpose of shared ontologies is the development of conventions to support the sharing and reuse of knowledge among systems [Patil et al., 1992], it seems reasonable to think of them as an appropriate basis for performing the annotation of learning objects. In order not to constrain the future evolution of ontology annotations, we have used RDF(S) as the annotation language and wrapped RDF instances as taxon elements. This has been done according to the LOM to RDF binding [Nilsson et al., 2003].

The annotation tool must comprehend external vocabularies to be able to submit annotations that are specific to a given domain. This task is carried out by the D-Ontology Import module. Imported ontologies are classified into several shared namespaces. Domain specific ontologies are easily imported as RDF(S) descriptions and wrapped into the manifest file. In case the referred ontologies are not available online, their RDF schemata are packaged as resource files along with the learning object. External ontologies used to support the instructional design and authoring process are managed through external components and interfaces that provide navigation and edition capabilities through the domain ontology concepts [Broekstra et al., 2002].

5 Conclusions and future work

In this paper we have presented an integrated framework for collaborative authoring and annotation of learning objects, which is being developed within the MD2 project. For this goal, a collaborative IDE of learning objects has been developed. We have also discussed some issues related to the integration of ontologies in learning object annotation.

The hypotheses of the MD2 project are three-fold. On the one hand, we think that collaboration can help to reduce the effort for the development team, since annotation tasks can be more easily distributed among the development team. On the other hand, the collaborative annotation process should help to improve the quality and reusability of learning objects. Finally, we think that collaborative annotations can facilitate the constructivist approaches of learning, as long as learners and instructional designers can be jointly involved in the development of learning material. Future work is aimed towards corroborating these hypotheses through field and case studies.

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