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A common framework for information sharing in e-learning management systems

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ABSTRACT

Internet Learning Management Systems (LMSs) are powerful tools that help us in our daily teaching and learning activities. Most users and software are mainly focused in content dissemination and group works, but the possibilities that Internet LMSs could offer go further. Some recent approaches use semantic web to improve the capabilities and user experiences in e-learning by mean of artificial intelligence and knowledge management techniques. In this work, we develop a procedure to achieve the integration of different e-learning systems, and to give semantics to entities and relations in the database of LMSs by mean of ontologies. This integration could ease the dissemination of learning resources and knowledge from the databases of the Learning Management Systems. Moreover, the semantic interpretation of database schemes would allow to find precise information quickly.

1. Introduction

Internet learning management systems are tools that teachers and learners are used to use since the last decade. In their early they provided features oriented only for content sharing, but they have evolved to give us a wide interaction between students and teachers, and a set of tools to ease the learning. Today most of LMSs allow us to share documents, media, forums, blogs, bookmarks, and portfolios.

Recently, knowledge management tools have been used to improve e-learning activities (Lau & Tsui, 2009). The advances in Web 2.0 and XML-based technologies are changing our concept about WWW by mean of the inclusion of semantics in web documents and media. In the semantic web machines are able to *talk* in terms of the same concepts and to share information. This provides a higher organization in the Web and therefore a better user experience. Research regarding semantic web for e-learning has provided a wide variety of papers, but most of them converge in the use of ontologies for knowledge representation and semantic interpretation of concepts. The most common definition of *ontology* in computer science is *the formal and explicit specification of a shared conceptualization of a domain* (Gruber, 1993). An ontology contains elements like classes, attributes, relations, and logic axioms to comprise the domain represented. A *reasoner*, in general terms, is a set of logic rules which may be used to infer or retrieve information about concepts or relations over the ontology, to provide new information or to validate/refuse an initial assumption. Nilsson, Palmr, and Naeve (2002) gives an overview of semantic web, the use of metadata, RDFs and ontologies for e-learning. It concludes that the good design of metadata could help in e-learning tasks like effective support for knowledge construction and access. Yli-Luoma et al. (2006) also discusses how semantic web could be used in e-learning, and describes tools that could be developed to support context, socialization, discussions and conceptual modelling. In Huang, Webster, Wood, and Ishaya (2006), it is proposed a process with four stages to improve learning personalization. In a first stage, a context-aware semantic information service is developed. At the second step information retrieval is applied for document access. Thirdly the psychological learning theory is used to control the knowledge flow in learning activities, and finally the learner personality is analyzed in order to provide a suitable self-learning. In Dietze, Gugliotta, and Domingue (2007), it is described the architecture of a service-based e-learning system using metadata for dynamic contexts. The works (Dzbor, Stutt, Motta, & Collins, 2007; Stutt & Motta, 2004) overview semantic web and its use for web learning, and propose a model to develop semantic services for learning web communities. Henze developed a framework for workspace personalization using RDF/S (Lassila & Swick, 2004) and a service-oriented architecture in Henze (2005a, 2005b). The works (Jovanović et al., 2007; Torniai, Jovanovic, Gaševic, Bateman, & Hatala, 2008) offer a system to provide teachers with feedback about the interaction between students and learning resources. Recently, the approach in Dunkel, Bruns, and Ossowski (2006) builds an ontology with the language DAML + OIL and fulfills the integration within an e-learning platform to give semantics for the contents. After that, a multi-agent architecture is applied over the e-learning system and a reasoning

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engine provides learners with intelligent recommendations for their tasks.

Despite the efforts to apply semantic web in e-learning, a gap is found when we try to integrate and give semantics to information inside the databases of LMSs. There has been much proposals to make ontology and database matching since the 90's. The main purpose of researchers in this area has been to give semantics to database relational models. Most of papers propose a set of heuristic rules either to do the matching or to infer an ontology that represents the database. For example, in Li, Du, and Wang (2005), the authors propose a heuristic method to build OWL ontologies from data in relational databases. In Lee and Whangbo (2007), the authors provide a method to extract an ontology from data in a database and to match the extracted ontology with a previously knows domain ontology. In Astrova (2005) and Astrova and Stantic (2004), a reverse engineering method is proposed to migrate data existing in relational databases to ontologies, by mean of the information obtained from web forms analysis. The work (Tijerino, Embley, Lonsdale, Ding, & Nagy, 2005) develops TANGO, a software system to study semantics among database tables using WordNet. The method proposed firstly generates small ontologies from tables, and then make semantic mappings between these ontologies with the purpose of creating a new major general/application ontology. Recently, in Sonia and Khan (2008), it is proposed a method to transform the information from a database into an ontology, in absence of tables and database metadata. To achieve this goal, the authors provide a collection of rules to infer the metadata on the fly, and then to identify class hierarchies and relations in an ontology. In Juric and Skocir (2007), the authors propose a set of rules to transform a database into an ontology. To achieve a higher standardization and semantic enrichment, the approach is supported by mean of mappings of WordNet terms into OWL concepts. The work we have found closer to our approach in the literature is explained in An, Borgida, and Mylopoulos (2005), which describes a method to map a relational database into an ontology using simple logic formulas automatically. However, the resulting mapping could suffer of ambiguity. A survey about ontologies, databases and methods for ontology and database mappings may be found in Martínez Cruz, Blanco, and Vila (2009).

Our contribution focuses in this context. The goal we pursue is to fulfill the semantic integration of the information existing in the databases of different and distributed e-learning sites. The benefits of such integration could offer advantages like extended online knowledge dissemination. Moreover, the search of concrete learning material could be easily fulfilled due to the semantic interpretation of entities and relations of LMSs databases. Our approach may be resumed in two stages:

- Firstly, an ontology for e-learning environments is developed.
- Secondly, we make a matching between the ontology classes and properties, and relational databases of e-learning Internet systems. The data from the databases could be imported and saved as ontology class/property instances. In this step, we obtain a common framework for data sharing between different e-learning systems. Moreover, the database is given with semantics, which provides the advantages of semantic web.

This article is organized as follows: Section 2 shows the main design of the ontology to model the knowledge embedded in an e-learning system. After that, Section 3 describes a model to give semantics to entities and relations in the database of a LMS. Section 4 provides a procedure to map the data from the database into ontology class instances and slots. Section 5 shows a case study over a LMS as a proof-of-concept and the implementation details. Finally, Section 6 describes the conclusions and further work.

2. Ontology design

There have been many efforts in the last years to apply semantic web in e-learning environments. However, most open source LMSs that institutions currently use such as *Moodle* (Dougiamas & Taylor, 2003), *A-Tutor* (A-Tutor, 2007), *Sakai* (Sakai, 2008), etc., are mainly focused for content sharing and users collaboration and unfortunately they do not take the advantages of Web 2.0 completely. In order to give semantics and to allow reuse and information sharing in LMSs it is required a common abstract framework to match entities and relations in the relational database with their meaning. In this section, we propose an ontology that could be the starting point to achieve this goal. After that, once the databases would be integrated within the ontology, information sharing between LMSs would be possible. Furthermore, a simple search could be applied over the ontology structure and the class instances and slots to obtain data about relations between teachers, learners and learning resources. Fig. 1 illustrates this idea.

The interactions between agents in an e-learning system (teachers and students) are tipically represented about people knowing other people. Furthermore, the learning resources in an e-learning platform usually have properties like maker, topics, etc., and they could be interpreted as an specialization or specification of a Document. The *Friend of a Friend* project (FOAF) is one of the most popular ontologies used in the semantic web for this purpose (Breslin & Decker, 2007; Hamasaki, Matsuo, Nishimura, & Takeda, 2007; Staab et al., 2005). Basically, FOAF is a vocabulary for describing people and relations such as who knows who. To achieve the goal of standardization, the ontology we build in this work is based in FOAF. However, FOAF is not a complete data sharing solution since its vocabulary and properties are very limited. We need to extend the FOAF ontology to consider fine grained relations between entities in LMSs. The language chosen for the ontology is RDF (Lassila & Swick, 2004) as FOAF does, since the goal we pursue is to provide an abstract knowledge structure. The use of other languages such as OWL would also be possible, but the description logic and class and relations constraints of this language would also make more difficult the integration of different database designs of the LMSs. Moreover, RDF is currently one of the most used languages in the semantic web.

The extension we propose is *foafLMS*, a hierarchical organization of actors and relations in the system, where the concepts *Agent* and *Document* are the main abstract representations of entities, and *Knows* and *theme* are the main abstract relations. We have used the software *Protégé* from the Stanford University to build the ontology design. Figs. 2 and 3 show an example of the hierarchical organization of the ontology.

In summary, we may overview that an *Agent* could be either a *Person* (a *Teacher* or a *Student*) or a *Group*. Some relevant groups are a *Department* (which is a set of teachers), a *Subject* (a set of teachers and students working in specific issues) or a *WorkGroup* (a set of people working together). A *LearningResource* is a *Document*, which is specialized in *ResourceForStudy* (learning material usually provided by teachers or a work group) and *Work* (documents generated by a student or a work group). There are different specialized learning resources such as *Notes*, *Exercises*, *Media* (*Video*, *Software*, *Audio* or *Image*), *Forums*, *Projects*, *Homework*, etc. Additionally, classes *Evaluation* and *Issue* give support for agent evaluations and association of document topics and agent interests, respectively.