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Collaborative e-learning systems using semantic data interoperability



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ABSTRACT

In a collaborative e-learning content management environment, the heterogeneity of data in different learning management systems presents many difficulties for data sharing; some of these difficulties are how to integrate data, produce results for user queries, and find the correct data from heterogeneous learning management systems. Over the last few years, numerous e-learning system architectures have been proposed; however, issues related to sharing and integrating data from different e-learning systems have been given less attention. Considering this need, this paper presents solutions for semantic data interoperability, distributed metadata management, and an agent-based query processing approach for supporting the exchange of learning content from different e-learning systems. The paper presents an empirical evaluation of the user acceptability of the proposed solutions to find qualitative measures of the users' acceptability and satisfaction; our proposed solutions resulted in high user satisfaction.

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1. Introduction

Now-a-days, e-learning systems are becoming important educational means for providing a single access view of learning materials. Each e-learning system can be considered as a closed system, since the system allows accessing learning materials only to the users of the institute where the system is implemented. However, users may benefit if they are allowed to access the learning materials of other e-learning systems.

Current e-learning systems do not allow an user to access e-learning content in other systems even though the user's institute has collaboration with other institutes. If the user is allowed to search and access learning content in other partner institutes' systems then the user will be benefited in learning. A collaborative e-learning environment is necessary for providing access to other systems keeping the autonomy of the independent e-learning systems. A collaborative e-learning environment facilitates sharing and accessing e-learning content (e.g., lecture notes, lecture videos, audio, text, examination samples, discussion, etc.) among users (i.e., teachers, students, and researchers) in different systems. As more and more educational organizations are moving into e-learning environment, more and more heterogeneous data are distributed over the Internet. How to form a collaborative e-learning environment from different e-learning systems is a challenging job. Dealing with the heterogeneity of data is a big issue in such a collaborative system. Generally, in a collaborative data sharing

environment, independent sources with different goals, schemas, and data agree to share data with one another. Each source independently curates, revises, and extends this shared data. At some point data sources may wish to exchange data by establishing a temporary data exchange session. The virtual integration of all the data sources to reach interoperability and support for remote access allows efficiently information management, sharing and distribution (Ullman, 1997).

In typical data integration (Lenzerini, 2002) and data exchange settings (Fagin, Kolaitis, Miller, & Popa, 2003) we are often dealing with one world, for example, a set of sources all containing information about videos or music files. Hence, data integration or data exchange between data sources is provided mainly through the use of views or schema mappings, i.e., queries that map and restructure data between schemas. However, in a collaborative e-learning environment sources may represent different worlds with different schemas and data vocabularies, and the real world entities denoted by different symbols in different sources may be semantically related (Serafini, Giunchiglia, Molopoulous, & Bernstei, 2003). In order to share data between e-learning data sources in a collaborative e-learning environment, semantic relationships are needed. For creating semantic relationships, a possible solution is to create a domain relation (Serafini et al., 2003) through value correspondences or value level mappings (Kementsietsidis, Arenas, & Miller, 2003) between sources since data vocabularies are different in sources. The value-level mappings map the data elements of a source domain to the data elements of another source domain. Once the semantic relationships are established, answers to a query posed to a source in the system is obtained by translating the query

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in terms of the vocabularies of the semantically related data sources and propagating and executing the query into the sources.

Finding a suitable content in a collaborative environment for a particular request by an user is another important challenge. For the last years, many web-based information systems have been proposed to provide useful information, recommend better services to the users (Ogescu, Bucharest, Plaisanu, & Bistriceanu, 2008). These systems use intelligent information filtering and decision support tools aimed at providing product, information, and service recommendations personalized to the users needs and preferences at each particular request context (Lamber, Girardello, Ricci, & Mitterer, 2009). Although, there are lot of scientific and technological development progress over the recent years, a significant portion of the decision-making information on choosing right course materials, course information, etc. is still based on manual searching and processed using unstructured information.

The objective of this paper is to propose a solution of data interoperability settings between two e-learning systems and a framework for a collaborative e-learning environment that goes beyond just the information systems connectivity but allows autonomous e-learning systems to share and search learning data efficiently internally or externally.

The contributions are listed below:

- Propose a formal data heterogeneity resolving solution using well-formed mapping techniques.
- Propose an approach for learning content management in a e-learning collaborative environment. For this purpose we propose a metadata structure and agent-based distributed query processing mechanism.

Section 2 discusses the related work. Section 3 presents a motivating example scenario of a collaborative e-learning environment. Section 4 discusses data interoperability settings between two e-learning data sources and a framework of a collaborative e-learning system. In Section 5, we present content management and efficient query processing mechanism. Section 6 shows evaluation results and we conclude in Section 7.

2. Related work

Authors in Alsadhan, Alhomod, & Shafi (2014) present a model for e-learning systems based on multimedia content. Authors mainly present a solution for multimedia content modeling, multimedia content development, and multimedia content integration that is applied for the development of e-learning systems for integrating multimedia content of different disciplines and subjects in a single e-learning system. However, this paper presents a learning content management system that connects different e-learning systems and provides a solution how content in different systems can be shared and accessed.

eNOSHA (Mozelius, Balasooriya, & Hettiarachchi, 2011) is an open source Learning Object Repository (LOR) that provides support to store and use learning objects from different collaborative institutes. The system mainly connects eNOSHA interface with the local learning management systems. eNOSHA system acts as an integrated view of the underlying systems. This is mainly a centralized content repository systems. However, the system proposed in this paper is a distributed system without any centralized system. If two e-learning systems want to collaborate then the system establishes a mapping policy using the proposed mapping solution.

Authors in Brusilovsky, Sosnovsky, Yudelson, Kumar, & Hsiao (2008) propose an approach for combining students knowledge gathered by different learning tools based on heterogeneous representations. The approach is based on manual mapping of

underlying domain. The authors also applied the approach for integration of two existing educational systems in the framework of undergraduate Java course. The approach mainly integrates two learning methods of a particular course not integrates two e-learning content management systems.

Authors in Adeola, Adewale, & Alese (2013) discusses a collaborative e-learning system that integrates different e-learning system architectures across different institutes for the purpose of sharing the knowledge and learning content of experts and professionals. They designed a database where all the learning contents are stored and accessed by users from different institutes. This paper proposes a collaborative e-learning system without any centralized database. Users of an e-learning system can also access the learning content of other systems without any centralized control.

3. A motivating e-learning system

Fig. 1 shows a collaborative e-learning scenario. There are three e-learning systems (UQU, Taif, and KFUPM) in the environment. The systems provides data about multimedia content of courses and data archives (e.g. sample exam papers, lecture notes, student and faculty information, course information, etc.). As we see collaborative e-learning environment is a complex system which needs different types of solutions to address different types of research challenges. In this paper we mainly focus on (i) data interoperability solution and (ii) content management and query processing technique for a collaborative e-learning environment. In the following we discuss these issues.

4. A model of collaborative e-learning environment

An e-learning system is student-centered where different parties (instructors, administration, registration, etc.) are involved in providing information to the system for the students. For a collaborative e-learning system, different e-learning systems share information with each other while the systems are autonomous. Therefore, data sources are autonomously designed and maintained. Although systems are independent, sometime collaboration is needed to share, exchange, and analyze e-learning data. For example, a student wants to register a course *C* into the university *A* while he is studying in the university *B*. University *B* can receive student's record from the university *A*'s e-learning system if there is a collaboration between *A* and *B*. University *A* can receive all the information about the course *C* from the university *B* for student's academic record evaluation. The challenge of this kind of collaboration is the data heterogeneity among the data sources.

4.1. Data interoperability setting between two e-learning systems

This section discusses mappings for data interoperability between two sources in e-learning systems. We assume that each e-learning system has its own local source. The local source is designed independently during the creation of the local database. The result of a local query posed in an e-learning system is produced from the local data source. An e-learning system also defines external schema that are used to share data to other e-learning systems. Fig. 2 shows the interoperability setting between two e-learning systems for sharing e-learning data. As shown in Fig. 2, each e-learning system provides a data interoperability layer, called wrapper, in order to establish a mapping with other e-learning systems. This wrapper hides the internal details. The wrapper module also define the policy which data the e-learning system wants to share in the collaborative environment. In the following we discuss how to create such a setting.

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