Respuestas
Año 17
No. 2
Diciembre 2012
ISSN 0122-820X
PP: 21-30

Model of Recommendation System for for Indexing and Retrieving the Learning Object based on Multiagent System*

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Recibido:
Febrero 2 de 2012

Aceptado:
Mayo 28 de 2012

Abstract

This paper proposes a multiagent system application model for indexing, retrieving and recommendation learning objects stored in different and heterogeneous repositories. The objects within these repositories are described by filled fields using different metadata standards. The searching mechanism covers several different learning object repositories and the same object can be described in these repositories by the use of different types of fields. Aiming to improve accuracy and coverage in terms of recovering a learning object and improve the signification of the results we propose an information retrieval model based on the multiagent system approach and an ontological model to describe the knowledge domain covered.

Keywords: *AI in education, multi-agent systems, learning objects, recommendation systems.*

Resumen

Este artículo propone un modelo de aplicación de sistema multi-agente para la indexación, recuperación y recomendación de objetos de aprendizaje almacenados en diferentes repositorios heterogéneos. Los objetos en tales repositorios son descritos por campos usando diferentes estándares de metadatos. El mecanismo de búsqueda cubre diferentes repositorios de objetos de aprendizaje y el mismo objeto puede estar descrito en esos repositorios por diferentes tipos de campos. Con el fin de mejorar la exactitud y cobertura en los términos de recuperación, así como para mejorar la significancia de los resultados obtenidos, se propone un modelo de recuperación de información basado en un enfoque de sistema multi-agente y un modelo ontológico para describir el dominio de conocimiento cubierto.

Palabras clave: *Inteligencia artificial en educación, sistemas multiagente, objetos de aprendizaje, sistemas de recomendación.*

*This article comes from the Master's thesis of Ronaldo Lima Rocha Campos funded by CAPES Foundation

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No. 2
Diciembre 2012
ISSN 0122-820X

1. Introduction

The effort and investment needed by educators and educational institutions to produce qualified learning content are considerable. This is especially important in the production of content for distance education because almost all the information and knowledge must be completely and explicitly covered by the learning objects (Downes, 2001). A learning object is any digital resource reused to support learning. Thus learning objects may be small parts such as images, sounds, videos or more complex parts such as courses or software (Wiley, 2000).

Owing to the large cost of producing learning content, there is a strong advantage in improving the possibility of reusing it. Therefore, the development of mechanisms to facilitate the reuse of learning content has attracted the interest of several research groups, organizations and educational institutions around the world.

Research in this area has originated many different ideas, standards and specifications. This research produces different ideas that guide the politics of production and the storage of learning objects.

This scenario explains the heterogeneity of the available technologies used to produce and store learning objects, as well as the definition of the granularity of objects. This heterogeneity makes painful and laborious the interoperability among the different tools used to produce, store and retrieve learning objects.

The production and use of the LOs is also related to its storage and dissemination. The digital repositories are responsible for managing and storing these resources (LOs), as well as to providing a number of features to allow different types of objects to be stored, cataloged and made available. Arise in this context, the terms Institutional Repositories (IR) and Learning Object Repositories (LOR). As the LOs produced with different and distinct technologies, and there being a wide variety of repositories to attend different demands, it becomes difficult to decide on the use of a particular repository and it is not always chosen correctly at first, which often leads to the adoption of other options and scenarios (Tarrant et al, 2009). The re-usability of learning objects is hampered by the diversity and heterogeneity of the architecture of the existing LOR. These repositories are created to store learning objects but such objects used to be stored in different ways, using different technologies and described by different structures of metadata (Downes, 2001).

The recovery of learning objects is heterogeneous because of the different standards and specifications for production and storage, and the large distribution of the repositories across the web; it is dynamic as well because of the volume of research in this area and the magnitude of the field. Moreover, it is clear that the lack of effective and specialized LO search tools does not allow wide reuse of the learning objects produced.

The existing tools used to retrieve information about learning objects are usually solely based on a syntax search. This type of search is not an efficient way to recover learning objects as they used to be in retrieving ordinary documents from the web. The information on regular web pages is not cataloged as it is in LO repositories. This characteristic hinders the use of semantic functions for recovering LOs.

This scenario justifies a research proposal based on the multiagent system (MAS) technology to build an intelligent search tool that facilitates the retrieval of learning objects available in heterogeneous scenarios of existing repositories. The MAS technology is characterized by the ability to model intelligent agents able to adapt to the environment, to act autonomously, to cooperate and to communicate with

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each other in order to achieve a common goal (Wooldridge, 2002). This model aims to increase the recovery and re-usability of learning objects by searching the learning content from several different LOR by the teachers, students or learning objects designers.

The recommender systems appeared in order to minimize the problem of overhead information. The recommendation system is intended to indicate or receive indications of products and services in a social process (Resnick; Varian, 1997).

Schafer (2000) defines the structure of a recommendation system with four steps: User identification, despite being defined as optional is responsible for generating user profiles and user groups. Data collection, step where data about the user and products are collected. It can be done in three ways: implicit, explicit and hybrid. Strategy recommendation, describes the technique (algorithm) used to link users to products and services. It is comprised of three basic methods: collaborative filtering (Resnick et al., 1994) relationship by content (Mooney; Bennett; Roy, 1998) or a mixed approach (Pazzani, 1999). View of the recommendations, describes how the products and services must be presented to the users. In this stage it is also made data collection in order to improve the system itself.

This paper proposes an LO intelligent search model capable of indexing and retrieving learning objects, regardless of the metadata standard used, located in different and heterogeneous repositories and provides the user with a ranking the learning objects based on their profile. It does so by using multiagent system technologies as well as domain ontologies to support the work of the designed agents in promoting a better recovery and re-usability of learning objects.

2. Background

The theoretical model of this research covers the basic concepts related to learning objects as well as formal specification of metadata for the LOs. Furthermore, the use of multiagent systems technology combined with retrieval techniques, usually used for Semantic Web to solve the problem of retrieving objects in distributed and heterogeneous environment using semantic aspects of learning object. The obtained results pointed to use representation of domain ontology to contextualize the domain specific concepts search problems and indexing and weighting information techniques to improve the accuracy, coverage and the performance of search tools.

Learning objects are educational resources that can be used in the learning process supported by technology (McGreal, 2004). The IEEE (IEEE-LTSC, 2005) defines learning objects as any material, digital or not, that can be used, reused and referenced in e-learning. According to McGreal (2004) certain features of a learning object can be highlighted: accessibility, interoperability, adaptability, re-usability, durability, retrieval, assessment and interchangeability. Learning objects can be based on text, animations, presentations, images, software, and have to be described by a set of metadata (data about data), according to some formal specification (Downes, 2001). The learning object is the learning content formally described by its metadata, stored in the repository, which can be combined with other learning objects to create larger objects such as lessons and courses (Nash, 2005).

Digital content repositories are softwares developed with the objective of storing and organizing digital resourses, thus providing search and content retrieving mechanisms (Downes, 2001; Nash, 2005).

The repositories have interfaces for submission or cataloging content, using one or more data standards, dissemination and collection interfaces, communication

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protocols, and search and retrieval interfaces. Digital repositories should deal with a series of requirements such as storage, cataloging, dissemination (harvesting), search and retrieval. It is not currently possible to distinguish at the current state of the art, just one particular accepted and adopted model, which could be used to guide all of those policies. There is thus, an heterogeneous scenario. The problem of heterogeneity has been addressed in several ways and according to Gil, De La Prieta and Rodríguez (2011), by creating repositories that are highly sustainable, they also become highly heterogeneous because they must deal with various types of storage, access to objects and consulting methods. As for Fabre; Tarouco. and Tamusiunas (2003), heterogeneity is more technically related, highlighting differences in both the implementation of the repositories (software) as to the differences in hardware that supports them.

Thus the concept of heterogeneity for search engines can be set upon two major pillars: access to the resources, and metadata standards used to describe objects. In this article we address these two areas in the model of agents, while mainly focusing on techniques that deal with different metadata standards.

Such approach is justified by the difficulty in representing the object semantic in its recovery and integration with other systems, Li et al. (2008) expose that the adoption of only one metadata standard for the integration of various systems is complicated, the demands are different from one system to another and, for that reason the use of a mapping technique called Crosswalks.

To ensure interoperability, the repositories are adopting one or more disseminating protocols. These protocols came out of the efforts to find efficient forms to replicate not only the structure, but the object of the repositories and end up defining a standard form to obtain access to these objects. In the same way these repositories are different according to the technology and the protocols used: Lightweight Directory Access Protocol (LDAP), Open Archives Initiative protocol for Metadata Harvesting (OAI-PMH; Open Archives Initiative Object Reuse and Exchange (OAI-ORE).

What can be noticed is that even though the access mechanisms to the resources (objects and metadata) deal with a range of technologies, the emergence and adoption of standards to make the systems inter-operable has helped to standardize such accesses. Regarding the description of objects in the current scenario, there is also a range of patterns that have emerged about demands and different ideas and to attend several purposes. Thus the concept of metadata is related to information structures that describe on various aspects, its own resources and, such concept is commonly related as being the data of the data, or the information about the information (Bargmeyer and Gillman, 2011).

One of the main reasons to the use of metadata is the easiness to information recovery in a relevant manner. Moreover, it helps in organizing, facilitates interoperation and resource integration, digital identification, filing and preserving. A complete study on the subject can be appreciated in Understanding Metadata (NISO, 2004). Among the main existing Standards, the most relevant ones and, therefore, most adopted are: Dublin Core, LOM and Obaa.

Dublin Core metadata set emerged in 1995 in a workshop sponsored by OCLC and NCSA. Its continuing development and specifications is managed by Dublin Core Metadata Initiative (DCMI) (Dublin Core, 2011). The initial objective was the creation of some fields to describe web resources by their original authors. With the growth of electronic resources and the lack of describers to catalog them, the standard defined some elements and simple rules to enable such cataloging. There were initially 13 fields, extended to 15:

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Title, Creator, Subject, Description, Publisher, Contributor, Date, Type, Format, Identifier, Source, Language, Relation, Coverage, and Rights (NISO, 2004).

Dublin Core was developed to be simple and concise, and to describe web based content. Though, the standard has being used with other types of documents that demand some complexity. There is a lot of tension around the standard; some defend a minimum, simpler set of elements, and the adepts a structured, more refined, extended vision. The Dublin Core metadata set is standardized by the following norms, ISO Standard 15836-2009 (ISO 15836-2009, 2009) and NISO Standard Z39.85 (NISO, 2007).

Created by IEEE Learning Technology Standards Committee (LTSC)[11], the educational objects metadata set (LOM) (IEEE-LTSC, 2010) is a IEEE standard (IEEE 1484.12.1-2002) (IEEE-LTSC, 2002) meant for the reuse and description of educational resources. LOM defines a minimum set of attributes to manage, locate (language) and validate educational objects. These attributes are grouped in eight categories: General, Life Cycle, Technical, Educational, License, Relations, Annotations and Classification, where each category is a metadata set in hierarchy (NISO, 2007). For its attributes being grouped in categories and each category composed of a hierarchical set, the standard representation is made in RDF/XML or Atom/XML, which facilitates the integration with various disseminating and search protocols. Due to its characteristics, flexibility and potential to treat digital resources and reuse, LOM standard was incorporated to the SCORM (Sharable Content Object Reference Model) (SCORM, 2011) reference model.

OBAA is a Brazilian technical and functional requirements specification standard for the production, edition and distribution of interactive digital content, allowing them to be used in Web platforms, mobile devices and digital television. This standard was developed by the Federal University of Rio Grande do Sul (UFRGS) in partnership with Vale dos Sinos University (UNISINOS) in response to a call from the Education, Communication, Science and Technology Ministries and uses it based on the LOM standard. OBAA is an extension of LOM. There were included some elements in the Technical and Educational categories and added another two; Accessibility and Segment Information Table to be able to meet the Brazilian needs in relation to these segments (Fabre, Tarouco and Tamusiunas, 2003).

Some important projects about learning object repositories are considered in this work in order to provide a comprehensive view of the architecture of these repositories: Lume - digital repository of the Federal University of Rio Grande do Sul (LUME, 2010), the International Bank for Educational Objects (Bioethanol, 2008) RIVED (Network Interactive Virtual Education) (RIVED, 2010), MERLOT (Multimedia Educational Resource for Learning and On line Teaching) (MERLOT, 2010) and the Federation Educa Brazil (FEB, 2012).

These repositories used to be based on database management technologies, LDAP, or XML, for ad hoc implementation but, recently have used specific specialized frameworks such as DSpace (DSpace, 2011) and FEDORA (Flexible Extensible Digital Object Repository Architecture) (FEDORA, 2010).

As regards the theoretical background of agents we consider a multiagent system loosely coupled with a network of problem solvers who work together to solve problems which go beyond their individual capability (Wooldridge, 2002). These problem solvers are essentially autonomous, distributed and heterogeneous in nature. We also adopt the FIPA reference model of agents (FIPA, 2010) and used JADE (Java Agent Development Framework) (JADE, 2010).

Besides the theoretical background related to multiagent systems and learning objects

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we consider retrieval techniques used for finding documents (Russell et al., 2004). These techniques aim to find the location of information that satisfies specific needs, from digital media (Manning et al., 2008) and techniques for knowledge representation to anthologies consisting of entities that can be classes, concepts, instances, individuals, relationships, properties, data types and values (Euzenat et al., 2007).

3. The Proposed Model

The objective of this model is to promote a better recovery and re usability of learning objects through the support of software agents capable of dealing with the heterogeneous scenario of learning object recovery environments and provides the user with a learning object ranking based on their profile.

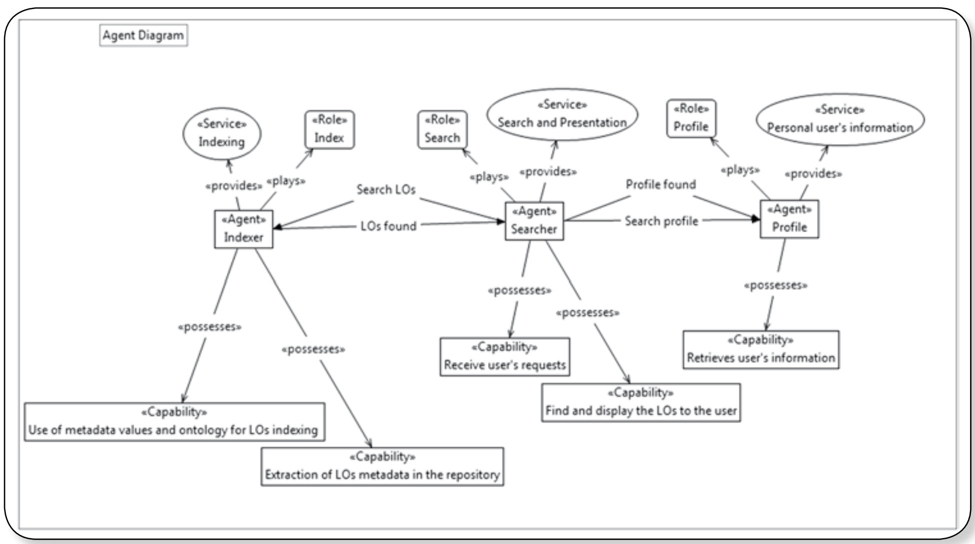
The proposed multi-agent system was developed to be able to index, classify, and retrieve learning objects in different repositories. The model created in Vian and Silveira (2011) was revised and extended not only to ensure good coverage and recovery by areas of knowledge, but also to prioritize relevant results. As described in Gil, De La Prieta and Rodríguez (2011) collaborative approaches have brought good results in the indexing of digital documents and works like MCcalla (2004), Recker, Walker and Lawless(2003) e Manouselis (2007) justify such approaches.

The system was developed with the JADE (JADE, 2010) framework which, according to his description, simplifies the system implementation process and complies with the FIPA (FIPA, 2010) standard.

According to the figure 1, the main components are: The learning objects repository set, the multi-agent system and web search service. The repositories can be quite different, both in their content and technology in which they were developed and, for each kind of repository there is an indexing agent. This agent uses a specialized database to correlate different elements of different metadata standards, taking into account the relationships between them to ensure their semantic.

In another part of the process, web service is responsible for interfacing with the user, from a search engine which indexes a variety of repositories to a search engine inserted in another application like, for instance, a learning management system (LMS). A profile agent is responsible for collecting data about a user who will request the search. Making the

Fig. 1. Agent organization diagram



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connection between these two ends there is a search engine connected to an agent system ontology domain.

Protégé (2010) was used to create and model an ontology that represents a number of concepts in computer science and it materialized in the OWL form. This ontology is used by agents to expand the consultations requested by the application server. To make this possible we used the JENA 6 (JENA, 2010) framework.

To address the different access mechanisms to objects and their descriptors, indexing agents have been adapted and extended to work with libraries JDOM and JLDAP, as well as to implement the OAI-PMH and OAI-ORE protocols.

The use of the techniques recommended content is shown to bring better results in the search for objects in repositories, as to make use of recommendation systems reduces the problem of information overload.

The models of recommender systems bring improvements such as: concepts relate to users, content ordering well as user profile, complementing the results aimed at leveling with objects of knowledge about a concept, identifying groups of users who provide valuable contributions, making a network confidence, and focusing on objects that are frequently accessed by listing them as the most current (Primo, 2006).

In this approach focusing on the agent Profile his interaction with the agent Search is as follows: the agent Profile works in a hybrid model with both explicit and implicit information of the user. Implicitly he obtained information from other systems as a LMS system or an curriculum page. Explicitly asking the user databases which he prefers to prioritize and building a profile of terms and taxonomies as suggested in D'Agostine (2009). Thus the agent Search requests information about the databases and indicates the terms required to search for the agent Profile, which makes use of this information and responds, indicating preferred bases and if there is some term that must be accompanied by a detailed (disambiguation or expansion).

In possession of such information the agent Search proceeds with the search for objects, triggering the agents Indexer. In this stage the terms can still be applied to a knowledge base (in this case a domain ontology) for a better selection of them and indexing results.

Upon receiving the response of agents Indexer the agent Search again triggers the agent Profile, this time with the search results. The agent Profile then goes (based on a similarity function) sort objects bringing the most relevant to the top. It triggered a feedback system user, performing a feedback in order to refine the user profile system.

4. Final Remarks

The proposed model allows searching heterogeneous repositories using semantic features and users information, increasing coverage and relevance of their results.

The option of using an open protocol based on XML for communication between the multiagent and the web search application incorporated features distributed throughout the system, since any application using the protocol is able to communicate with the system, making it more accessible. This feature allows the use of the tool in a more transparent way on the part of other systems, like the LMS. Thus a module for LMS Moodle is being developed, which is going to allow search and content implementation through its own platform.

At the current stage of development the system is already functional, having implemented the following agents: Searcher, ldap and OAI-PMH (protocol agents). The Searcher is also integrated with the JENA

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framework being able to expand and establish relationships between the terms and synonyms referred to it.

The Human-machine interface is through a web application that communicates with the SMA via XML protocol. It is already possible to search the repositories CESTA, LUME and UNASUS/UFSC. For now only one domain ontology was created (information security).

The model for classifying objects based on user information, statistics and collaborative evaluations of objects, despite being in the initial phase, has already shown good potential. And because of that potential is being developed an ontology for the domain of medicine, with the aim of preparing a survey of specialists.

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