E-learning Multi-agent Recommender for Learning Objects

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ABSTRACT

The main efforts in e-learning are focused on allowing the interoperability between the all possible resources such a Learning Objects (LOs). These kinds of educational resources would be automatically managed through different Learning Management Systems (LMS) and also Learning Object Repositories (LORs). The basic and central movement of the automatic LOs reutilization happens by endowing these with semantic content which allows their efficient search, selection and composition.

For these tasks it is necessary the incorporation of aspects related to the LOs quality inside its semantic description that will facilitate its management. This paper proposes a methodology in order to promote LOs of quality and supported by multi-agent architecture to complete a LO personal retrieval from multiple sources.

Categories and Subject Descriptors

H.3.3 [**Information Storage and Retrieval**]: Information Search and Retrieval – *Information filtering, Search process, Selection process.*
H.3.5 [**Information Storage and Retrieval**]: Online Information Services – *Data sharing*
I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence – *Intelligent agents.*

General Terms

Management, Standardization, Experimentation.

Keywords

Learning Objects, Intelligent Agents, Recommendation System.

1. INTRODUCTION

The possibility that educational standards offer by managing the information results in facilitating interoperability and reutilization for components in diverse platforms; the existence of educational modeling languages that allow to construct any educational material in addition with pedagogic sense will opens an important possibility for improvement the e-learning systems in a near future.

Specifications will allow the exchange of the LOs without interoperability problems but what do we understand for LO? How is it possible to guarantee the quality of its contents? The capture of guessed right decisions is based on the analysis of the information, therefore, the evaluation of the LOs quality must be resident in concrete concepts about the LO, it means what it is a quality LO and how it is tried to reach.

One of the LOs characteristics is that they are resources which have been added with metadata for their management. It means that metadata are created independently from the resource which is annexed to them, in order to pack them all together to turn into LOs.

Nowadays, some researches suggest how to evaluate LOs as a resource such as Nesbit or Vargo proposals ([15], [16], [20]). These authors developed the Learning Object Review Instrument (LORI) that is in use inside well known repositories as MERLOT, CLOE or DLNET. However there is no still an offer widely used that considers evaluating LOs and its characteristics from a technical and pedagogic point of view, with a clear definition of all elements implied, with a well-defined criteria and instruments.

LOs are placed inside repositories in order to allow their better retrieval. The LOs' repositories (MERLOT[1], CAREO[2], CLOE[3], etc.) are software systems with educational resources and their metadata store (or only the above mentioned), and generally they provide some type of interface that allows their recovery. Any interaction for LOs recovery can be carried out in a manual way or be automated across different software for example across an Agents' architecture or even by treating as Web Semantic Services.

LORs have a high degree of heterogeneity in its characterizations. The lack of proper standards with larger granularity owed to the prompt growth and not consistency as well as the heterogeneity of existing standards gives the non-existence of a common vocabulary. In the same way the coexistence of different definitions it indicates the need to formalize the common repositories' architecture while making them more flexible. All these aspects would grant the LOs the possibility of storing all the myriad of conceptualizations.

Due to the LOs heterogeneity mentioned before, the success of any development depends on the initial extraction from a repository as well as their integration with other LOs. The above mentioned protocol implies several aspects: LOs's extraction for different sources, LOs's classification for the management maintainable and accessible, reclassification of the LOs by agreed with different requests, customization and mapped among the different LOs representations.

A solution that allows mechanizing these processes passes for constructing and to homogenize the LOs description by adding metadata by means of a formal ontology and a normalized process

[1] http://www.merlot.org/
[2] http://careo.ucalgary.ca
[3] http://cloe.on.ca/

in the LOs. The implied task in the development of domain ontologies that would adapt the syntactic and semantic coverage that they descriptive. This allows selecting and comparing the terms over the same knowledge base and representations treating it about learning grounds and adding personalized aspects related with the user.

This approach will allow a correct maintenance of the repositories as well as the evaluation and extraction of a quality metrics in the LOs evaluation. LOs metadata can be used to register the quality reflected in their evaluation and the intelligent agents constitute a powerful tool for automatic retrieval and filter information according to the user needs.

The paper explains in section 2 the main concepts and characteristics to evaluate the LOs from a technical and pedagogic perspective elaborating a range of valuation that will be included in their metadata. Section 3 describes the quality criteria to classify LOs and several aspects about the evaluation instrument. Section 4 introduces the multi-agent architecture proposal and the mechanism implied to extract and treat the LOs including the criterion of the quality of the LO in its selection and recommendation. We conclude with some relevant aspects and work in progress considerations in the conclusions section.

2. LO CONCEPT AND ITS CHARACTERISTICS

LO concept has emerged mainly by economic reason. The idea promotes to reuse learning material in order to avoid interoperability problems for e-learning platforms. In this way their production cost can decrease because they don't need to be created again. Nowadays a lot of LOs definitions exists ([9], [14]], [16], [21)] it means there is not a general consensus about LOs definition; however there are some consensus about their characteristics.

This element has characteristics of independent units, which are able to be reused for other educational situations and platforms [17]. According to this, the two main characteristics are their reusability and interoperability in order to be exported to different kind of platforms [18].

Each one of LOs has metadata (data about data) for their description and administration. In this way it is possible to know what kind of LO we are trying. According to this, knowledge management for e-learning based on reusable units of learning means the possibility to access specific content according to the learners' needs. This stage is possible due to standards, which were established as an attempt to avoid interoperability platform problems, however they don't guarantee the LOs content quality.
In order to manage them for e-learning systems, it is important to respond what we understand for LOs.

We consider a LO as a "unit with a learning objective, together with digital and independent capabilities containing one or a few related ideas and accessible through metadata to be reused in different contexts and platforms" [12].

We support the idea that LOs need to have a specific learning objective in order to direct the contents and activities to promote learning. By other side we are refering to LOs as digital entities rejecting LOs as "any thing".

The possibility of labeling LOs through metadata schema (e.g. RDF[4], OWL[5], etc.) promotes their accesibility and automatic processing. The automatic processing of digital sources is a prerequisite in order to support intelligent services for semantic web [3].

2.1 Semantic aspects for LOs

The Semantic Web is based on two fundamental connected concepts: semantic and syntaxis. The former, detailed by the semantic and taxonomical relations of the meaning that the contents have in the Web, is defined by the ontologies. The latter makes possible the automatic manipulation of these meanings by stablish the common structure where insert the semantic of any domain.

There is a disparate work in ontology production as a result of the proliferation of logic languages and information models that have combined to yield even more ontology forms. This sparsity is added with the multitude of editing environments. These tools and methodologies, reported in ([6], [10], [19]) along with the ontologies built with them, generally exist without proven interoperability. This is one of the challenges facing the practice along with establishing methods to integrate ontology components with enterprise information systems and standards we can find detailled in [4] and [6].

The ontologies are intended to serve as consensual rallying points to exchange and interpret information. Clearly, the wider range of applications and other ontologies that can conform an ontology, the greater its utility and the mutual utility of the interrelating ontologies.

This requires formal compatibility on syntactic levels as well as semantic levels structured in description content models. Such descriptions are extensions of the Web markup languages known as ontology languajes [5]. They allow users to write explicit, formal conceptualization of domains models [8]. The main requirements are:

1. a well defined syntax
2. a well-defined semantics
3. efficient reasoning support
4. sufficient expressive power
5. convenience of expression

This set of goals, detailed in [1], fit with most system of logic and in same way is proven that to achive the third and fourth propierties simultaneously is difficult [11]. These requirements in Web ground identify the need for developping a well defined language for integrating ontologies with web standards (in particular RDF/RDFS and XML/XMLS).

Several research groups worked at this line in parallel initatives, mainly two: Europe with OIL[6] and United States in DAML-ONT[7], developed as part of the US DARPA Agent Markup Language (DAML). Both initiatives melt into the DAML+OIL Web Ontology Language that nowdays is OWL (Ontology Web Language). OWL[8] became a W3C Recommendation in February

4 http://www.w3.org/RDF/

5 http://www.w3.org/TR/owl-features/

6 http://www.ontoknowledge.org/oil/

7 http://www.daml.org/2000/10/daml-ont.html

8 http://www.w3.org/2004/OWL/

2004 as the standardized and accepted ontology language for the Semantic Web. This ontology representation language allows describe resources in detail.

Description logics (DLs) are a family of formalisms that allow the representation and reasoning about conceptual knowledge in a structured and semantically well-understood manner [2]. Some of these description logics (DLs) combine knowledge representation on an abstract, logical level with an interface to concrete domains. These hybrid DLs provide the basis for expressive ontology languages. The logic-based formalism in OWL [1] is as in others web ontology languages based on these description logics. However, this language itself did not define any reasoning engine.

3. EVALUATION INSTRUMENT AND QUALITY CRITERIA

In order to value LOs it is important to define what we understand for quality LOs. According to RAE (ww.rae.es), quality is an inherent characteristic of a thing that makes it better or worse than other ones. In order to define what a LO quality is, we think it is neccesary to consider their characterisctics to establish evaluation criteria from pedagogycal and technical points of view and compare their quality according to the users need.

On this basis the proposal of our work is to define some quality criteria in order to value LOs with quantitaive and qualitative evaluation translating this information in numbers and adding them to LOs metadata. After that we suggest to appply intelligent agents in order to promote a suitable LOs searching according to their quality and users needs.

In order to evaluate LOs in a suitable way we suggest quality criteria into pedagogycal and technical aspects. For pedagogical aspects we consider logic meaningful and psychopedagogical meaningful. The first one is directed to users' characteristics and the last one is directed to curricula charcteristics. By oter side for technical evaluation we suggest criteria according to usability (colours, text, size, etc.) and map navigation design.

The quality criteria mentioned above is considered into an evaluation instrument which contain an evaluation process directed by experts together with a rating scale [13], in this way it is possible to add numerical data which reflec their quality into metadata information. On this basis we suggest the following rating scale [13] because we think it aims to specify experts' opinion in a suitable way.

D/N = Don't Know
1 = Very low
2 = Low
3 = Medium
4 = High
5 = Very high

According to this rating scale the results are averaged in order to obtain the final quality LOs value. As we explain in the next section the final number is able to be incorporated into LO metadata information and use intelligent agents in order to manage LOs according to their quality in an automatic way.

4. EVALUATION THROUG INTELLIGENT AGENTS

Intelligent agents engaged in multi-agent systems (MAS) deal with aspects of cooperation, coalition formation and some others characteristics that fit with the complex systems description about extract LO from distribute repositories in the internet, to evaluate these, to recommend these, etc conform complex criteria. This kind of agent architecture offers a solution form others because:

- Each agent has incomplete information or capabilities
- No global system controls
- Works with decentralized data
- Asynchronous computation
- Social ability are included with all the opportunities in the develop

Table 1. Metadata elements selection to look for LOs

Metadata	Information managed by intelligent agents
1.2. Title	Significative words
1.5. Keywords	Significative words
1.6. Coverage	Words related with the LO context
5.1. Interactivity Type	Expositive, mixed, active
5.2.Learning Resource Type	Imagen, lesson...
5.3. Interactivity Level	Very low, low, medium, high, very high
5.4. Semantic Density,	Very low, low, medium, high, very high
5.6. Context	Primary school...
5.8. Difficulty	Very low, low, medium, high, very high
5.11. Language	
9. Classification	(according to table 2)

In a very general sense, the elements of the system are treated as multi-agents, relatively autonomous entities which have a set of different rules to interact with each other.

The interaction rules may also be associated with local variables, reducing direct communication among agents which in turn must be hardly influenced by the environment changes with the flexibility and needed permeability to consider a set of LO information specially related with their context of use that can be treated by adapting techniques from DAI (Distributed Artificial Intelligence). On this basis it is possible to define an ontology model about the LO characteristics that aim to look for LOs according to their quality and users need.

IEEE LOM propose nine optional metadata information categories in order to describe LOs, however, there are not a general use of them because each one of this categories have a lot of elements available for LOs descriptions, so most of them can be unnecessary and bring confusion in order to define the type of information to complete.

About this situation, Morales et al. in [13] suggest to consider some metadata information categories which are able to be completed with objective and specific information. On this basis, table 1 shows metadata categories and the type of information that can be considered for intelligent agents in order to look for quality LOs according to their quality criteria in an automatic way.

Any additional information about LO quality can be exposed into "9.3 description" element. In this way it is possible to specify for example some things about how to improve their quality, educational experiences, etc.

Finally, the "9.4.Keyword" element, as shows table 1, aims to look for LOs according to their quality classification.

Table 2. **LOs value**

Nº	Name	Example
9	Classification	
9.1	Purpose	**quality**
9.2	Taxon path	
9.2.1	Source	("is", "LOs value")
9.2.2	Taxon	[**"3,6"**, ("is", "high")]
9.2.2.1	ID	**"3,6"**
9.2.2.2	Enter	**"high"**
9.3	Description	**"LO has a high quality because...**
9.4	Keywords	"high", "quality", etc.

IEEE LOM Metadata categories don't consider a specific metadata element in order to define their quality. However the 9.classification metadata element aim to classify LOs according to some "proposals" (discipline, idea, prerequisite, educational objective, accesibility restrictions, educational level, skill level, security level and skill level) on this basis me suggest the proposal "quality" into "9.classification" metadata element in order to define LOs value. To achieve this we define LOs quality according to an identifier (number obtained from the evaluation instrument) and their enter value as shows table 3.

Table 3. LOs value

Identifier	Enter
1,0-1,5	Very Low
1,6-2,5	Low
2,6-3,5	Medium
3,6-4,5	High
4,6-5,0	Very high

Classification exposed in the table 2 is generic by any of the number LOs values mentioned before. If we add this kind of information to the keyword element, LOs can be searched by textual value as "quality", "value", "high" or numerical number for example "3,6".

The possibility of adding numerical values to metadata information promotes the possibility to consider intelligent agents in order to find and compare LOs according to their quality. To achieve this it is neccesary to consider a multi-agent architecture as we explain in the next section.

4.1 Architecture Multi-Agent Proposal

User has to deal with spread amount of partial and heterogeneous information along distributed, large, open, and heterogeneous LORs. Several are the tasks involved in several searches with spread information, as well as the any automatic visualization for the retrieval LOs, etc. Any LO publication in their LOR is expressed in terms of metadata, implicit o explicit, some of which have been explained in previous paragraphs. The goal is to develop a system based on multi-agent paradigm that extract LOs for each user search from the repositories in the Internet and selects the more relevant according aspects relating with LO and user characteristics.

The architecture of the multi-agent system proposed is composed with intelligent software agents coordinated to identify and to recover the more relevant LOs. In the first approximation, according to these tasks are identified six agents, and their relations, to give support to the architecture. These agents visualized in the Figure 1, appear in the architecture with a gross granularity and high level of abstraction as a principal components.

Agents involved in the system of search and recommendation of bearing quality aspects for the LO in a context. To validate the LO in a domain (Computer in Education, Organic Chemistry, Databases in computation, etc.) is needed to build an ontology according to validate and establish a filter where to pound the retrieval resources. This domain ontology is placed in LOs knowledge base. At the same time the user interacts with the system where the User Modeling extracts this information and store it in the user knowledge base. Both knowledge bases will be used in the process of recommendation.

The extracted LOs therefore are shaped to the user by cataloguing them in terms of importance; this is supported by the recommendation agent. The information turns out to be like contextual of the LO, across the LOM metadata, and on the other hand the information about the user who realizes the searches with a proper ontology that stores the interaction of the user with the system, its competitions, etc.

The recommendation agent cross the recovered LOs from the Collect Agent from the repositories and catalogued by the Cataloguer Agent with the user stored information allowing fulfilling a personalized ranking by means of inference the context user metadata.

The process of recommendation begins for the user with the explicit request by means one interface of search based on the income of the table 1. These key-words will allow realizing the search of the OA in a series of available repositories in Internet. All the recovered across the recollection agent are normalized by the Normalizer Agent, according to an ontology that defines the structure of the gathered [12] that are based on the definition proposed for LO. It is in this normalization process where the quality of the OA will be added.

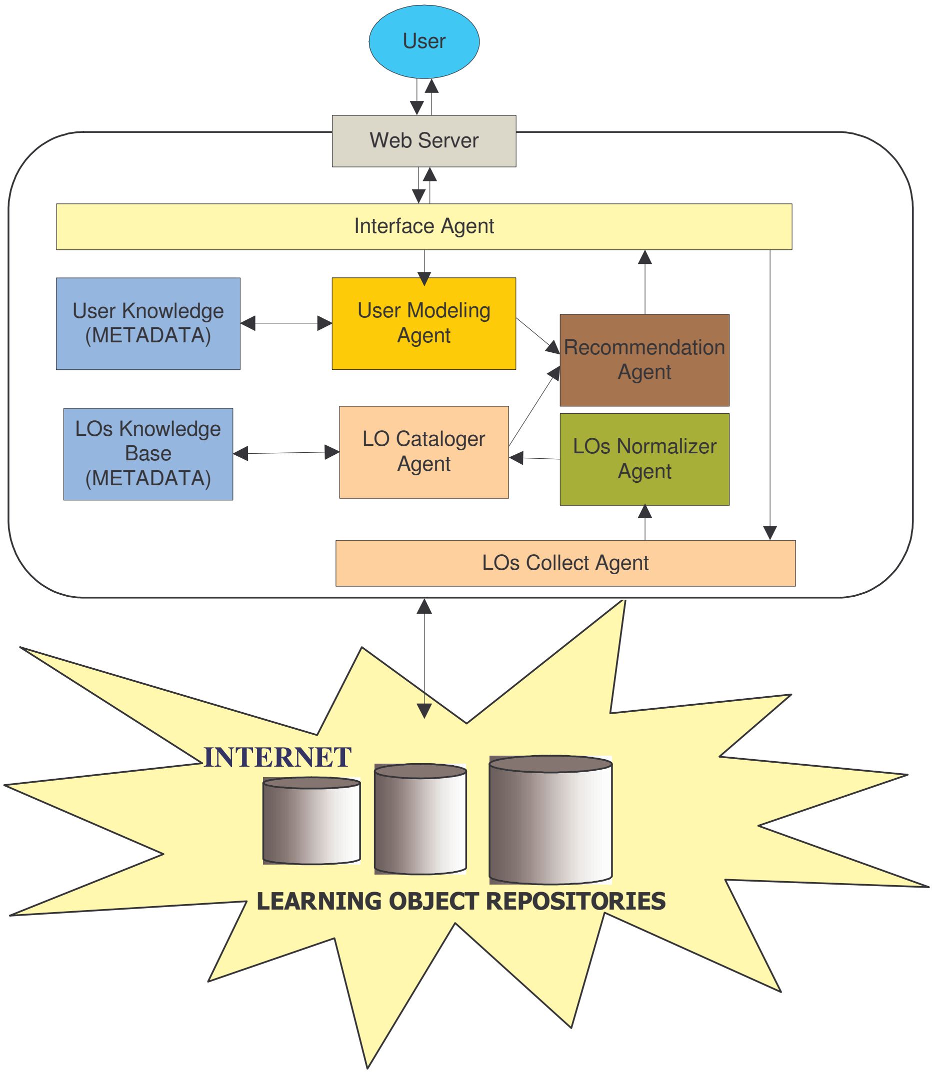

Figure 1. Conceptual Multi-agent Architecture for LO retrieval and recommendation

As soon as they have been normalized including information of quality they will be scaled with the LO context metadata. During this process Cataloguer Agent establish a ranking between all retrieval LOs. Later, the Recommendation Agent makes another ranking in these pre-catalogue LOs but including the metadata relative to the context of the implied user (extracted from user knowledge). This mechanism generates LOs relevancy with regard to the user. These rules of inference with the user knowledge add characteristics of personalization in the recovery and arrangement of the selected LOs.

5. CONCLUSIONS

This article proposes the incorporation of a value that reflects the quality of LOs and details about their implementation on the basis of the LOM metadata considering the element "9.clasification". It is explained how the quality of LOs are valued from diverse points of view. The obtained valuation is translated into a number that allows that they should be catalogued in a context attending to the element of metadata mentioned before. This proposal allows the incorporation of the quality in the LOs management it means the definition of ontologies for a domain facilitating their search and cataloguing process. Hereby, the metadata can be used not only to look for but also to value and to access to those who have been considered like of quality.

Multi-agent architecture proposed is based on a system for the personalized recovery of LOs from Repositories distributed in the Internet. The LOs search and cataloguing mentioned above includes the quality of the object and there is outlined the particular point that occupies the work of our group at present; the design and implementation of a system of recommendation of that it could be integrate in the above mentioned architecture.

The goal is to develop an architecture that results as an immediate connection between the set of Learning Objects that user consider with quality and according his/her grounding relied in the semantic content that brings OWL and the set of agents that represent the recommendation. The work try to build a solutions for real-life applications, based on distributed artificial intelligence that will bring a great promise for the further advancement in this ground.

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