Implementing Standard Reference Models for e-learning Systems

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Abstract - *Active development in the field of e-Learning has led to multiple organizations and specifications that try to provide some interoperability to systems, tools and learning contents. The great amount of specifications, exacerbated by its intrinsic complexity, has resulted in many commercial tools that agree specific norms or even subsets of one specification. Therefore, few actual systems have implemented proposed reference models. This paper exposes the experience from the University of Alcala TIFyC research group that, through several years and research, has developed an e-Learning applications' set which conforms current specifications and which implements one of the existing reference models, namely the IMS Global Learning Consortium reference model.*

Keywords: e-learning, learning object, learning management system (LMS), repository, federated search.

1 Introduction

E-learning systems were pushed forward on the mid 90s, as a new kind of distance education, offering new and improved communication and interaction features. As a result of that, a large quantity of systems and commercial tools came out, willing to offer e-learning services. On top of that, e-learning contents and content-makers were also put forward. This situation quickly turned into a problem: the systems lacked interoperability. It was very difficult to combine them. In order to solve this problem, a set of institutions appeared, and they were put in charge to develop recommendations and guidelines to ensure interoperability. The main idea was to avoid using proprietary systems that implies a subduing to a unique vendor (technological lock-in). However, countless guidelines were proposed, and many of them were so abstract that even today, those proposals have not been adopted as a reference model. As a general rule, current systems are based on a single specification, or a small subset of them.

Since 2005, the University of Alcalá TIFyC research group has participated on multiple PROFIT projects related to e-learning, financed by the Spanish Industry, Tourism and Commerce Ministry. As a result of this research work, a set of tools have been developed, aiming to provide a global solution to users in the internet learning cycle, covering all the needed functionalities. Supporting the most widely spread international specifications is considered as a main requirement. Following this approach, contents and systems developed by third parties would be easily integrated in the proposed model. Adopting a reference model eases this task, one that defines the running elements (users, agents, systems, processes). This paper puts down the mentioned development, explaining the process that led to a model following the IMS Global Learning Consortium specifications. Chapter 2 further develops the basic concepts related to e-learning, the associated specifications, and the implemented reference model. Chapter 3 describes EDVI's learning content management system, which was created during the first research project, and subsequently improved on the next reviews. Chapter 4 explains the characteristics and capabilities of a learning object repository that was also created during the project, and which is also part of the developed reference model. Chapter 5 describes one of the most innovative and interesting elements from the project. It is the federated searching system SROA, capable of performing distributed searches looking for learning objects in multiple repositories. Chapter 6 puts forward present and future research lines, which are turning into new systems or improvements of the current ones. Finally, chapter 7 summarizes the results and draws conclusions.

2 Basic concepts

Nowadays, in the e-learning arena, the learning objects' paradigm leads almost all the research initiatives. This paradigm promotes the creation of reusable and small learning units, called learning objects. These objects are assembled and/or aggregated afterwards, creating bigger learning units (courses, lessons, modules) [1]. Thus, learning objects can be defined as "minimal units in which training materials can be organized, in order to ease contents' management: creation, indexation, storage, delivery, use, reuse, evaluation and training improvement" [2]. Together with the learning objects appears the concept of metadata. In

order to complete some of the previously mentioned operations (indexation, distribution, search, and reuse) on the learning objects, is completely necessary for them to be properly tagged using descriptive data sets. These data sets are named metadata, and they have been standardized. The learning object creator must define as much metadata as he can for the training materials, in order to facilitate all the related the operations. The most popular & used specification concerning metadata is the LOM (Learning Object Metadata) standard, from IEEE – LTSC [3].

Nowadays, there are multiple international institutions gathering forces to focus on the research in this area. Those initiatives usually produce guidelines or specifications to ensure interoperability and portability among processes and products. The final desirable objectives are: reuse, interoperability, accessibility, durability, adaptability and productivity. As a matter of fact, those organizations can be summarized, as shown on table 1

Organization name	Webpage
ISO/IEC JTC1 SC36	http://jtc1sc36.org/
IEEE LTSC	http://ltsc.ieee.org/
CEN/ISSS WS-LT	http://www.cenorm.be/
ADL	http://www.adlnet.org/
AICC	http://www.aicc.org/
IMS	http://www.imsproject.org/
European Schoolnet	http://eunbrux02.eun.org
ARIADNE	http://www.ariadne-eu.org/
PROMETEUS	http://www.prometeus.org/
GEM	http://www.geminfo.org/
EdNA Online	http://www.edna.edu.au/
DCMI	http://dublincore.org/

Table 1. E-learning institutions and initiatives.

Among the existing standards, the most used and referenced, and thus used on our systems are:

-Learning Object Metadada (LOM), by IEEE [3]. This standard describes the set of metadata a learning object must implement.

-Shareable Content Object Reference Model (SCORM), by ADL [4]. This standard is composed of three parts, and it is used to specify content's structure, in order to make them portable among different systems and platforms [5], and also the communication protocol that can be established between the contents and the platform they are hosted in [6]. It also defines how to sequence the contents and how to navigate through them, and so they can be customized to the user's preferences.

-Digital Repositories Interoperability (DRI), by IMS [8]. This standard defines the interfaces (operations) that must be made public by any learning object repository to be accessible by other systems. Some of these operations are search, store, and retrieval.

-Question and Test Interoperability (QTI), by IMS [9]. This standard defines a data model to represent questions and questionnaires to be included in courses, etc.

Regarding the systems implied on the learning process over the internet, the most important ones are the following:

-LMS (Learning Management System): This software allows the distribution and management of contents on-line. Its main goal is to automate the actions and processes related with training: user management, training material control and management, and communication services management.

-LCMS (Learning Content Management Systems). Makes possible creating, storing, management, and developments of contents (as learning objects).

Repositories are another essential component. A repository can be basically defined as a learning object storage system. A more complete description is shown in chapter 4

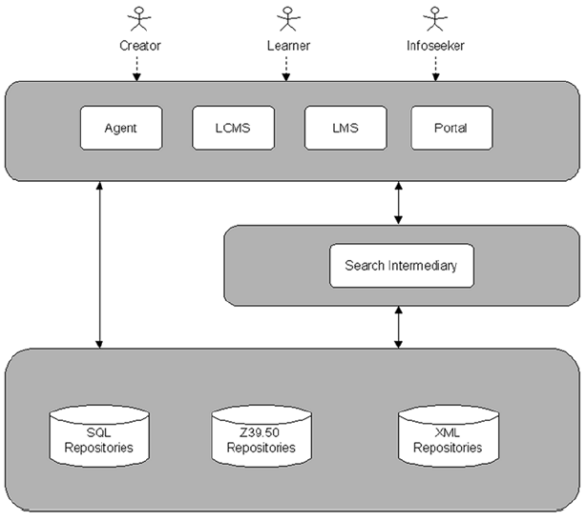

Figure 1. Reference model from IMS [8]

Figure 1 shows a general reference model system for accessing multiple repositories, as proposed on the DRI [8] specification. This model defines several types of users, like the creators of training materials (the creators), the users that use those training materials (the learners), or even a more general type of user: one that simply looks for information in the repositories (the infoseek). According to this diagram, the

process of searching information on a repository can be performed using the mechanisms offered by the repositories themselves, which are based on several technologies and query languages, such as SQL, Z39.50, XML-XQuery, etc. It is also possible to perform a search through an intermediate system

In our research group, we developed every component described in the standard reference model. This architecture has been named SIGA (Sistema Integral de Gestión del Aprendizaje, Integrated Learning Management Architecture), and it is composed of the following components (figure 2):

- LMS EDVI
- LCMS
- SROA Learning objects federated search system (Search Intermediary)

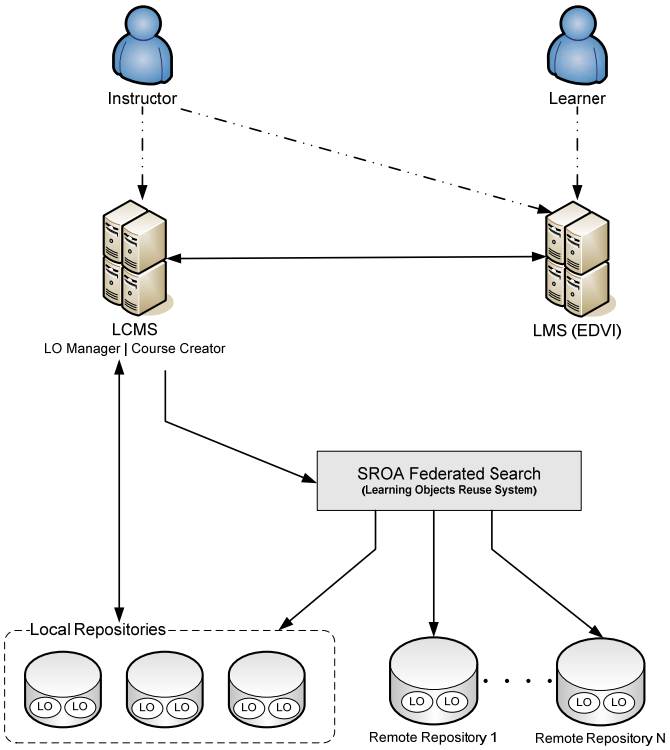

Figure 2. SIGA (Sistema Integral de Gestión del Aprendizaje, Integrated Learning Management Architecture)

On the following chapters, each and every one of this systems are described in detail.

3 EDVI Learning Content Managementnt System

The EDVI system (Educación a Distancia Vía Internet, Internet Based Remote Training) [10] [11] is a Web application LCMS, meeting the following requirements:

-Programming language: Java, specially focusing on JSP and Servlets.

-Web Server: Apache Tomcat.

-Database Server: Any SQL compatible server. The application was successfully deployed on the most popular database servers (PostgreSQL, MySQL, MS SQL Server and Oracle).

Is worth mentioning the predominant use of open source software, also multiplatform, which allows its use on Windows systems as well as on Linux ones.

It has a friendly-intuitive interface, a hierarchical menu distribution, and a help mechanism as you go through the application that makes EDVI a powerful tool. Summarizing, the main goals and the main characteristics of the EDVI system are the following:

-Eliminates the obstacles caused by timetables and localizations.

-Makes the learning task easier for the student.

-Internationalization (i18n). All the messages the application uses are in external text files, which makes easier switching from one localization to another.

-Management control based on profiles: learners, tutors, and administrators.

-Progress control of the learning cycle.

-Course management. Creation and delete operations are supported. Course related information management is also supported. Operations include learners and tutors assignments.

-Statistics retrieval. Different statistical data can be shown depending on the user profile.

-Internal messaging system for the application users.

-Additional communication tools, including a chat, a forum, and a virtual whiteboard increases the communication possibilities of the users.

-QTI questionnaires. Ability to create QTI questions and questionnaires, as well as support for taking questionnaires by the learners.

-Multiple algorithms for tests evaluation [11].

-SCORM 2004 compliance on content packaging (CAM) and partially on contents-platform communication (RTE).

-QTI specification compliance [9] on questionnaires creation and evaluation.

Figure 3 shows the EDVI system structure and a course structure on such platform.

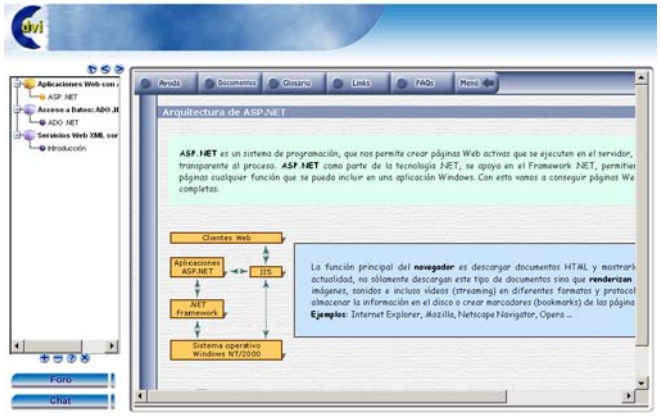

Figure 3. EDVI LCMS

4 Content Management System and repository

A learning object repository is a training resources' collection which is accessible through a communication network. The main goal is facilitate reusing educational content. The base idea is to avoid needing a predefined knowledge of the collection structure, which can contain the resources themselves, or only metadata with a location reference [8]. In order to complement our system a user-friendly tool was created (figure 4). Actually, this software is the learning content management system previously depicted on chapter 2. The system we propose is a tool to manage all the contents used to build courses. The following elements are required for this task:

-Courses and learning objects management. Ability to create, delete, and search learning objects and complete courses in the repository where they are stored.

-Course creation. Ability to build courses from learning objects directly stored in the repository or searched through the federated search system. These courses can be incorporated afterwards to the EDVI LMS system, so the learners can work with them.

5 SROA Federated search system

The SROA (Sistema de Reutilización de Objetos de Aprendizaje, Learning Objects Reuse System) [12-19] is a federated search system that works over multiple distributed repositories. This system implements the "Search Intermediary" of the reference model, as proposed on the DRI specification (figure 1). Federated search systems search using multiple sources and combine the results to give return to the user the simple set reducing duplicity (deleting repeated entries). The technological base is composed of the following:

- Web services. WSDL, SOAP and UDDI technologies.
- SOA (Service Oriented Architectures)
- Java Technologies: Servlets and JSP.
- Apache/Tomcat and Systinet servers.
- MySQL database system.

Figure 4. Content Management System

One of the main characteristics of the SROA system is its multilayer architecture (figure 5). The system was designed on the following layers:

-Interface layer (or Access and Presentation, layer 4): this layer is the part of the system where the users can interact with the system, and also provides the necessary components so other systems can interact with this one. On top of that, additional tools are included to perform tasks by the users.

-Services layer (layer 3): This layer hosts the application services, which provide e-learning specific capabilities, and the more common services used by the application components.

-Interoperability layer (layer 2): this layer can be deconstructed on the following ones:

- Integration Layer (layer 2b): This layer introduces the mechanisms and data flows required to dispatch requests from other systems as well as from users. Those requests are attended and then processed.

- Services Directory Layer (layer 2a): Much like the traditional directory services, which are capable of storing information about net resources, this layer can search all the needed services for accessing to distributed repositories.

-Data layer and available systems (layer 1): External systems, those who maintain an active communication with the SROA system, can be found on this layer. In this case, they are distributed repositories where the learning objects are stored in.

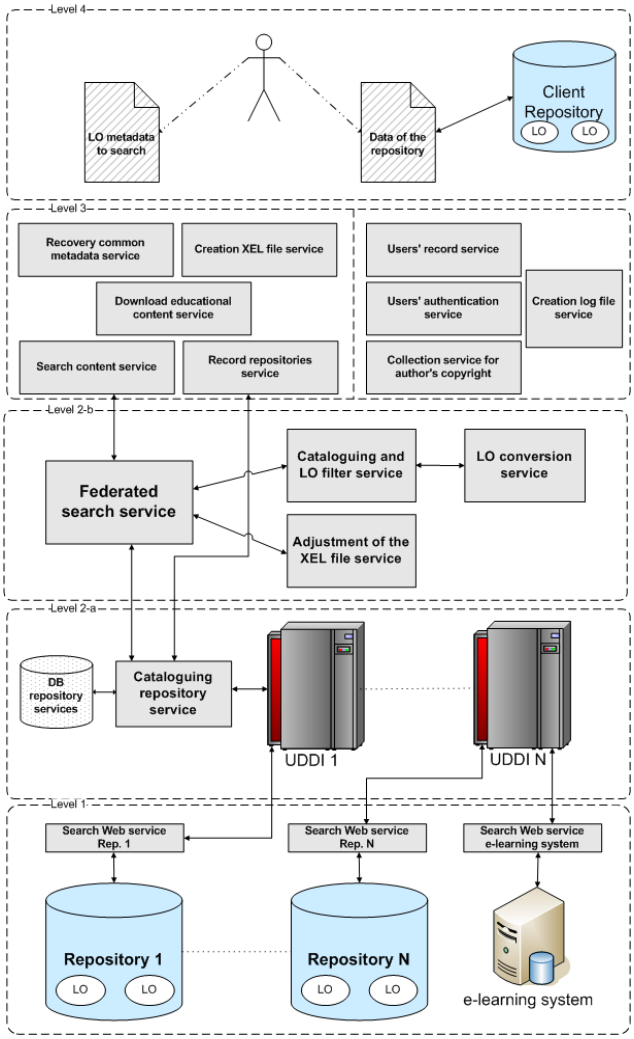

Figure 5. SROA system architecture layers

The SROA system provides two important operations:

-Repositories catalog. Operations related to repositories, such as to add new definitions for repositories, etc. Federated searches are performed on all the repositories which have been catalogued.

-Learning objects search (figure 6). Looks for learning objects accordingly to defined search patterns. Obviously, creators must tag their learning objects with the proper metadata info. The SROA system uses the most common metadata elements in the searches. This kind of info, however, is configurable.

Figure 6. SROA search results screen

Learning objects found by the SROA system can be then stored in local repositories and, in this way, complete courses can be built. These courses can be made accessible to the users via the EDVI LMS.

6 Present and future research lines

Research work has not finished, even with these systems fully developed and working. Currently our research group is working on improving the actual systems as well as developing new ones accordingly to the following research lines:

-Ontological searches. Since the semantic web concept was introduced [21], multiple systems are moving to a meaning-based functionality. Specifically, we are considering improving the search system, evolving into

a semantic search system based on ontologies. It also must be taken into account the possibility on integrating ontological web services, because at the end, the SROA system works as a service oriented architecture.

-Negotiation and payment services integration. We have detected a high necessity for creators and distributors to ensure their intellectual property and exploitation rights, and as the same time, make sure they receive their corresponding revenues. From this point of view, it is important to define digital rights control mechanisms for the learning objects, and to integrate the current systems with payment management and e-payment mechanisms [23, 24]. We are currently working on these research lines in order to build a learning object negotiation system. The main goal is to design and to build the required mechanisms to automate these tasks, rights' protection to all participants.

-Automatic content generation and sequencing. Finally, we consider important the inclusion of metadata inside the current learning objects, as well as some more recent technologies, such as competency integration, which facilitates designing and building of intelligent systems that automatically sequence (sort) and generate training material. As we have tools to perform distributed searches, the following step is to perform searches that retrieve a set of learning objects which are suitable to the needs of a user or group of users, sort these learning objects and box them as customized courses. The final goal is to automate the work of contents creators and to offer real customization to the learner.

7 Results and conclusion

On this paper we have shown the set of researching works carried by the Alcalá TIFyC research group to implement one the reference models in the e-learning field. As a result of this work, three interconnected systems were developed: the EDVI system, the content management system and the SROA search engine. These systems meet a great range of necessities, and implement the required functionality to offer a solution to the distant learning process. The main advantage of those systems is their support to the main existing specifications. This point guarantees the integration with existing systems as well as the new ones in the proposed model. It also guarantees interoperability with contents developed by third parties, as long as the learning objects are properly tagged, packaged, and published. As for the drawbacks, we want to point out the limited number of DRI-compliant repositories that exist nowadays, although the number of properly tagged and SCORM packaged learning objects is large. The fulfillment of these specifications will be a great step forward for the distance learning technologies and will allow further and fruitful research on this field.

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