Toward an Agent-Based Platform for Learning Objects Management

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Abstract. The current paper proposes a platform for learning objects management, based on the paradigm of intelligent agents. Such platform offers a personalization of the information based on user's behavior, an intelligent search capability for seeking some information between the objects and their ramifications, as well as the current state of the resources that compose to a certain object. This will allow the identification of the right objects to create suitable educative courses. The main contributions of the paper are: in first place, the proposal of integrating the technology of intelligent agents to a platform of learning objects, which makes more easy and precise the search of objects in several repositories located, mainly, in geographically distributed places; Second of all, the improvement of a technological tool which supports the process of education, through a scheme of distance education, utilized by the University of Colima; Finally, we intend to promote the adaptation of these educative schemes to the new technological advances, brought by Computer Science and Telecommunications in last years.

1 Introduction

In last years, Internet has changed the form in which people communicate trade and learn. In the educative context this change is reflected on the form that materials are designed, developed and distributed. Nowadays, the demand of education has increased by diverse social and demographic factors. Before this situation, new educative schemes have arisen in the academic world. One of them is distance education, which intends to satisfy such demand and to apply new technological paradigms to the daily task of teacher and student. Within this scheme, a new technology called learning objects is being increasingly outlined as a technological innovation in instructional design due, primarily, to his generative, adaptive and scalable potential.

A learning object, according to [1], is defined as a digital entity with instructional design features that can be used, reusable or referenced during the computer-enabled learning process.

The characteristics of an object are:

- *Interoperability:* The Capability of integration.
- *Reusability:* The capability of being combined within new courses.
- *Scalability:* Allows integrating to more complex structures.
- *Self-generation:* The capability of new objects generation based on it.
- *Management:* Concrete and correct information about offered content ad possibilities.
- *Interactive:* The capacity to activity and communication generation between involved users.

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- *Accessibility:* Access facility to appropriate content in appropriate time.
- *Durability:* An Expiration Time of object's information in order to avoid to become obsolete.
- *Adaptability:* Characteristic to fulfill the needs of learning of each individual.
- *Conceptual Self Contention:* The capability of being self explained and to allow integral learning experiences

The most important characteristics in this case of study are: scalability and self-generation, which allow the creation of knowledge networks that can become too complex for searching objects in order to fulfill a specific criteria.

The University of Colima, aware of the relevance of this sort of educational resources, has developed a platform to manage learning objects which gives to the academic community the opportunity of knowing and using the objects that have been implemented on the different centers which generate educational resources within the University itself (CEUPROMED, CIAMs Network, CEUVIDITE, CENEDIC, etc).

Along with the creation of this platform, new problems have emerged. For instance, every time a new resource is attached to an existing object, it is mandatory that this resource could be considered by the search engine, because it could happen that neither the original object fulfill the specified criteria nor the resource match the profile of the user that request it. In addition, there is the case that these criteria could be either fulfilled within an attached resource, by combining two related objects or, yet, by combining an internal object with an external one.

Our proposal is strongly based on the framework of a technological platform previously developed by the University of Colima which allows managing the set of learning objects that have been implemented on the different centers of this house of studies. Some related works to this field of study have been accomplished. It is the case of M.Chan that in [3] is proposing a Mexican Repository of Learning Objects. L.Iriarte and others in [4] propose a mechanism to create repositories of learning objects automatically. A.Saad in [5] introduces a model to interconnect Learning Objects in specific learning paths via a spreading activation mechanism. On the other hand F.A.DorÇa and others in [6] propose a multiagents architecture to distance education where they contribute with the idea of a pedagogic agent able to conforming courses according to the user's capacities.

In this paper we deal with an improvement for such platform which uses a multitier architecture, based on intelligent agents, that is divided as follows:

- **Presentation Layer:** It allows to the user to interact with the platform.
- **Agent Layer:** It gives the required functionality for creating, transferring and using one or several intelligent agents that will easier the search of learning objects. It will also allow content personalization according to the preferences showed by the user and based on his behavior.
- **Management Layer:** It gives the required business logic to retrieve information both, from this platform and from external ones
- **Communication Layer:** It offers a set of physical protocols and standards that allow interacting to different devices and agents over a communication network.

We consider that, by using a schema like the above to manage learning objects, will bring the next advantages to the current platform:

- User Notification of any object which has been recently created in the platform and that matches user's behavior.
- Intelligent object search for composed or core objects that fulfill thoroughly user's criteria and his objectives.
- State notification of each resource that compounds the object.

The rest of the paper is divided as follows: section 2 broadly explains the proposed platform and its details. Section 3 explains the presentation layer of the platform. Section 4 shows the parts in which the agent layer is divided into as well as introducing the basic concepts for agent-s usage. Section 5 gives an outline of the proposed management and communication layers. Finally, in section 6, it is mentioned the obtained conclusions and future work.

2 The Architecture

As it was previously mentioned, the University of Colima, pursuing to improve its distance education solution (EDUC), has implemented a learning objects set from the different research and study centers of the same institution [1]. These learning objects comprise a diversity of fields of study and they range from medicine to engineering, etc. However, the raising number of objects implemented by this institution has brought the necessity of having a technological solution that may their manipulation easily and suitably. To satisfy such necessity, the University of Colima implemented an XML-based ASP-built technological tool that allows managing the objects previously indicated.

Such tool is supported on a platform of two layers, constituted, mainly, by a presentation layer and a data management layer which, in turn, are in charge of providing the required functionality to the user. In spite of having a tool like the previous one, the University of Colima platform has met some problems. Firstly, the problem, due to the constant increment of the object's resources of finding the appropriate object that can satisfy the designed of a desired course. Another problem founded is represented by instructor's exhaustive work to control and managing his distance course groups. The architecture for this platform is shown in the following figure:

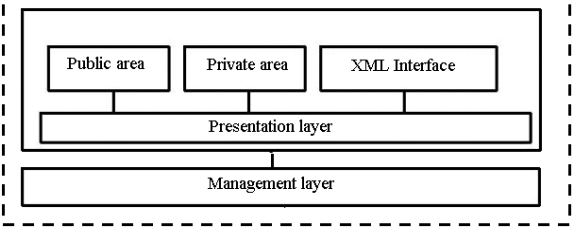

Fig. 1. Current platform's architecture for learning objects management

Based on the exposed necessities, we propose an improvement to the platform previously developed through an integration of intelligent agents that can make easier the search of objects or resources that match a certain profile. This integration is focused on the insertion of two additional layers to the previous model, achieving, in this way, a high level modularity and interoperability.

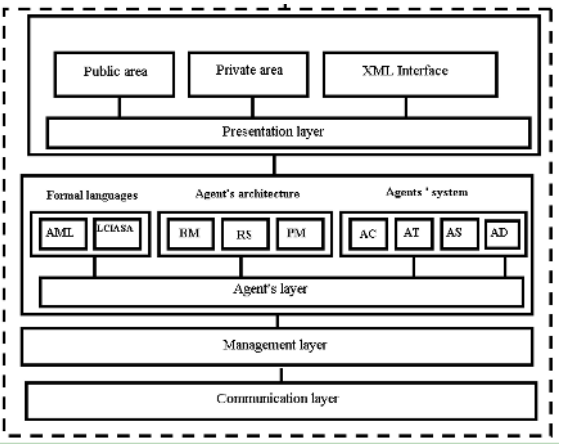

Fig. 2. Proposed platform's architecture

The architecture of the new platform is shown in figure 2. As it can be appreciated, the proposed architecture is a multi-tier one where each one communicates through a physical interface based on the communication protocols that are defined on its last layer. It is worthy to point out that, even though the model suggests a communication in a top-down way, it is possible to access to any layer in an independent way.

Once the user has decided to access to the platform, the presentation layer is in charge of authenticating the user's identity and of presenting the information to the user. This layer carries out a double work. On one hand it authenticates the user and on the other hand it formats the retrieved information in each interaction with the tool. Next, the agent's layer organizes the information according to the preferences and necessities of the user. This situation causes that the management layer carries out the work of recovering the information from the different repositories that are managed by the platform. Once the information has been retrieved, the communication layer is in charge of transferring it, based on the protocols that are defined inside this layer, to the end user.

As for the security part, the proposed model has two main security mechanisms that assure a reliable access to the resources of the platform. The first one is the authentication method given by the presentation layer that allows the user to use the complete features of the solution through a customized username and password. However, to assure the interoperability of the platform, it is proposed that this access could be based on XML by using the standard of IEEE for XML digital signatures on the future. The second mechanism is based on an intelligent agent that assures the invocation of other agents or objects in a reliable way.

While respecting the modular design of the solution, not only is it achieved to reuse the technology already developed, but also a solution that could be used in similar platforms for learning objects management.

3 Presentation Layer

The presentation layer of the platform is divided into three main areas: a public area, a private area and a XML Interface. Each one offers different types of access to the

users of the platform, allowing them to use different features or, in the case of the XML Interface through a standard interface to other users and even to connect external platforms. The presentation layer also has the peculiarity of formatting the recovered information through XSL to offer the user a more appropriate approach of the information. Figure 3 sample in detail the areas that compose to the presentation layer.

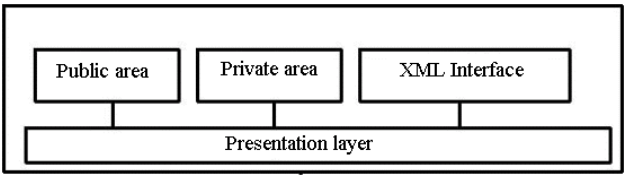

Fig. 3. Presentation layer

The first area, allows the user to be authenticated, it shows the objects recently attached to a repository to the user, the most visited objects and the disciplines in which are classified. Also, it allows carrying out searching and provides a summary of the content of the objects that are returned as a result; besides, the user can create an account that allows him to enter and to obtain more information or the complete content of the objects. The purpose that the user could be identified is to create a profile that allows observing his behavior and that will be useful to offer suggestions.

In the second area, the user's authentication is required through a customized username and password. Once authenticated, the platform offers the possibility to carry out queries that show the complete profile and location of the object, as well as adding to each one: comments, resources and calendars. In this section it is possible to define the preferences and profile of the user, what allows an easy access on the future. Although all users can also add objects to the platform in this section, those will be revised by a committee observer of the same institution before doing it. This revision will only be carried out regarding the structure and form; this is done with the purpose of assuring that the given information corresponds to the topic of the object.

The third area allows that any application could carry out queries to the platform by using XML. Only if the query is requested in a private area, it will be necessary the user identification since, otherwise, an error message will be returned. This feature allows the integration of the platform to external platforms, either compatibles or incompatibles. As XML is a broadly utilized standard, we believe that by offering this characteristic will cause an extensive collaboration, among private and academic institutions, to share the different repositories of learning objects from all over the world.

4 Agent's Layer

Once the user has access to the platform through some of the three areas of the presentation layer, the logic of the platform uses the layer of intelligent agents. This layer is in charge of providing the necessary functionality for the manipulation of the intelligent agents that will guide the searching process of learning objects on the different repositories. The main purpose of these agents resides in offering the contents of the

objects according to the preferences shown by the user, based on his behavior. It is important to mention that intelligent agents try to solve the problem of finding the appropriate object for the desired course. These agents help us to identify learning objects that have been recently modified and that, by ignorance of the user or insufficient descriptions of the object, are not in the right classification.

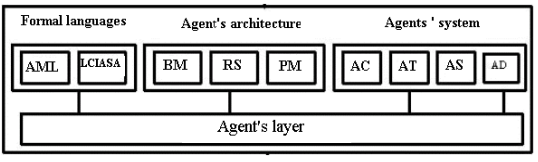

Fig. 4. Agent's layer

The agent's layer is conformed by an agent's system that, in turn, is based on agent's architecture and a formal model. In figure 4 these elements are shown.

An agent's system is a platform that can create, to interpret, to execute, to transfer and to eliminate agents. An agent's system can only be identified by its name and by its address; a host can have one or more systems of agents.

It is defined three common types of relative interactions to the interoperability of agents:

1. Agents' remote creation (AC)
2. Agents' transfer (AT)
3. Agents' invocation method (AS and AD)

Agents' remote creation: In the remote creation of agents, a program of the client has an interaction with the agent's target system to request an agent, of a particular class, to be created. The client authenticates the agent's target system, establishing the authority that the new agent possesses. The client provides the initialization arguments and, when necessary, the class to create an instance and to execute the agent.

Agents' transfer: When an agent is transferred to another agent's system, the agent's system creates a request providing a name and location that identifies the target place. If the agent's source system links the agent's target system, the agent's target system must fulfill the request or to return a failure indication to the agent. If the agent's target system is unreachable, a failure indication must be returned to the agent's source system.

Agents' invocation: An agent's invocation takes place when methods from another agent references to the source agent objects, if it is authorized. The communication infrastructure should invoke the suitable method and return the result of the invocation or return failure identification. When an agent invokes to a method, the security of the information that is given to the communications infrastructure that performs the invocation of the method, must correspond to the agent's authority.

To this end, the agent's system is based on an agent's architecture BI (Belief-Intentions), which can be considered as a subset of the BDI architecture [7] that, in turn, is included as a special case in the ICE architecture (abbreviation of $I^2C^2E^2$: Information, Intention, Communication, Cooperation, Evaluation, Empowerment). The proposed Architecture is used to specify the functionality of the agents within the system. This architecture contains the needed data and storage structures to define the agent's capabilities.

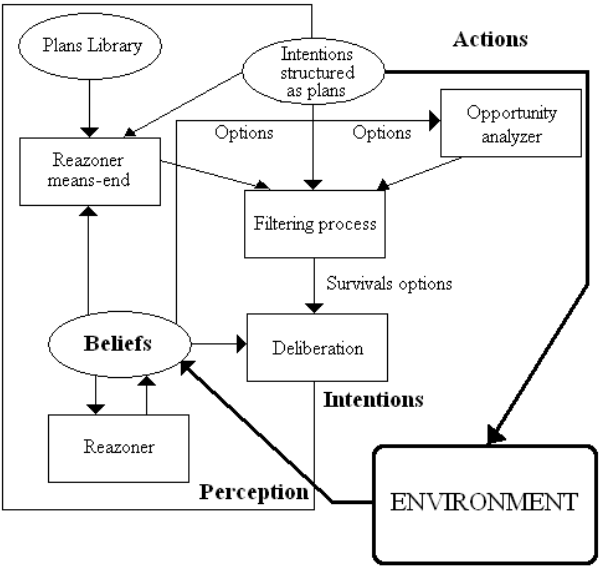

Fig. 5. Agent's architecture

In Fig. 5 the key data structures and their organization to describe the functionality of the agents are shown. Below it is given an outline of the concepts that are associated to the agent's architecture.

This architecture has its foundation on the philosophical tradition of the practical reasoning understanding witch is the process of deciding time after time which action must be execute in the attainment of the proposed goals. The practical reasoning involves two important processes: first, to decide which goals are pursued, which is called deliberation process and second, to decide how to achieve such goals, this process is called "means-end" reasoning.

Plans' library: Set of plans stored as procedures, this plans' library can be seen as a subset of the beliefs that an agent has about the plans and under which circumstances they are required to perform a task. *The Intentions structured as plans, are the plans that the agent is performing in the current time.* Additionally, the agent's architecture contains a reasoner that allows him to decide about the world. The "means-end" reasoner is invoked once that an intention has been created, for each of the existing partial plans, with the purpose of proposing sub-plans to determine which plans could be used to reach the agent's intentions, an opportunity analyzer that senses the environment with the purpose of determining subsequent options for the agent.

A filtering process and deliberative process, the filtering process is the responsible one of summing up the subset of the courses of the potential agent's actions, that have property of being consistent with the current agent's intentions, the selection among the options that compete is made by the deliberative process which receives the remaining options after being filtered and it ponders the options some against other and it updates the structured intentions as plans.

The beliefs repository contains a representation of what the agent knows from itself and from its environment, as shown in Fig. 5.

The Agent's system is also based on a formal model that contains two main parts: an Agents Meta language (AML) and an object language (LCIASA). These two languages are proposed by N. Farias in [2] as verification and specification languages for agent-based system. The Agent's system uses this model to describe functions and operations of the system in a precise way.

5 Management and Communication Layers

The management layer has as purpose to retrieve all the information from one or several repositories. On other hand the communication layer, includes all the standards and protocols that are required for the information transfer, as well as its corresponding retrieval. Because of this reason, the management and communication layers work as closed to achieve these goals that, sometimes, they get overlapped offering, one to another, the requested or required features.

Following the process of information retrieval, which is performed by the management layer, is explained. Every time that any user sends a query to the platform, this carries out a request to the database servers, which generates a XHTML document that is returned as the answer. If the query is sent through the XML interface, then the returned document is XML.

To conclude, a brief mention of the protocols and standards that conform to the communication layer and the parts in that they are used is made. The platform is designed to work on the WEB; also by having XML interface, it allows the integration of mobile devices through WAP (Wireless Application Protocol) or any other application that wishes to obtain information from the platform itself. As the communication protocol, the platform uses TCP/IP.

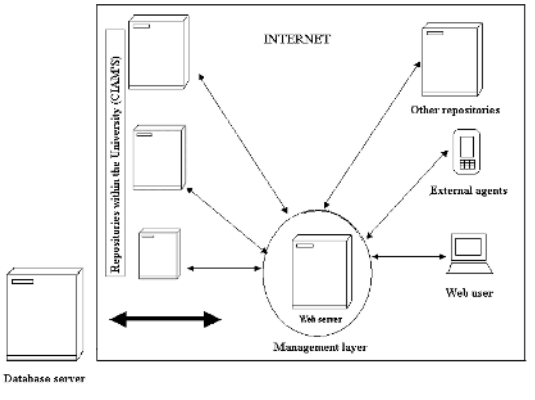

Fig. 6. A schematic view of management and communication layers

The database is designed in MS-SQL Server, which allows a large storage, security and stability capacity. It is based on the recommendation AMS v3.2, which provides a technological infrastructure that supports the indexation, management and storage of educational objects that work under LOM and KPS standards (Knowledge Pool System). LOM (Learning Object Metadata) it is a standard that specifies syntax and semantics of educational objects metadata. LOM is defined by the IEEE P1484.12

(Learning Objects and Metadata Working Group that is part of the IEEE Learning Technology Standards Committee), at the moment this initiative is denominated LTSC.

The proposed programming language is ASP (Server Activates Pages) that allows an express development besides other benefits that are beyond the context of this article.

6 Conclusion

The platform for learning objects management proposed in this article intent to provide a better option to the user so he could find the right learning objects, within one or more geographically distributed repositories.

It is important to point out that in the case of the selected platform; the objects implemented by the University of Colima are attached to the IEEE LOM standard. This could give the idea that the platform can only be used with platforms that use the same standard. This is a mistake. Since the platform offers an XML interface, it enables to the external user to integrate it to his daily use. In future work we propose to build web services that allow to the platform to use learning objects repositories that are based on different standards.

We suggest continuing this work in future, incorporating coordination, and cooperation and negotiation protocols in order to generate a tool useful for distance teaching instructor.

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