

Intelligent Learning Objects: An Agent Approach to Create Interoperable Learning Objects

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Abstract. Reusing learning material is very important to design learning environments for real-life learning. The reusability of learning objects results from the product of three main features: modularity, discoverability and interoperability. We proposed learning objects built based on agent architectures, called Intelligent Learning Objects (ILO). This paper discusses how the ILO approach can be used to improve the interoperability among learning objects, learning management systems (LMS) and pedagogical agents.

1 Introduction

This paper addresses the improvement of interoperability among learning objects in agent-based learning environments by integrating learning object technology and the multi-agent systems approach. According to Downes [3], Mohan & Brooks [10], and Sosteric & Hesemeier [11], a learning object is a piece of learning content that can be used several times in different courses or in different situations. According to Downes [3], the cost of developing learning materials for e-learning can be large, but if related courses are taught, the subject matter is similar and the cost of developing learning material can be shared. The learning object approach promises to reduce significantly the time and the cost required to develop e-learning courses. The use of reusable learning objects to create learning environments improves speed, flexibility and economy.

A learning object must be modular, discoverable and interoperable in order to be reused [5]. To achieve these features and improve the efficiency, efficacy and reusability of learning objects, many people have dedicated a great effort. The main focus has been on standardization. Organizations such as the IMS Global Learning Consortium [7], IEEE [6], ARIADNE [1], and CanCore [2], have contributed significantly by defining indexing standards called metadata (data about data). Metadata contain the information to explain what the learning object is about, how to search, access, and identify it, and how to retrieve educational content according to a specific demand.

Mohan & Brooks [10] point out some limitations of current learning objects. According to them an instructional designer must carefully examine a large amount of learning object. The task of finding the right object may be quite time consuming and the learning object metadata are not very useful in supporting pedagogical decisions.

On the other hand, the state of the art in intelligent learning environments (ILE) points to the use of architectures based on the multiagent paradigm [8]. Using the multiagent approach can result in faster, more versatile and lower cost systems. We proposed the intelligent learning object (ILO) approach as a useful way of enabling the reusability of agents making up pedagogical systems.

2 Intelligent learning objects

An intelligent learning object (ILO) is an agent that promotes learning experiences to students in the same way as learning objects used to do. For this reason, an ILO can be seen as a learning object built through the agent paradigm. The technological basis of this approach is combination of the technologies for learning objects and for multi-agent systems.

As a learning object, an intelligent learning object must be reusable. The *reusability* is given as a result of three features: **interoperability**, **discoverability** and **modularity** [5]. In a learning object approach, metadata is used to give discoverability by describing the pedagogical content of the learning object. To enable the **discoverability** feature in ILO, we have adopted the IEEE *1484.12.1 Standard for Learning Object Metadata* [6]. The **modularity** of learning objects can be reached with a good pedagogical project. The design of the pedagogical task of an ILO must be made according to the expertise of some object matter specialists and pedagogical experts. Some **interoperability** can be reached by the use of well-known standards. For this reason, we adopted two learning object standards: a) the IEEE *1484.12.1 Standard for Learning Object Metadata* [6]; and, b) *IEEE 1484.11.1 Standard for Learning Technology – Data Model for Content Object Communication*. The 1484.11.1 standard is defined for communication of learning objects with *Learning Management Systems* (LMS). We use this standard in interactions among ILOs.

To assure interoperability among agents we have adopted the concepts defined by FIPA [4]. FIPA is an organization which defines standards to enable interoperability for multiagent systems. The main concern of FIPA is the definition of standards to enable the communication between agents. A well-defined

communication framework is vital for interoperability among agents. We have used this reference model to define a communication framework for ILOs. The ILOs must use this framework in order to communicate with each other.

3 The ILO multi-agent architecture

The ILO architecture [12] encompasses three types of agents. The *Intelligent Learning Object Agents* are responsible for playing the role of learning objects. They generate learning experiences for the students in the same sense of learning objects. The *LMS Agents* are abstractions of learning management systems. They are responsible for dealing with the administrative and pedagogical tasks involving a learning environment as a whole, providing access to the ILOs for the students and storing information about the students.. The *ILOR Agents* are abstractions of learning object repository systems. They are responsible for storing data to permit a user or an agent to find ILOs. Figure 1 illustrates the proposed agent society.

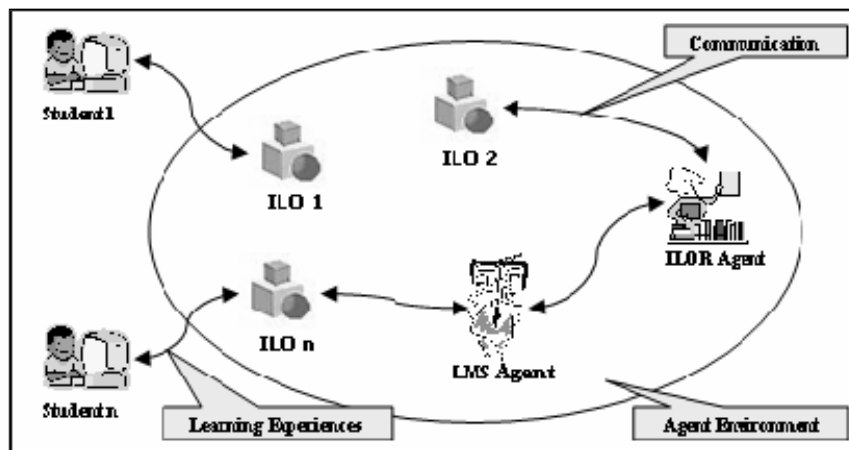


Figure 1. Proposed agent society

The students interact with the LMS agent in order to have learning experiences. The LMS agent asks the ILOR agent to search the appropriate ILO. The ILO is then responsible for generating learning experiences for the students. All these communications are performed by message exchanging using FIPA-ACL [4].

4 Case study

We developed an extended FIPA framework composed of a set of Java classes designed to build ILOs as easily as possible and applied this framework to the agent-based learning environment described by Lucas [9]. Such a system is composed of an ILO playing the role of a special calculator and an animated pedagogical agent

(see Figure 2) playing the role of an animated tutor to help primary school students to learn some fundamental mathematical properties of multiplication.



Figure 2. The APA giving an instruction.

The animated pedagogical agent works like an LMS and the calculator pedagogical agent is a typical ILO. The communication between the two agents is performed using the FIPA communication framework.

5 Conclusions

Intelligent learning objects are able to improve the adaptability, interoperability and interactivity of learning environments built with these kinds of components by the interaction among the learning objects and between learning objects and other agents. This concept of communication is more robust than a single method invocation as the object-oriented paradigm used to be.

The test bed application showed that the proposed approach of agent-based learning objects promises to be useful to improve the interoperability of learning objects, pedagogical agents and agent-based learning environments. The pedagogical agents are capable of providing suitable messages to the student and interact with the learning objects in a powerful way. This interaction provides more reality to the environment, and the student feels that he/she and the agents are active characters in the learning process.

While the development of educational content is converging to the use of standards towards reusability, we are still developing *ad-hoc* pedagogical-agent-based learning environments. This is the issue that this paper addressed. We should start to think about reusability when developing pedagogical agents. We need to go

towards the use of reusable and interoperable pedagogical agents. The convergence between learning object and agent technologies seems to be promising.

Acknowledgement

This project is granted by Brazilian agencies: CNPq, CAPES and FAPERGS.

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