Using Intelligent Learning Objects in Adaptive Educational Portals

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INTRODUCTION

The learning object (LO) approach is based on the premise that the reuse of learning material is very important to designing learning environments for real-life learning. According to Downes. (2001), Mohan and Brooks (2003), and Sosteric and Hesemeier (2002), a learning object is an entity of learning content that can be used several times in different courses or in different situations. One of the benefits of the reusability is that it significantly reduces the time and cost required to develop e-learning courses. For Friesen (2001), reusability is given as a result of three features: interoperability, discoverability, and modularity. The interoperability is the capability of working in different environments. The discoverability is the capability of being discovered based on the educational content. The modularity is the capability of having learning material that can be, at the same time, big enough to be coherent and unitary and small enough to be reused. These features would be very useful if added to pedagogical agents (PA) (Johnson & Shaw, 1997).

There are many benefits of integrating learning objects and agents: An intelligent agent is a piece of software that works in a continuous and autonomous way in a particular environment, generally inhabited by other agents, and able to interfere in that environment, in a flexible and intelligent way, not requiring human intervention or guidance (Bradshaw, 1997). An agent is able to communicate with others by message exchange using a high-level communication language called Agent Communication Language (ACL), which is based on logic concepts.

The main focus about learning objects has been on the definition of standardization. Organizations such as IMS Global Learning Consortium, IEEE, ARIADNE, and CanCore, have contributed significantly by defining indexing standards called metadata (data about data). Metadata structures 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.

Therefore there are some limitations of current learning objects: An instructional designer must carefully examine each learning object in order to add it in a learning environment. In addition, the current learning object metadata standards are not very useful to support pedagogical decisions. Because of this the task of finding the right object may be quite hard work and time consuming.

Silveira, Gomes, & Vicari (2004), proposed the development of learning objects based on agent architectures: the intelligent learning objects (ILO) approach. In this article we show how this approach can be used to improve the reusability of pedagogical agents by adding learning objects features to them. These features can be useful to build interactive and adaptative educational portals.

BACKGROUND

As defined in Silveira et al. (2004), an ILO is an agent that is able to promote learning experiences to students the same way as LOs do. This is the reason why an ILO can also be seen as an LO built through the agent paradigm. Based on these concepts, we can consider a PA with LOs features as an ILO. This is the basic concept we will adopt in the remaining of the article. This section presents some simple scenarios that can be enabled with the use of LOs features in PAs.

- **Discoverable Pedagogical Agents:** For discoverability, imagine a PA specialized in teaching mathematical properties of multiplication using exercises. In a given moment, this PA perceives that a student has difficulties during the learning process. Based on this perception, the PA decides the student must see some examples, but it does not have the skill to display examples. So, it looks in the agent society for other PAs with this skill. In this task it consults information about the educational content of other PAs in the society. It can do this directly with Pas, or through an agent specialized on providing this kind of information. The conceptual models are already developed for the learning objects technology. Metadata standards allow to describe the educational

content of an LO, and learning object repositories (LOR) make possible to store LOs and to make their metadata information available so that humans and software systems can consult them.

- **Interoperable Pedagogical Agents:** The teaching scenario described can only be reached if we have interoperable pedagogical agents. With interoperability we can imagine a big set of PAs communicating with each other, to share pedagogical information, for example, and being able of working together to solve the student's teaching/learning difficulties.
- **Modular Pedagogical Agents:** In the teaching scenario, we mentioned a PA teaching some topic about mathematics. It is worth highlighting that the topic must be comprehensive enough to be unitary and coherent, but small enough to be reused in different courses. This feature is the modularity. For example, the subject "properties of multiplication" is a modular topic in mathematics. The same PA teaching properties of multiplication can be used in higher education courses as well as in undergraduate courses.
- **Reusable Pedagogical Agents:** Now, imagine you have a big set of PAs that are interoperable, discoverable, and modular and you want to build a mathematics course. Instead of having to develop your own PAs, you can choose among your set of PAs which of them are suitable for your course. In this task, you consult their metadata information, assemble the agents in a course, and then deliver it in some kind of learning environment. The principles for this are also defined in the learning objects technology. Learning management systems (LMS) are systems used to deliver courses using LOs. The LORs can be used to search suitable learning objects. If you assemble your course like this you can reduce the time and cost required for its construction.

Finally, imagine that the educational content of some of the PAs you used in the mathematical course can be also used in a physics course you want to deliver. You can get these agents and merge with others and your course is ready to be delivered. That is reusability.

PEDAGOGICAL AGENTS AS INTELLIGENT LEARNING OBJECTS

The next section discuss the fundamental issues related to the use of agents as learning objects.

Requirements for Intelligent Learning Objects

As a learning object, an ILO must be reusable. To be reusable it must be interoperable, discoverable, and modular. As the technological basis of an ILO is composed of agents and LOs technologies, we need to treat these features in the two levels.

Achieving Modularity

The *modularity* of learning objects can only be reached by a good pedagogical project. Hence, the design of the pedagogical task of an ILO must be made according to a pedagogical expert and the expertise of some object matter specialists.

In the field of agents, we adopted the Wooldridge (Wooldridge, Jennings, & Kinny, 1999) conceptions in order to achieve modularity. These authors see agents as coarse-grained computational systems, each making use of significant computational resources that maximize some global quality measure. Hence, the ILO agent should not attempt to solve the problem on its own. This is the modularity principle in MAS.

Achieving Interoperability

Interoperability can only be achieved by the definition and the use of standards. In the field of LOs, we adopted two well-known IEEE standards for learning objects: the IEEE *1484.12.1 Standard for Learning Object Metadata* (LOM) IEEE (2004) and the *IEEE 1484.11.1 Standard for Learning Technology—Data Model for Content Object Communication* (DMCOC) IEEE (2004). The LOM is used to describe the metadata information of the ILOs and the DMCOC is used for the communication of pedagogical information among the ILOs.

In the field of agents, we adopted the FIPA (2002) concepts. The FIPA defines standards to enable interoperability for MAS. FIPA believes that having a well-defined communication structure is vital for interoperability among agents. Among the FIPA developments there is: a language for the communication among agents, the FIPA-ACL; a language for encoding the contents of communication messages, the FIPA-SL; a set of interaction protocols that define patterns of message sequences with associated semantics. We used these technologies to define a communication framework for ILOs. The ILOs must use this framework in order to communicate with each other.

Achieving Discoverability

In learning objects, the *discoverability* is yielded for the use of metadata information to describe the pedagogical content the learning object loads. To enable this feature, we adopted the LOM IEEE (2004).

The discoverability in the field of MAS is the ability to be discovered in terms of tasks and services provided. In addition to some services provided by the FIPA architecture, our communication framework contains a set of dialogues that ILOs should use.