INFORMÁTICA NA EDUCAÇÃO: teoria & prática Porto Alegre, v.12, n.1, jan./jun. 2009. ISSN digital 1982-1654
ISSN impresso 1516-084X

OBAA Project: An approach to interoperable learning objects based on Web and digital television

Projeto OBAA: Uma abordagem com objetos de aprendizagem interoperáveis baseados na web e na televisão digital

Marta Rosecler Bez
Universidade Federal do Rio Grande do Sul

Júlia Marques Carvalho da Silva
Universidade Federal do Rio Grande do Sul

Elder Santos
Universidade Federal do Rio Grande do Sul

Tiago Primo
Universidade Federal do Rio Grande do Sul

Alexandro Bordignon
Universidade Federal do Rio Grande do Sul

Abstract: This article presents the studies conducted in the OBAA project – Agent Based Learning Object. Some definitions of learning objects, repositories, interactive digital television, and multi-system agents are presented. Standards to build learning objects and programs for digital television were investigated and analyzed in order to specify a new multiplatform pattern, in which contents that can be used in web and digital television are built.
Keywords: OBAA. Learning Objects. Digital TV. Multi-Agent System. SCORM.

Resumo: O presente artigo descreve os estudos realizados no projeto OBAA – Agente Baseado em Objeto de Aprendizagem. São apresentadas algumas definições de objetos de aprendizagem, repositórios, televisão digital interativa e multiagentes do sistema. Normas para construir objetos de aprendizagem e programas de televisão digital foram investigadas e analisadas, a fim de se especificar um novo padrão multiplataforma sobre o qual é construído o conteúdo que pode ser usado na web e televisão digital.
Palavras-chave:OBAA. Objetos de Aprendizagem. TV Digital. Multiagentes do Sistema. SCORM.

BEZ, Marta Rosecler et el. OBAA Project: An approach to interoperable learning objects based on Web and digital television. *Informática na Educação*: teoria & prática, Porto Alegre, v. 12, n. 1, p. 119-126, jan./jun. 2009.

1 Introduction

The OBAA project (Agent Based Learning Object) aims at combining technologies of Learning Objects (LO) and Multi-Agent Systems (MAS). Learning objects are built based on agents to provide more flexibility, adaptability and interactivity to learning environments. The general objective of this project is to develop a specification for interactive learning objects operating in web and digital TV platforms, meeting pedagogical and accessibility requirements. Among specific objectives are converging the technology of agents from learning objects and pervasive computing to construction and recovery of LO in reasonable time and in varied contexts; developing a specification for publication of LO that enables its easy identification by current web search mechanisms, that is, they should be codified by an interoperable format.

This paper is organized as follows: section 2 presents the technologies studied in the OBAA project, specifications for LO, repositories, and standards for Digital TV and Multi-Agent Systems. Section 3 discusses abstract architecture, interaction between repositories and the standard for process management.

Development of LO and their adaptation to the platforms are presented in section 4. Section 5 brings an explanation of the web and digital TV platforms, followed by final considerations in section 6.

2 Study of Technologies and Actualities

The OBAA project was initially divided into four study groups: pedagogical, digital TV, intelligent aspects, and content management. The **Pedagogical** group is in charge of studying specifications, analysis of existing LO in some repositories, development of operable LO in web and Digital TV. The **Digital TV** group is responsible for studying the standards for digital TV, focusing on the ISDB-Tb (International System for Digital Broadcasting – Terrestrial – Brazilian flavor), and assisting the adaptation of LO selected by the Pedagogical group, making Brazilian definitions for digital TV compatible with the web technology.

The **Intelligent Aspects** group is responsible for implementing a multi-agent architecture and defining a multi-agent society. Finally, the **Content Management** group studies LO in CESTA and SACCA repositories. Figure 1 shows the structure, concepts and technologies used in the OBAA project. The activities mentioned here are described in subsequent subsections.

2.1 Specifications for Learning Objects

Learning objects are educational contents, usually in digital format. To do so, it is necessary to establish specifications that ensure its reusability, accessibility, interoperability and durability (ADL, 2006). Specifications to develop learning objects are concentrated in three stages: production, generation and execution.

Each stage has specific computing requirements, generating different artifacts.

Production concerns development and description of learning objects.

Development is guided by instructional design, i.e., how information should be presented and is based on pedagogical and psychological theories. Data are informed in the description of learning objects, generating metadata. Nowadays, most specifications study this stage.

Generation focuses on “packaging” learning objects, that is, generating the file with content

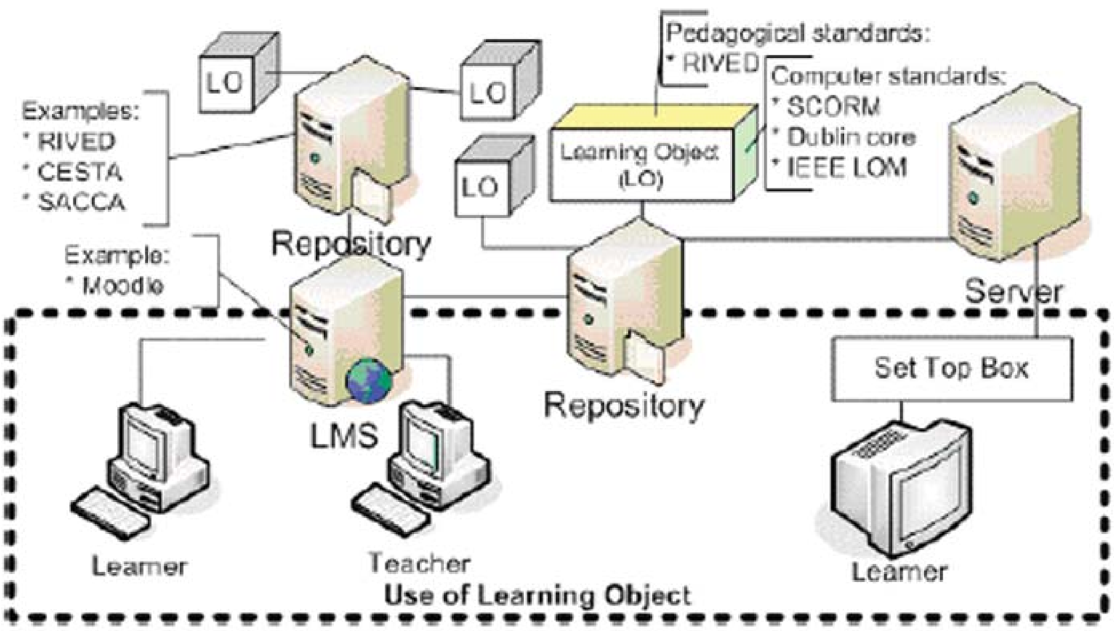

Figura 1 – Concepts and Technologies related to the project and metadata, ensuring their execution by virtual teaching-learning environments adherent to such specification.

Finally, specifications for execution guide implementation of modules to execute LO in virtual teaching-learning environments, enabling execution of LO and management of data of the student's model.

Such definitions (specification, generation and execution) are proposed by the authors to facilitate understanding of specifications. In addition, what each specification actually proposes is presented, since not all describe the three stages.

Some examples of specifications for learning objects are IEEE LOM (2002), in Core (2007), and SCORM (ADL, 2001). IEEE LOM provides a set of metadata describing technical content and some pedagogical characteristics of LO, and is considered as the most complex specification.

Dublin Core (2007) also describes metadata, but it only contemplates the information considered essential on LO. SCORM (ADL, 2001) is considered as a more complete specification as it provides guidelines that permeate stages of specification, packaging and execution.

2.2 Repositories for Learning Objects

Repository is the name given to systems that store and recover learning objects, facilitating the development of new courses. CESTA (Collection of Entities to Support Use of Technology in Learning) is a repository developed by Universidade Federal do Rio Grande do Sul (UFRGS) and created to organize educational objects (CESTA, 2007).

SACCA (Automatic System of Audiovisual Content Cataloguing), also developed by UFRGS, is a repository of audiovisual contents that operates semiautomatically; a user performs analysis of video and definition of the keywords that will be included in cataloguing (SACCA, 2007).

RIVED (International Virtual Education Network) is a repository that has learning objects exploring pedagogical and technological perspectives to complement activities, especially in school teaching (RIVED, 2007).

Internationally there are many learning object repositories, whose standardization is an interesting object of study. Among existing repositories, the following stand out: OpenCourseWare, which provides free courses and the material used in IMS format (Instructional Management System) (MIT, 1999); MERLOT (WEECH, 2002), which is characterized for being one of the largest repositories of learning objects; and CLOE – Co-Operative Learnware Object Exchange (ROSE, 2003), a repository of learning objects of the University of Waterloo (with restricted access to some Canadian universities) that, in addition to storage, enables collaborative development of learning objects and relationship with existing objects in the database.

2.3 Standards for Digital TV

The basic metadata for the digital television are composed by SI (Service Information) and PSI (Program Specific Information) tables. Those tables contain the necessary and sufficient information to demultiplex (the process of separating multiple analog message signals or digital data streams that where combined into one signal over a shared medium) and present TV Programs (T-REC-H.222.0).

The drawback of these description tables lies in the fact that they do not have sufficient metadata to support the range of intelligent applications that are available today. For that reason, Alves, Kulesza, Silva, Juca and Bressan (2006) mentions that standards like MPEG-7 and MPEG-21 (firstly adopted for web applications) were adopted as an alternative for the Digital Television.

Presently there are other patterns based on the MPEG-7 and MPEG-21, for instance: TV-Anytime (TVA, 1999), Material eXchange Format (MXF) (EDWARDS, 2006) or Tru2Way (Tru2Way, 2008).

These metadata standards aim to bring a set of fields that better describe the content, providing a better way to reach interoperable objects.

2.4 Multi-Agent Systems

In recent years many educational systems are being implemented according to the agent paradigm. An interesting useful capability of intelligent agents concerns their potential learning ability. This feature gives Intelligent Learning Objects the ability to acquire new knowledge and perform different behaviors during their existence, according to their experience. Thus, by interaction with the learners and other Intelligent Learning Objects, an Intelligent Learning Object is able to evolve. It is not static like current learning objects.

The autonomy of Intelligent Learning Object provides it with the capability to act based on its own behavior and knowledge with no external intervention. The pro-activity feature ensures that the Intelligent Learning Object must act in order to satisfy its own objectives.

Mohammed & Mohan (2005) present a study called Agent Based Learning Objects (ABLOs), which allows more sophisticated types of learning object and acts on its behalf, importing agent characteristics such as self-awareness, portability and social interactivity.

Stoilescu (2008) describes some works related to learning objects and multiagent systems. He concludes that there is no popular application of Intelligent Agents using Learning Objects that has entered into the global educational mainstream. There are only projects and tests. Sometimes local solutions cannot be generalized.

3 Abstract Architecture

One stream of work on the project aims at establishing a standard to achieve interoperability. Since technical issues on the web and digital TV are considered, the set of standards must normalize which technology will be used on each specific case. Technology for video encoding, programming languages compatible with web and TV, and encoding of web documents are a few examples of technologies that need to be standardized (at least stating which technology will be used in each case). If we simply adopt the most adequate solution to date, the proposed standard will last as long as the technology. To deal with this situation, a common approach on standard development is adopted, the definition of an abstract architecture.

The abstract architecture specifies a view of the standard with a high abstraction level. Following this approach, we first specify the requirements and then a high-level component infrastructure. Technology and protocol issues are outside the scope of the abstract architecture and are left for its concretizations (specific standards for specific issues). A component specified on the abstract architecture will not necessarily lead to a software component, but most likely will generate a set of standards to accommodate the component's functionality. Focus on functionality allows for different concretizations of the same component, thus enabling the standard to survive through technology evolution.

The defined component infrastructure represents a general structure for the concrete standards. The core components are the repository, learning process management and communication. Figure 2 illustrates the interaction between those components and

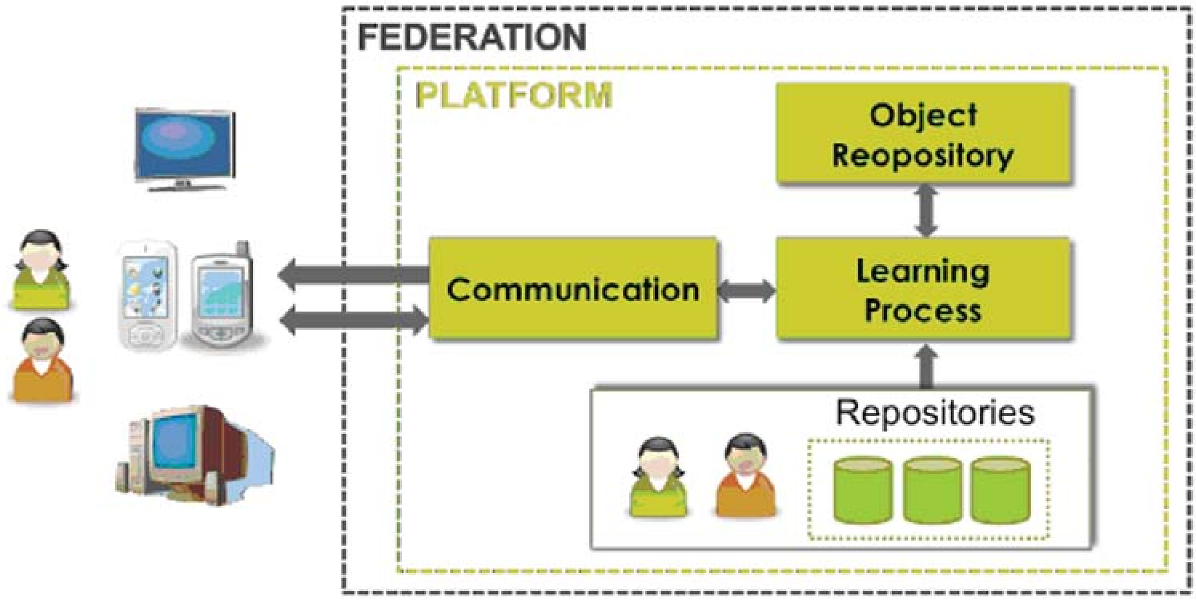

Figure 2 – OBAA Abstract Architecture

 Porto Alegre, v.12, n.1, jan./jun. 2009. ISSN digital 1982-1654
ISSN impresso 1516-084X

end users. In addition, the figure shows what is considered to be a platform and also that federation services are expected to support the structure.

The bottom of the Figure 2 illustrates the interaction between legacy repositories and our standardized learning management process. The purpose is to allow compatibility with already developed learning objects. This can be achieved by providing mappings between different standards, such as LOM, and ours.

The learning process management component specifies the requirements to support the utilization of interactive learning objects and the consequent mandatory and optional systems to fulfill the requirements. This part of the standard is grounded by a set of utilization cases to cover different interaction requirements (from web users, most interaction, through simple digital TV users, limited interaction). From the use cases, we establish the user model used on more complex scenarios allowing the adoption of learning strategies. Optional components are specified in terms of requirements and general guidelines for definition and implementation: learning object recommendation, search and authoring systems.

The learning object repository, in its abstract view, provides a set of meta-data and structures to represent the learning objects and store the user model learning process information. The learning object specification was developed considering the current state of the art and adapting and extending it to our interoperability requirements. One concretization of that component is an ontological model implemented with OWL – Web Ontology Language.

The communication component specifies the interaction among the servers and different client platforms (web and digital TV). This component specifies the requirements for protocols and communication technologies. Minimal requirements, state-of-the-art functionalities and a future perspective on communication possibilities compose such specification. Concretizations of this component are highly technical standards defining even the end-users set-topboxes and server capabilities and configurations.

This set of high-level components form the base for technology independence.

Use of the standards is exemplified through a set of application examples that provide developers with a guideline on how to build new learning systems using the standard.

4 Production of Learning Objects

Based on the studies conducted, it was necessary to search for learning objects and verify whether they were pedagogically correct. The study was initially performed using a RIVED repository, because it was considered as a repository of learning objects used nationwide and web-based. However, learning objects were not available under a given specification, with metadata describing them. Another difficulty was the fact that learning objects were not followed by their source codes. This would prevent one of the project stages to be performed, that is, conversion of a web content for Digital TV. The solution found was to use learning objects provided by the CESTA repository and that had access to source codes.

By converting content into Digital TV, it would not be possible to make a simple content conversion, since navigability is different between both technologies; in addition, the present Digital Television Technology does not support Flash applications and EcmaScript is optional, thus there is no guarantee that this technology will be present at the set-top boxes. Therefore, it was necessary to readapt the learning object, enabling access to its content through remote control, using only interactivity buttons, arrows and select. The learning object content was built using only HTML files. Production of content for Digital TV was aided by the Composer tool (GINGA-NCL, 2009), which allows creating NCL files through wizards, saving the author from the complexity of programming NCL textually. The generated learning object is considered simple, but insufficient to verify its feasibility.

5 Execution Platform for Learning Objects

Execution of learning objects involves use of two platforms. This section describes the process of preparation and development of execution environments for learning objects. Initially the web-based environment is described, in which the LMS Moodle was used for tests. Next, efforts relative to execution of learning objects in Digital TV platform are presented.

5.1 Execution Environment for Web

A framework based on Multi-Agent Systems was developed, in which the following entities could be represented: learning objects, repositories, LMS, and students. As a result, the ILO – Intelligent Learning Object framework was obtained. This study proposes a framework for application of intelligent leaning objects based on the SCORM model. The SCORM specification was chosen because it provides a complete documentation on the development of learning objects, from conception to execution. Development of this project required modeling of a multi-agent system, followed by its implementation using a platform of agents as support. For modeling, the MaSE – Multi-agent System Engineering methodology was used, providing specifications and diagrams for analysis and modeling (DELOACH; WOOD, 2000). During implementation, the agents were developed through the JADE platform (2007), while ontology for communication was built using the Protegé tool.

eXe Learning (2007) and CourseLab (2008) tools were used to perform tests as they are easy to use and can be exported to the SCORM format.

The study has currently been directed to testing the framework with execution environments of learning objects. For web-based learning objects the LMS Moodle (2007) was used to perform tests, as it implements a module for SCORM learning objects and has an open code. Results were satisfactory. Next stages include execution of the framework using an execution environment for Digital TV.

5.2 Execution Environment for Digital TV

Considering the usability challenges of the Digital Television, in section 4 we presented the solution found to adapt learning objects to digital television.

To present this learning object in the television environment, a simulator had to be used (Virtual Set Top Box), due to the fact that at this moment there is no settop-box hardware available for the tests.

The Virtual Set Top Box implements the declarative part of Ginga (Ginga – NCL). NCL stands for Nested Context Language, which is responsible for specifying interactivity, time and space synchronism between media objects, adaptability, interoperability and support to non-linear interactive live programs (GINGA-NCL, 2009), according to the Brazilian Digital Television standard.

Our next step will be the execution of Java Agents, because according to the NBR 15504 (2008) the set-top-boxes must support Java applications. However, until the date this paper was written the specifications for these applications had not been published yet. The advantage of this lies in the fact that the presented multi-agent platform may be supported, since it is based on Java.

6 Final Considerations

Another study developed in this project and related to multi-agent systems is the creation of an authoring tool using an ontology based on specification metadata.

Such knowledge repository should be adequate to a formal specification that defines minimal and maximal requirements of learning objects to run in the platforms, especially for learning objects based on Digital TV.

Experience in this project led to the conclusion about the need of developing proper search mechanisms for learning objects. CESTA was investigated, but it is still not adapted to work as a repository with characteristics of agents. This is an ongoing activity in the OBAA project.

Studies comparing existing metadata standards in Digital TV and educational metadata are also ongoing. This study will help in the creation of a unique standard that comprehends pedagogical, educational and technological aspects relative to broadcasting and reproduction of programs in the Digital TV platform.

Acknowledgments

This project is funded by MCT/FINEP/MC/FUNTEL, Platforms for Digital Contents – 01/2007.

References

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. *ABNT NBR 15602-3*. Televisão digital terrestre: codificação de vídeo, áudio e multiplexação. Parte 3: Sistemas de multiplexação de sinais. 2008. Disponível em: <http://www.abnt.org.br/tvdigital/TVDIGITAL.html> Acesso em: 17 set. 2008.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. *ABNT NBR 15604 2007.* Televisão digital terrestre: receptores. 1. ed. 2007. Disponível em: http://www.abnt.org.br/imagens/Normalizacao_TV_Digital/ABNTNBR15604_2007Vc_2008.pdf. Acesso em: 30 nov. 2007.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. *ABNT NBR 15604: 2007*. Televisão digital terrestre: receptores. Versão corrigida 2008: incorpora a Errata 1 de 07.04.2008. Disponível em: <http://www.abnt.org.br/tvdigital/TVDIGITAL.html> Acesso em: 17 set. 2008.

ADL. *Sharable Content Object Reference Model*: The SCORM Overview, Version 1.2. 2001. Disponível em: <http://xml.coverpages.org/SCORM-12-Overview.pdf> Acesso em: 10 jan. 2007.

ALVES, L.G.P.; KULESZA, R.; SILVA, F.S.; JUCA, P.; BRESSAN, G. Análise Comparativa de Metadados em TV Digital. In: SIMPÓSIO BRASILEIRO DE REDES DE COMPUTADORES, 24., 2006, Curitiba. *Anais*. Curitiba: SBRC, 2006. Trabalho apresentado no II WORKSHOP DE TV DIGITAL.

CESTA. *Coletânea de Entidades Superiores ao uso de Tecnologia na Aprendizagem*. Disponível em: <http://www.cinted.ufrgs.br/CESTA> Acesso em: 24 nov. 2007.

CLOE. *O Co-Operative Learnware Object Exchange*. Disponível em: <http://learnware.uwaterloo.ca/projects/CCCO/cloe_stories.html> Acesso em: 24 nov. 2008.

CLOE, R.D. *Learning impact studies lite*: Evaluating learning courses. Report presented to the Office of Learning Technologies Human Canada. 2003. Disponível em: <http://lt3.uwaterloo.ca/CLOE/MERLOTConferencePaper10.doc> Acesso em: 4 nov. 2007.

COURSELAB. *CourseLab*: free e-Learning authoring tool. 2008. Disponível em: <www.courselab.com> Acesso em: apr. 2008.

DELOACH, S.A.; WOOD, M. *Developing Muiltiagent Systems with agentTool*. Berlin: Springer-Verlag, 2001. (Lecture Notes in Artificial Intelligence)

DUBLIN CORE METADATA INICIATIVE. *Using Dublin Core*: the elements. 2007. Disponível em: <http://dublincore.org/documents/usageguide/elements.shtml> Acesso em: 24 jul. 2007.

EDWARDS, T. *RFC 4539*: media type registration for the society of motion picture and television engineers (smpte) Material Exchange Format (MXF) 2006. Disponível em: < http://tools.ietf.org/html/rfc4539> Acesso em: 22 de jul. 2008.

EXELearning. 2007. Disponível em: <http://exelearning.org> Acesso em: 28 oct. 2007.

GINGA-NCL. 2009. Disponível em: <http://www.ncl.org.br/ferramentas/index_30.html> Acesso em: 5 jan. 2009.

IEEE LOM. *Draft Standard for Learning Object Metadata*: IEEE 1484.12.1-2002, 15 jul. 2002. Disponível em: <http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf> Acesso em: 7 jan. 2007.

JADE. **J***ava Agent Development Framework*. 2007. Disponível em: <http://jade.tilab.com> Acesso em: 25 june 2007.

MERLOT. *Multimídia Educational Resource for Learning and Online Teaching*. Disponível em: <www.merlot.org> Acesso em: 24 nov. 2008.

MIT. *MIT OpenCourseWare – MIT*. 1999. Disponível em: <http://ocw.mit.edu/> Acesso em: 24 nov. 2008.

MOHAMMED, P.; MOHAN, P. Agent based learning objects on the Educational Semantic Web. In: ANNUAL LORNET CONFERENCE, 2., 2005, Vancouver. *Proceedings*... Vancouver: University of Illinois at Urbana-Champaign – USA, 2005. P. 15-18.

MOODLE. *Welcome to the Moodle community!* 2007. Disponível em: <http://www.moodle.org> Acesso em: 18 dec. 2007.

RIVED. **Conheça o Projeto**. Disponível em: <http://www.rived.mec.gov.br/site_objeto_lis.php> Acesso em: 4 nov. 2007.

SACCA. *Sistema Automático de Catalogação de Conteúdo Audiovisual*. Disponível em: <http://www.cinted.ufrgs.br/SACCA/> Acesso em: 24 nov. 2007.

STOILESCU, D. Modalities of Using Learning Objects for Intelligent Agents in Learning. *Interdisciplinary Journal of E-Learning and Learning Objects*, Santa Rosa , CA, v. 4, 2008. Disponível em: <ijello.org/Volume4/IJELLOv4p049-064Stoilescu394.pdf > Acesso em: dec. 2008.

T-REC-H.222.0 International Telecommunication Union H.222.0 Technical Corrigendum 1 (06/2008) Series H: Audiovisual and Multimedia Systems. Disponivel em:http://www.iec.ch/cgibin/getcorr.pl/yab/iso/isoiec138181cor1%7Bed1.0%7Den.pdf?file=iso/isoiec13818-1-cor1{ed1.0}en.pdf. Acessado em:13 jan. 2009.

TRU2WAY. *Tru2Way TM*. Disponível em: <http://www.tru2way.com/> Acesso em: 13 jan. 2009.

TVA. *TV-Anytime Forum*. 1999. Disponível em: <http://www.tv-anytime.org> Acesso em: 1 june 2009.

WEECH, T.L. MERLOT: Multimidia Educational Resource for Learning and Online Teaching. *Informing Science*, Illinois, v.1, n1, p.1571-1577, set. 2006.

Recebido em janeiro de 2009
Aprovado para publicação em abril de 2009

Marta Rosecler Bez
Universidade Federal do Rio Grande do Sul, Brazil, martabez@feevale.br
Júlia Marques Carvalho da Silva
Universidade Federal do Rio Grande do Sul, Brazil, julia@univali.br
Elder Santos
Universidade Federal do Rio Grande do Sul, Brazil, ersantos@inf.ufrgs.br
Tiago Primo
Universidade Federal do Rio Grande do Sul, Brazil, tiagoprimo@gmail.com
Alexandro Bordignon
Universidade Federal do Rio Grande do Sul, Brazil, tiagoprimo@gmail.com