Copyright Management for the LUISA Semantic Learning Content Management System

Roberto García[1], Tomas Pariente[2]

[1] Universitat de Lleida. Jaume II 69, 25001 Lleida, Spain
rgarcia@diei.udl.es

[2] ATOS Origin SAE – Atos Research and Innovation.
Albarracín 25, 20037 Madrid, Spain
tomas.parientelobo@atosorigin.com

Abstract Semantic Web technology is able to provide the required computational semantics for interoperability of learning resources across different Learning Management Systems (LMS) and Learning Object Repositories (LOR). The EU research project LUISA (Learning Content Management System Using Innovative Semantic Web Services Architecture) addresses the development of a reference semantic architecture for the major challenges in the search, interchange and delivery of learning objects in a service-oriented context. One of the key issues, highlighted in this paper, is Digital Rights Management (DRM) interoperability. A Semantic Web approach to copyright management has been followed, which places a Copyright Ontology as the key component for interoperability among existing DRM systems and other licensing schemes like Creative Commons. Moreover, Semantic Web tools like reasoners, rule engines and semantic queries facilitate the implementation of an interoperable copyright management component in the LUISA architecture.

1. Introduction

The widespread adoption of e-Learning solutions across the World Wide Web has placed the focus on the interoperability requirement, specially referring to learning resources across different Learning Management Systems (LMS) and Learning Object Repositories (LOR). This interoperability is required in order to build the knowledge-intensive, open and accessible learning services that our knowledge society demands.

The central paradigm of such technology is the notion of learning objects (LO) as digital reusable pieces of learning activities or contents. However, transportability across platforms is only a basic step towards higher levels of automation and possibilities of delegation of tasks to software agents or modules. Such advanced technology requires richer semantics than those offered by current metadata specifications for learning resources. Semantic Web technology and the use of ontologies are able to provide the required computational semantics for the automation of tasks (Collazos & García, 2007), in this case those related to learning objects as selection or composition.

This paper concentrates on one of the issues of e-Learning systems interoperability, that of the learning contents copyright terms. Most e-Learning systems provide little support for copyright interoperability. They provide some attributes that can be used to specify the licensing terms of a given learning object but their main function is to just provide a placeholder for content licensing terms. The copyright attribute values are free text and there are not predefined terms or guides about how to build these licenses. At most, they rely on predefined licenses specialised on concrete licensing schemes like open content.

This is also a problem of other content management systems and consequently there are some initiatives, related with Digital Right Management (DRM), trying to establish standard ways to represent copyright terms. DRM languages define the terms and grammars that can be used in order to represent licensing terms. However, most of them are more like rigid access control languages that lack flexibility, make interoperability among different DRM languages more difficult and are not able to model copyright (Rosenblatt, 2005).

Our proposal for interoperability at the copyright level is also based on Semantic Web technologies and methodologies (Lytras & García, 2008). This approach makes it possible to attain a greater level of expressivity while modelling licensing terms, with greater flexibility, interoperability facilities and capable of representing part of the underlying copyright law notions. This papers presents the overall platform LUISA in Section 2, then focuses on DRM and copyright issues and how they are solved using Semantic Web technologies in Section 0. The key component for Semantic DRM is the Copyright Ontology presented in Section 3.1. The ontology is then used in order to model the licenses for learning contents, as shown in Section 3.2. Conclusions and future work in Section 4.

1.1. Related Work

This paper concentrates on the copyright management part of the LUISA platforms and, due to space limitations, in this paper we just analyse the related work for this part. Currently, some effort has been placed on interoperability at the learning objects licensing level (Porter, 2003; Kang, Kim, Park, Lee, & Kil, 2006). The main problem of existing e-Learning systems is that they do not provide structured and formal ways to express the licensing terms of learning objects.

For instance, Sakai[1] defines some predefined and simple copyright status sentences that provide very limited information and little support for computerised copyright management of learning objects. For instance, it is possible to state: "Material is in public domain" or "I hold copyright". Moreover, there is the "Use copyright below" option that provides a text box that allows providing a textual description for other legal status.

Something similar happens with Moodle (Cole & Foster, 2007), even if metadata schemes like LOM (Harman & Koohang, 2006) are reused. LOM provides as set of attributes for stating for learning object rights, there are the "Cost", "Copyright and Other Restrictions" and "Description" attributes. However, there is the same problem as in the previous case, the "Description" attribute is the more informative one but there are no restrictions about its content, it is an unstructured attribute so little help can be anticipated for automated processing.

Recently, many Learning Objects Repositories have adopted a set of more expressive and legally formal licenses defined by the Creative Commons initiative (Lessig, 2002). However, Creative Commons (CC) licenses are restricted to open licensing schemes, like in Open Courseware[2]. Although some extensions for user defined licensing schemes have been recently added, CCPlus[3], these extensions suffer from the same limitations. The extensions are based on user defined additions and not in formalised license building blocks.

Due to the limitations of the previous approaches, there have been some attempts to adapt generic Digital Rights Management (DRM) languages for learning objects licensing (Liu, Yang, Yan, Jin, & Deng, 2005; Iannella, 2004). The main DRM languages come from standardisation efforts like ISO/IEC MPEG-21 (de Walle & Burnett, 2005). MPEG-21 Rights Expression Language (REL) is a XML schema that defines the grammar of a license building language.

Thought DRM standards are a good solution in more or less closed environments, where the involved systems adhere to one of the existing standards, they do not scale well to open environments like the Web. They cause interoperability issues like the ones identified by the Electronic Frontier Foundation (Doctorow, 2005), which are one of the main complains highlighted by DRM end-users.

Moreover, the syntax-based approach of most DRM languages, due to its limited expressivity, makes it very difficult to accommodate copyright law into DRM systems. Consequently, DRM standards follow a traditional access control approach. The limited support for copyright law is a concern for end-users because DRM systems fail to accommodate rights reserved for them.

Our contribution tries to leverage DRM systems to copyright management systems, which support the whole value chain, from creators to consumers, and build on top of copyright law. The proposal is based on a copyright ontology, described in Section 0, that provides the building blocks and restrictions that make it possible to model licensing terms for learning objects in a very flexible way.

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[1] Sakai Project, http://sakaiproject.org
[2] OpenCourseWare Consortium, http://www.ocwconsortium.org
[3] Creative Commons Plus, http://wiki.creativecommons.org/Ccplus

This approach is related with other ontological approaches to DRM, which are much more expressive than XML-based grammars (Pease & Rust, 2008). Additionally, our proposal contributes the copyright dimension and support for the whole value chain, from learning objects authors to consumers. This support is difficult to attain if the underlying legal framework is not taken into account. Moreover, our proposal, like the LUISA architecture, is based on Semantic Web technologies. They are chosen in this project in order to build and open and flexible learning management systems as it is detailed in the next section.

2. Semantic Learning Management Architecture

LUISA, a project funded by the European Commission under the ICT sixth Framework Programme from March 2006 to August 2008, addresses one essential problem: the location of (the appropriate) learning resources for some given needs (of learners, instructors or groups). In order to achieve this, LUISA exploits the advantages of a Semantic Web Service architecture to addresses the development of a reference semantic architecture for the major challenges in the search, interchange and delivery of learning objects in a service-oriented context.

This entails the technical description of the solution in terms of current SWS technology, and also the provision of the ontologies and facilities required to enhance existing learning technology systems with the computational semantics capabilities. LUISA is put in a context of relevant learning scenarios – both academic and industrial. The outcomes are expected to make a significant contribution to the automation of learning systems beyond current standards, fostering the advancement of Web-based learning with an increase in the capacity to locate and negotiate learning resources. Figure 1 shows the main functional blocks of the LUISA architecture, which are detailed next.

At the top there is the *Interface Layer*, which contains all of the applications that may access the functionalities provided by the LUISA Infrastructure as well as the tools that support the development of items stored within the infrastructure. Below, there is the *Negotiation Layer*, which aims at supporting the learning objective of an end-user by using the functionalities provided by the Semantic Web Service Layer below and implementing the organizational rules. The composition of learning objects based on the organizational rules or driven by the user request is also performed in this layer. Then, there is the *Service Layer*, which acts as a SWS broker for the bottom layer, the *Data Layer*, which contains all systems that provide resources to support a learning process.

During the negotiation process, learning objects are selected and combined in order to fulfil user needs. One of the aspects into consideration during this process is the copyright situation of the involved learning object. In order to make different rights expression languages interoperable, the DRM module infrastructure uses a Copyright Ontology, e-Learning licenses expressed using this ontology and some reasoning mechanism detailed in the next section.

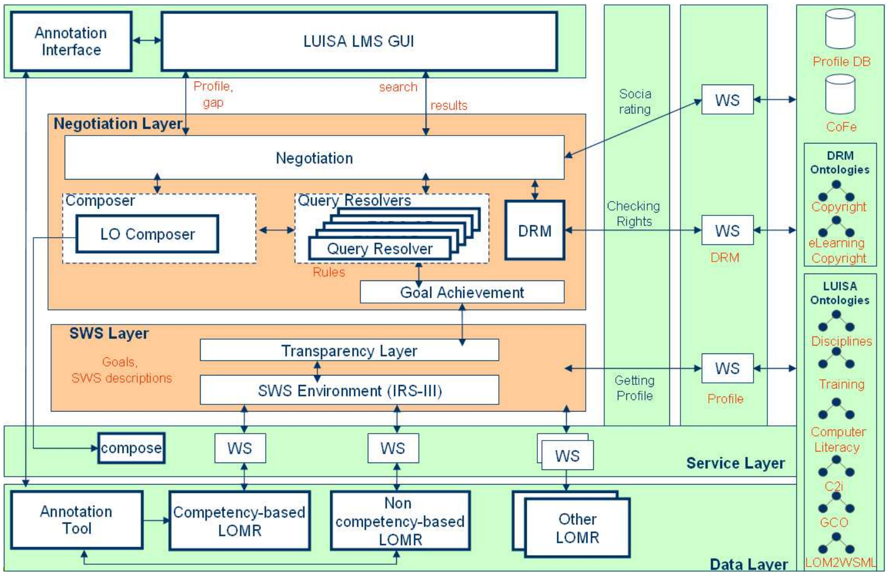

Figure 1. The LUISA architecture

3. Semantic Learning Copyright Management

The previous reference learning management architecture is complemented with a copyright management module that is also based on Semantic Web technologies. This module is capable of dealing with the underlying legal framework and, simultaneously, benefits from computerised support. Semantic Web technologies make it possible to attain a greater level of expressivity for copyright licenses modeling, based on ontologies as knowledge representation tools (García, 2005). This allows including the underlying legal framework into the formalisation. This is a key issue in order to build a generic framework that facilitates interoperability.

The result of this approach is the Copyright Ontology[4], detailed in Section 3.1. The ontology is implemented as an OWL Web ontology (McGuinness & van Harmelen, 2004) based on the Description Logic (DL) variant, OWL-DL. This implementation facilitates development because license checking is implemented using existing Semantic Web reasoners, as it is shown in Section 3.2. There, it is also shown how to model learning objects licenses based on the Copyright Ontology building blocks.

[4] Copyright Ontology, http://rhizomik.net/ontologies/copyrightonto

3.1. Copyright Ontology

The Copyright Ontology formalises knowledge from the copyright legal domain in order to define a more expressive and interoperable license modelling framework. It is true that copyright law diverges depending on local regimes but, as the World Intellectual Property Organisation[5] promotes, there is a common legal base and fruitful efforts towards a greater level of copyright law worldwide harmonisation.

Starting from this legal framework, the Copyright Ontology models the primitive actions that can be performed on the creations. The actions make creations evolve through their life cycle, from abstract creations to the concrete things or events that are consumed, as it is shown in Figure 2.

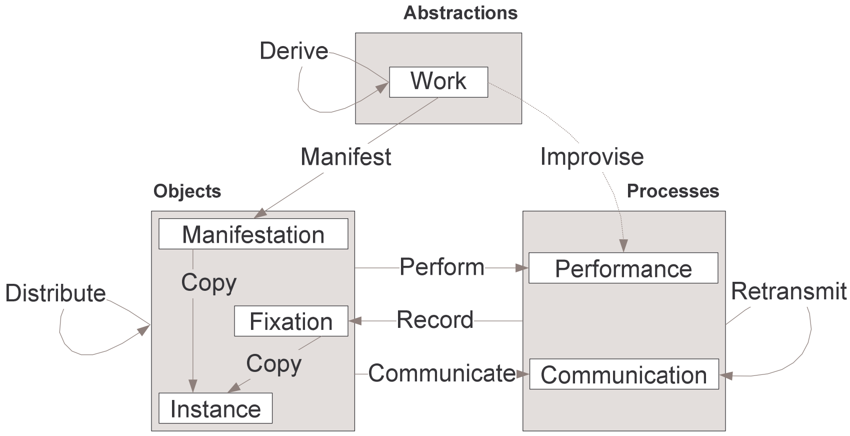

Figure 2. Relations between action and creation

A Work is a distinct intellectual or artistic creation. It is the original idea behind many possible expressions based on it. For instance, some pedagogical ideas and methodologies for a concrete subject that are realised into physical things that might be perceived. One kind of physical realisation of a Work is a Manifestation, its materialisation in a concrete medium, a tangible or digital object. For instance, a learning object. There might be many copies called Instances.

On the other hand, there are Performances, the expression in time of a Work. For instance, a teacher's dissertation in a classroom. The Performance might be recorded into a Fixation, which then can be copied and distributed (e.g. a CD copy of a learning object) or communicated, the process when the public is not present at the place and or time where the communication originates. Examples of Communication are a broadcast of the teaching session or a Web streaming.

The previous set of primitive actions and kinds of creations make it possible to build licenses for all the different forms that a learning object can take as long as

[5] WIPO, World Intellectual Property Organization, http://www.wipo.int

copyright law is concerned. These actions are regulated by the rights in the Rights Model. For the economic rights, these are the governed actions:

- **Reproduction Right**: to reproduce, commonly speaking *Copy*.
- **Distribution Right**: *Distribute*. More specifically *Sell*, *Rent* and *Lend*.
- **Public Performance Right**: *Perform*; it is regulated when it is a public performance and not a private one.
- **Fixation Right**: to fix something, *Record*.
- **Communication Right**: generically *Communicate*, other related actions depending on the intended audience are *Broadcast* or *Make Available*.
- **Transformation Right**: *Derive*. Specialisations are *Adapt* or *Translate*.

The action concepts are complemented with a set of relations that link them to the action participants. This set is adopted from the linguistics field. It is based on case roles (Sowa, 2000) and shown in Table 1. Their use is illustrated in the next section while modelling licenses in the e-Learning domain.

Table 1. Action Model case roles

	initia-tor	**resource**	**goal**	**essence**
Action	agent, effector	instrument	result, recipient	patient, theme
Process	agent, origin	matter	result, recipient	patient, theme
Transfer	agent, origin	instru-ment, medium	experiencer, recipient	theme
Spatial	origin	path	destination	location
Tempo-ral	start	duration	completion	pointIn-Time
Ambient	reason	manner	aim, consequence	condition

3.2. Copyright Licenses for Learning Objects

As it has been shown, the Copyright Ontology defines a set of primitive building blocks, inspired by the underlying copyright legal framework. They are combined in order to model licenses. Licenses should capture the obligations, permissions and prohibitions that make sense in the copyright domain.

First of all, action patterns are introduced as the way to state what is obliged, permitted or prohibited by a license. The previous actions and case roles are used to model action patterns in the copyright domain. Patterns are implemented as

OWL classes made up from the combination of classes for actions, e.g. *Copy* or *Access*, and a set of OWL restrictions.

Each restriction defines a constraint on how members of the class, the domain, are related through the specified property to other ones, the range. Restrictions are combined using the intersection, union and complement logical operators in order to compose action patterns. For instance, Figure 3 shows the conceptual model for a license that combines commercial and open access terms.

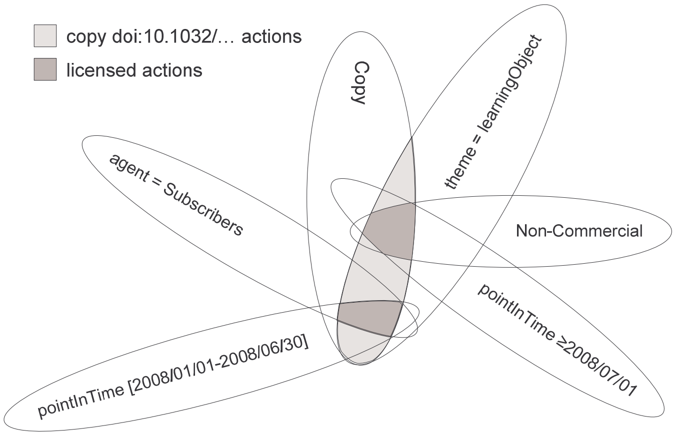

Figure 3. Building an action pattern as an intersection of restrictions

Table 2 shows the OWL-DL logic notation for the class definition that models the commercial copy pattern in Figure 3, called Pattern. Each restriction reduces the initial set of actions, which corresponds to all *Copy* actions (1). First, (2) models the time range. Constraints (2) and (3) restrict the range of *agent* to instances of the "Subscribers" class and *theme* to just the instance "learningObject".

From this point, it is possible to implement pattern matching using DL reasoners, which are specially suited for classifying individuals into classes. They can answer if an individual, considering its relations to other individuals and attribute values, satisfies all the restrictions of a class pattern and, thus, can be classified as an instance of that class. This functionality is used to check if a particular action, modelled as an individual, is included by an action pattern, modelled as a class.

Table 2. OWL-DL Class for the commercial copy action pattern

Pattern ≡	Copy ⊓	(1)

$$\forall \text{pointInTime}. \geq 2008\text{-}01\text{-}01, \leq 2008\text{-}06\text{-}30 \sqcap \quad (2)$$

$$\exists \text{agent.Subscribers} \sqcap \quad (3)$$

$$\exists \text{theme.}\{\text{learningObject}\} \quad (4)$$

$$\text{Condition} \equiv \text{Transfer} \sqcap \quad (5)$$

$$\exists \text{recipient.}\{\text{owner}\} \sqcap \quad (6)$$

$$\exists \text{theme.}\{\text{3EurosAmount}\} \quad (7)$$

$$\exists \text{agent.Subscribers} \sqcap \quad (8)$$

$$\exists \text{aim.Pattern} \sqcap (\leq 1 \text{ aim}) \quad (9)$$

Action patterns are then used in order to state what is permitted by a license. Permissions are modelled by a new action, *Agree*, and the permitted pattern is linked using the *theme* case role. Following with the example in Table 2, in order to authorise the pattern that it models, an instance of the *Agree* action is connected to the class Pattern through the *theme* case role.

Conditions and obligations are also modelled using patterns that must be satisfied. The *condition* case role is used to associate the condition pattern with the conditioned pattern and the *aim* case role to state that a concrete action satisfying a condition pattern is geared towards fulfilling the specified action pattern. The Condition pattern in Table 2 models the condition required to exercise the actions captured by Pattern. The condition is that the “owner” agent (6) receives a 3 Euros (7) transfer (5) from the “consumer” agent (8). The condition pattern is linked to the conditioned one using the *aim* case role as shown in (9).

The combination of the patterns in Table 2 builds up a simple license for a learning object based on Copyright Ontology terms. Table 3 shows and example copy action *copy_01* that is included by Pattern. It is associated with an economic transfer *transfer_01* that fulfils the required Condition pattern. Consequently, it would be authorised.

Table 3. Copy action, and conditioning transfer, authorised by Table 2 license

:copy_01 a co:Copy ;	:transfer_01 a co:Transfer ;
co:agent :consumer ;	co:agent :consumer ;
co:theme :learningObject .	co:recipient :owner ;
co:pointInTime "2008-06-19"^^xsd:date ;	co:theme :Amount3Euros ;
:consumer a :Subscriber.	co:aim :copy_01.

The pattern matching part of the previous license checking is performed by an OWL-DL reasoner like Pellet (Sirin, Parsia, Grau, Kalyanpur, & Katz, 2007). The main limitation of the OWL-DL implementation is that it is not possible to restrict using OWL the agent in the Pattern and the Condition to the same instance because there are not variables in OWL-DL. In order to overcome this limitation, we have used the Semantic Web query language SPARQL (Prud'hommeaux & Seaborne, 2008), which is also used to check that a given action is classified into a class pattern that is permitted by an agreement, which completes the implementation of the license checking process.

4. Conclusions and Future Work

This papers presents the European project LUISA, a reference architecture for Learning Content Management, and concentrates on the DRM module responsible for learning objects licensing terms integration, copyright management and license checking. This module, as the whole LUISA architecture, is based on Semantic Web technologies and methodologies.

In the case of the copyright management module, this choice makes it possible to develop a Copyright Ontology that captures copyright terms in an interoperable and flexible way. Moreover, it is possible to take profit from Semantic Web tools, reasoners and semantic query engines, in order to easily implement license checking. Future work concentrates now on modelling the whole range of licenses used in the LUISA project and performing a detailed test of the copyright management module. Another objective is to test the scalability of this solution.

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