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Towards semantically enriched e-learning assessment

Ontology-based description of Learning Objects

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***Abstract*— The aim of this paper is to present the progress done in the development of an ontology network, named AONet that conceptualizes the e-assessment domain and supports the semi-automatic generation of assessment. Particularly, this paper is focused on ontology-based description of assessment as an educational resource, including the mappings between metadata standard specifications. The hypothesis of this work is that a proper description of assessment resources improves its location and retrieval by educators, learners and software systems and favors reuse and collaborative work.**

e-assessment, ontology network, ontology matching

I. INTRODUCTION

During the last years, ontologies, the backbone of the semantic web technologies, have been used with different purposes in the e-learning context including assessment. Chang and Chen [1] propose a tool for peer assessment to satisfy the requirements of cooperative learning. Gladun et, al. [2] propose a domain ontology to assess learners' skills. In this case, the domain ontology is not only the learning instrument but also a means for testing and teaching. Also, in research literature, different approaches that define ontology as a structure to guide the automated design of assessment can be found in [3, 4]. However, most of these approaches are based on individual ontologies that only model a part of the assessment domain considering only the structural aspects of the assessments. Related to assessment in an e-learning environment, in [5] authors propose the used of semantic web technologies to generate semantic feedback in the learning process. Despite the efforts made in this sense, much work still remains to be done, especially considering the description of assessments for proper location and retrieval by educators, learners and software systems.

This paper is essential in any e-learning situation, but it is critical in environments in which educational resources are available in open access repositories and collaborative work. The main objective of this paper is to show advance done in the AONet ontology network [6] and discuss in detail the ontology that conceptualizes the description of assessment as an educational resource. To develop AONet the NeOn methodology was followed [7].

This paper is organized as follows. First the AONet ontology network is presented. Then, the Assessment Metadata Ontology, which defines the main concepts for semantically describing an assessment, is discussed in depth. Following, the use and limitations of the ontology are discussed. Finally, section four concludes this work.

II. BACKGROUND TECHNOLOGIES

The aim of this section is to present the AONet (Figure 1) that consists of six ontologies, which conceptualize three different aspects: course topic domain, educational resources, and assessment. The relations defined in [8] were considered.

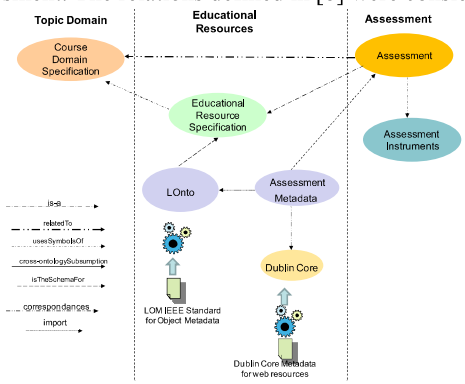

Figure 1. AONet Ontology Network

The Educational Resource Specification Ontology conceptualizes the educational resources used by the educator in the learning process. This ontology is related to the Course Domain Specification ontology through the relatedTo relationship.

For a complete description of educational resources we selected LOnto Ontology [9] that semantically conceptualizes the LO that is based on LOM [10]. LOnto is related with Educational Resource Ontology through the isTheSchemaFor relationship.

Assessments are part of educational resources involved in the learning process when educator needs to assess the knowledge and skills acquired by learners. So, as a subset of LOnto, we proposed Assessment Metadata Ontology. For the development of this ontology, we considered key elements for proper description of an assessment resource.

Then, the ontology network has the Assessment Ontology [11] that models an assessment structure, which is related to Educational Resource Specification ontology

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through the cross-ontologySubsumption relationship. In the same way, this ontology is related to Educational Domain Specification ontology through the relatedTo relationship.

There are different instruments to evaluate learning processes, which are modeled by the Assessment Instrument Ontology [12]. The Assessment ontology has the usesSymbolsOf relationship with the Assessment Instrument ontology.

III. ASSESSMENT METADATA ONTOLOGY

A. The Requirements Specification

From a didactics point of view, assessment is necessary to evaluate the learning process and thus, is also of relevance for the learning situation. It provides information to guide and enhance the learning process.

The correct and complete description of an assessment promotes collaborative work. That is, the evaluation process involves different actors, with specific role, then a complete description of assessment resource enhances activities involved in the process and benefit sharing and reuse.

In this context, the *Assessment Metadata* Ontology has to be able to answer the following competency questions among others: *Given an assessment, who is the author?, Which is the creation date of an assessment?, What are the assessments created by an educator?, Which is the context that an assessment was designed for?, How long does it take to deal with the assessment for the intended audience?*

B. Assessment Metadata Ontology Conceptualization

With the aim of developing the Assessment Metadata Ontology, a subset of element from LOnto was imported since it is based on the LOM that is suitable for describing learning objects. However, this ontology is a lightweight one. Then, in order to conceptualize assessment metadata elements and relations in a suitable way, a reengineering was carried out to add axioms and deduction rules (DR) to this ontology. As a result the Assessment Metadata Ontology was obtained (Figure 2). The main concept of the Assessment Metadata Ontology is *Assessment Metadata* with several subclasses as *Educational*, *General, Rights, etc.* corresponding to the categories of the ones proposed in LOM. The main components of the *General* subclass mostly correspond to LOM and DC matching. The proposed values for the ontology metadata were considered as instances.

- *Status:* could be "draft", "final", "reviewed" or "unavailable" according to its development state.
- *InteractivityType:* describes predominant mode of learning supported by this assessment.
- *Intended End User Role:* describes principal user(s) for which this LO was designed.
- *Interactivity Level:* describes the degree of interactivity characterizing the assessment. We assumed that an assessment requires "very *high*" interactivity level.
- *Context:* since this work is developed in the university context, its value is "*higher education*".
- *Difficulty: h*ow hard it is to work with or through this assessment for the typical intended target audience.

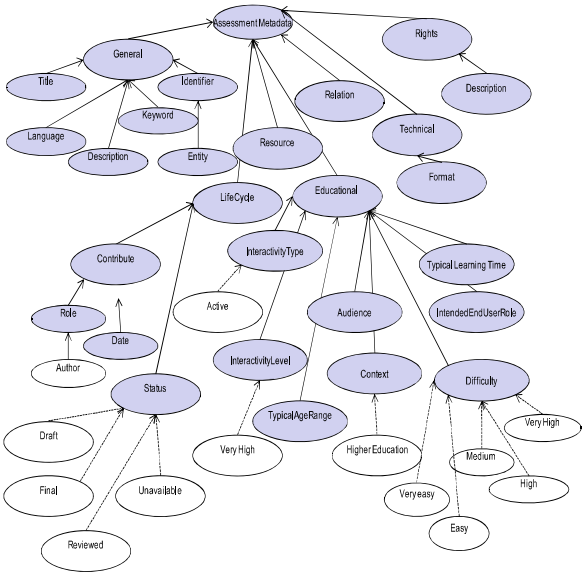

Figure 2. Assessment Metadata Ontology.

- *Language:* it is proposed *Spanish* as default value.
- *Typical Learning Time:* models approximate time it takes to work with the assessment for the typical intended target audience, characterized by Context metadata.
- *Description:* models comments on how this assessment is to be used.

Considering that an assessment is also a web resource when it is managed in an e-learning environment or it is available in an open access repository, we have enriched this ontology by defining correspondences between it and the Dublin Core Metadata Ontology. Dublin Core (DC) [13] is a widely used standard to describe web resources in general.

Through the matching process considering syntactic aspect of the ontologies, the correspondences among elements has been found [14]: *dc:title* and *lom.general.title;* and *dc:format* and *lom:technical.format* metadata. Then, a manual matching process was executing considering the semantic aspects of both ontologies by analyzing the LOM and DC standards. One of the resulting correspondences is: (i) *dc:creator* refers to *lom.lifecycle.contribute.role.author*. Both represent the designer of an assessment; (ii) *dc:subject* metadata is related to *lom.general.keyword*. According with DC, *subject* is used to identify core elements in a resource, while keyword is used to identify phrases describing the assessment topic; d*c.relation* metadata is related to *lom.relation.resource*. Both refer to other resources identified with the resource been described.

C. Assessment Metadata Ontology Formalization

Before implementing the ontology, axioms were formalized in order to restrict the way in which relations can be performed because the only definition of relations is not enough to describe an assessment in a consistent way. These axioms have been written in first order logic (table I).

TABLE I. AXIOMS FOR ASSESSMENT METADATA ONTOLOGY

Description	First-Order Logic
1. the interactivity type of an assessment is "active"	ℑ|=∀xAssessment(x)⇒(∃yInteractivityType(y)∧isSchemaFor(y,x) ∧y="active"
2. the interactivity level of an assessment is "very high"	ℑ|=∀xAssessment(x)⇒(∃yInteractivityLevel(y)∧isSchemaFor(y,x) ∧y="very high"

D. AssessmentMetadata Ontology Implementation

Assessment metadata ontology has been implemented in OWL2 [15] by using the Protégé ontology editor. The axioms shown in table I, were implemented as DR in SWRL.

E. Assessment Metadata Ontology Evaluation

The evaluation of an ontology consists of two activities: verification and validation. Ontology verification answers if the ontology was built in the right way, whereas ontology validation answers if the right ontology was built.

As regards verification, the consistency of the ontology was evaluating by using the Pellet reasoner. This reasoner evaluates if there are axioms that are contradictory each other. In addition, a tool, called OOPS!, which scans ontologies looking for potential modeling errors, was used.

F. Use and limitations of assessment metadata Ontology

Search engines can take advantage of the correspondences defined in the development of Assessment metadata ontology. As it is shown in figure 3 the matching process gives as result a set of correspondences which in term is used by mediator to find the assessment that meet the query. Mediator works transforming queries against the common ontology into a query to the information source and translates the answer in the other way.

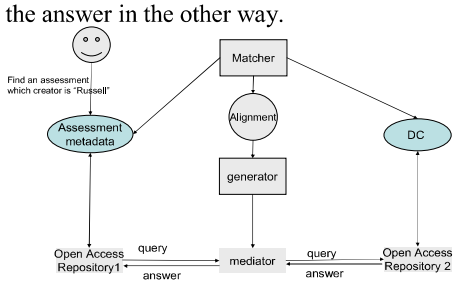

Figure 3. search engine

IV. CONCLUSION AND FUTURE WORK

This work has shown the progress in defining an ontology network whose purpose is to conceptualize the assessment domain in a learning process. Mainly, this work focused on describing the Assessment Metadata Ontology for proper description of assessment resources. Two important standards widely used were considered: LOM and Dublin Core. Both syntactic as semantic matching among them were performed. Assessment Metadata Ontology was developed considering the most used standards for proper description of assessment not only from a contextual point of view but pedagogical one, improving its location and retrieval by educators, learners and software systems, both in e-learning environment as in open access repository. We have introduced the integrity axiom in order to restrict the way in which an assessment can be described using Assessment Metadata Ontology. In the future, we will acquire additional validation for a broad evaluation and refinement of the ontology. Also, a tool that supports the generation of assessment is being developed.

REFERENCES

[1] T. Chan, Y. Chen, "Cooperative learning in E-learning: A peer assessment of student-centered using consistent fuzzy preference", Expert system with application. Elsevier Vol 36(4), pp. 8342–8349, 2009.

[2] A. Gladun, J. Rogushina, F. García-Sanchez, R. Martínez-Béjar, J. Fernández-Breis, "An application of intelligent techniques and semantic web technologies in e-learning environments", Expert Systems with Applications, Elsevier, 36, pp, 1922–193, 2009.

[3] D. Castellanos-Nieves, J. Fernández-Breis, R. Valencia-García, R. Martínez-Bjar, M. Iniesta-Moreno, "Semantic web technologies for supporting learning assessment", Information Sciences, 181, pp 1517–1537, January 2011.

[4] M. Cubric, M. Tosic, "Achieving maturity: The state of practice in ontology engineering in 2009", International Computer Assisted Assessment Conference, Springer, ISBN 978-3-642-05150-0, 2010.

[5] J. T. Fernández-Breis, F. Frutos-Morales, A. E. Gil, D. Castellanos-Nieves, R. Valencia-García, F. García-Sánchez, M. M. Sánchez-Vera, "Recommendation of Personalized Learning Contents Supported by Semantic Web Technologies", 4th World Summit on the Knowledge Society, pp 540-545, Mykonos, Greece, September 21-23, 2011.

[6] A. Gómez-Pérez, M. Fernandez López, O. Corcho, "Ontological engineering with examples from the areas of knowledge management, ecommerce and the semantic web", Springer, London, 2004.

[7] M. Suarez-Figueroa, A. Gomez-Perez, M. Fernandez-Lopez, The NeOn methodology for ontology engineering. Chapter 2. Ontology engineering in a networked world. Springer-Verlag Berlin Heidelberg, pp. 9-34, 2012.

[8] C. Allocca, M. D'aquin, E. Motta, "DOOR-towards a formalization of ontology relations", Proc. Int. Conference on Knowledge Engineering and Ontology Development, pp 13-20, 2009.

[9] L. Romero, J. Godoy, "An ontology for semantic definition of learning objects", Proc. 5th Conf. Ibérica de Sistemas y Tecnologías de Información, Santiago de Compostela, pp. 420-426, 2006.

[10] IEEE Standard for Learning Object Metadata. (2002). Learning Technology Standards Comittee of the IEEE Computer Society. 1484.12.1-2002.

[11] L. Romero, M. Gutiérrez, M. Caliusco, "Conceptualizing the e-Learning Assessment Domain using an Ontology Network", International journal of artificial intelligent and interactive multimedia. Vol 1(6). ISSN 1989-1660. pp 20-28, 2012

[12] L. Romero, M. Gutiérrez, M. Caliusco, "A Conceptualization of e-Assessment domain", Anales CISTI 2013. Conferencia Ibérica de Sistemas y Tecnologías de Información. Pp 710 – 715 Vol I(2) ISBN 978-989-96247-9-5, 2013

[13] National information standards organization, "The Dublin core metadata element set", ISSN 1041-5635, 2013.

[14] J. Euzenat, P. Shvaiko, "Ontology matching", Springer-Verlag Berlín 2007 ISBN 978-3-540-49611-3.

[15] W3C OWL Working Group. "OWL 2 Web Ontology Language", Document Overview (Second Edition), W3C Recommendation 11 December 2012, http://www.w3.org/TR/owl2-overvie