An Ontology for the OBAA Metadata Standard

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Abstract. *This paper proposes ontologies for the LOM, OBAA, and IMS AccessForAll learning object metadata standards. Those standards define the hierarchical structure and the axioms for the proposed ontologies. The OWL 2 was used to describe those ontologies. The lowest granularity as possible among the individuals that compose a learning object is aimed. The results present the possibility to describe learning objects as individuals according the OBAA standard, verify its consistence, use the inference process.*

1. Introduction

Shadbolt et al. define the Semantic Web as a Web of actionable information. Information derived from data through a semantic theory for interpreting the symbols. The semantic theory provides an account of “meaning” in which the logical connection of terms establishes interoperability between systems [Shadbolt et al. 2006]. A large quantity of interconnected data is relevant for the Semantic Web takes form. This data have to be in a standard, be reachable, and manageable by tools.

The adoption of common conceptualizations, referred as ontologies, achieves the data integration. The ontologies that will furnish the semantics for the Semantic Web must be developed, managed, and endorsed by communities. The idealized Semantic Web makes substantial reuse of existing ontologies and data. It is a linked information space in which data is being enriched and added [Shadbolt et al. 2006].

Studer et al. presented the ontology term as being “a formal, explicit specification of a shared conceptualization”, merging Gruber and Burst definitions [Studer et al. 1998]. Thus, the education domain can use ontology representation and its search mechanisms for learning objects.

The Institute of Electrical and Electronic Engineers (IEEE) characterizes a learning object as an entity, digital or non-digital, that may be used for learning, education, or training [of Electrical and Committee 2002]. Then, in the Semantic Web context, learning objects must be well-defined. Laleuf and Spalter mentioned that the learning resource representations must support the finest-grained level of granularity required by the core technologies [Laleuf and Spalter 2001].

Learning objects are a useful type of data representation. Standards describe its representations, but those standards do not have well-defined ontologies. Considering this, the development of ontologies for the LOM, OBAA, and IMS AccessForAll standards is proposed.

Therefore, this present work aims to use the ontology approach to describe learning objects. For this approach, an OBAA ontology based on the OBAA metadata standard

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was developed. This standard proposes to help in the definition of interoperable learning objects.

The ontology representation chosen was the Web Ontology Language 2 (OWL 2)[1], a recommended pattern by the World Wide Web Consortium (W3C). Beyond its wide utilization in the scientific community, it is an ontology specification compatible with the Semantic Web.This representation was made through Protégé[2] tool, a knowledge-based framework, ontology editor, free, and open source. The Hermit reasoner performed the reasoning process, in its version 1.3.6.

The semantic of the learning objects will furnish interoperability between systems. Its also possible to verify the learning object consistency and access its semantic via Universal Resource Identifier (URI). Therefore, an OBAA ontology may be used in recommendation systems, repositories, or in a learning object authorship application.

This paper follows in the Section 2 with the characterization of the OBAA metadata standard, what it provides and its extension from others metadata standards. Section 3 describes related works and the differences with this proposal. The steps for the ontology creation are described in Section 4, showing how the metadata information was transposed into ontology concepts. Section 5 illustrates its application, describing learning objects and realizing inferences about technical and metadata profiles.

2. The OBAA Metadata Standard

There are some metadata standards that define learning objects, such as LOM [of Electrical and Committee 2002] and OBAA [Vicari et al. 2009]. Metadata is data used to describe other data or loosely defined as data about data, as mentioned by Bargmeyer et al. [Bargmeyer et al. 2000]. This paper proposes an approach to transpose this conceptualizations to an ontology model.

Barcelos et al. cited that the OBAA metadata proposal [Viccari et al. 2010] is one of the OBAA project main results and it defines an extension of the IEEE-LOM standard. This proposal provides several new metadata which allows object interoperability among multiple digital platforms beyond the Web platform, supporting new platforms such as Digital TV and mobile devices. It also provides specific metadata for accessibility and pedagogical issues [Barcelos et al. 2010].

The IMS AccessForAll standard provides the metadata accessibility resources [Consortium 2004]. The proposal above also mentions that the proposed metadata intends to ensure freedom to the developer of pedagogical content. Therefore, the professional encounters no technological restrictions. The proposed set of metadata establishes a wide structure for cataloging, enabling different forms of application according to the needs of each learning object designer.

In the next section different ontology modelings for LOM and OBAA metadata standards are mentioned. Their principal characteristics and the proposal changes in their approach are also analyzed.

[1]http://www.w3.org/TR/owl2-new-features/
[2]http://protege.stanford.edu/

3. Related Works

LOM ontologies are easier to be found in papers for the fact that the IEEE LOM standard is well-established. However, there are several works that not mention how was the engineering process to create a LOM ontology [Dietze et al. 2007] [Chang et al. 2007b]. Chang et al. work [Chang et al. 2007a] shows generic principles of LOM Ontology binding. However the whole process is not exemplified, as in how cardinalities and conditional value spaces were done.

There are others papers that have a richer LOM ontology description. Ghebghoub et al. present individuals representing the possible list values of LOM elements. For example, Difficulty has five levels, ordered from easy to very difficult. One concept represents these elements, DifficultyLevel and five individuals of this type (easy, veryDifficult, etc.). Then, the hasDifficultyLevel relation links the LOM general category to these concept [Ghebghoub et al. 2008]. This approach increases the ontology granularity. Likewise, in the previous work of Gluz and Vicari [Gluz and Vicari 2011], the LOM and OBAA ontologies are not fine-grained because all the information is associated with a Metadata individual. In other work, Sanchez-Alonso et al. created the LOM ontology with WSML language and instances represent primitive types, as strings, [Sánchez-Alonso et al. 2007]. These works lead to many individuals in theirs representations and this work aims to reduce this quantity.

Then, this paper suggests an OBAA ontology that is compatible with the LOM ontology. Both have a minimum possible granularity of individuals. Moreover, these ontologies were designed with OWL 2 and some of its new features such as qualified cardinality restrictions and property chains that are not mentioned in works above.

The minimum granularity is aimed because it is easier to understand and to represent learning objects than a wide educational resource description. It is also important to improve the reasoning process.

4. Ontology Creation Process

The ontologies creation process was done from technical reports of metadata standards: LOM [of Electrical and Committee 2002], OBAA [Vicari et al. 2009], and IMS AccessForAll [Consortium 2004]. The transformation of metadata in ontologies is quite intuitive. The OBAA standard of metadata furnishes the data in an organized way (with hierarchy, domain, ranges, etc. defined).

Since the metadata were organized respecting an hierarchy, the ontology began to be created in a top-down approach. Noy and Mcguinnes describe a top-down development as a process that starts with the definition of the most general domain concepts and subsequent specialization of concepts [Noy and Mcguinness 2001].

The following subsections subdivide this section. Class Hierarchy: how to create a relation between educational metadata and ontology classes. Properties: how to define the semantic of the metadata contents. Cardinalities: how to restrict the number of metadata contents. Annotations and Documentation: how to integrate metadata information in ontology. Individuals: how to represent and consist the metadata contents.

4.1. Class Hierarchy

The process started transforming each metadata item in one ontology class, respecting the predetermined hierarchy, resulting in classes and subclasses. Qin and Finneran performed similar methodology, where learning object has each one of its components normalized in a group of classes into a more generic class [Qin and Finneran 2002].

The class nomination was made respecting the metadata name proposed in the respective technical reports of LOM, IMS AccessForAll, and OBAA. However, the Protégé tool does not allows entities to have the same name in the same ontology, because of the ontology Unique Name Assumption (UNA). In LOM, for example, the metadata identifiers 1.4, 5.10, 6.3, 8.3, and 9.3 all have the same name: Description.

Thus, to obtain classes with different names, it was concatenated to the metadata name the father metadata name followed to the point character, until it results in a unique name. For example, General and Rights contain the Description metadata. So, the result classes will be General.Description and Rights.Description.

The metadata Rights group contains the metadata Cost, Copyright and Other Restrictions, and Description. This resultant class hierarchy group is illustrated in Figure 1.

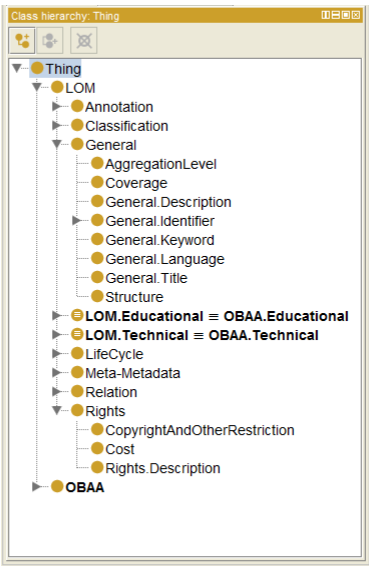

Figure 1. LOM general hierarchy and detailed hierarchy class of the metadata group Rights.

In the end, LOM.Educational and LOM.Technical classes were made equivalent respectively to OBAA.Technical and OBAA.Educational. Figure 1 shows these equivalences. Moreover, the Accessibility class from IMS had its superclass set to OBAA.

The class hierarchy is used to determinate the domain of a property. This domain is relevant to identify the types of the learning object and classify it posteriorly. Moreover, it is possible to define the cardinality of the property in a class level.

4.2. Properties

The properties were defined according to the metadata characteristic. Whether the metadata is a leaf node, a correspondent data property will be made; if the metadata is a container type with a maximum cardinality greater than one, an object property will be related to it. So, if a container metadata has cardinality one there will not be an object property for it.

For the nomenclature, the data properties have the same name of the classes. The only difference is that the first letter is in lower case. On the other hand, the object properties are nominated with the prefix “has” followed by the class name.

Last, the properties domains and ranges were defined. The reasoner defines the types of the individual from domains, so it is important for further inference. Whether a metadata has a conditional value space, as in Name (number 4.4.1.2), this restriction is done in the superclass level and the property range is a set with all possible values.

It was chosen to define one property for each class instead of sharing properties in different classes, even if the property would have the same range. This was decided because the reasoner defines the type of the individual always from the property domain. Therefore, if a domain is a union of classes, the profile inference will be prejudiced. Mostly when it is necessary to know which specific property was filled, because a common super class type is assumed. Moreover, the cardinality verification was done in an incorrect way, not been possible to have different cardinalities in different classes for the same property.

The Figure 2 exemplifies a property creation part of Outras Infâncias learning object related to the LifeCycle metadata group. The individuals OutrasInfancias-CORE and OutrasInfanciasLifeCycleContribute1 are linked by the hasLifeCycle.Contribute object property.

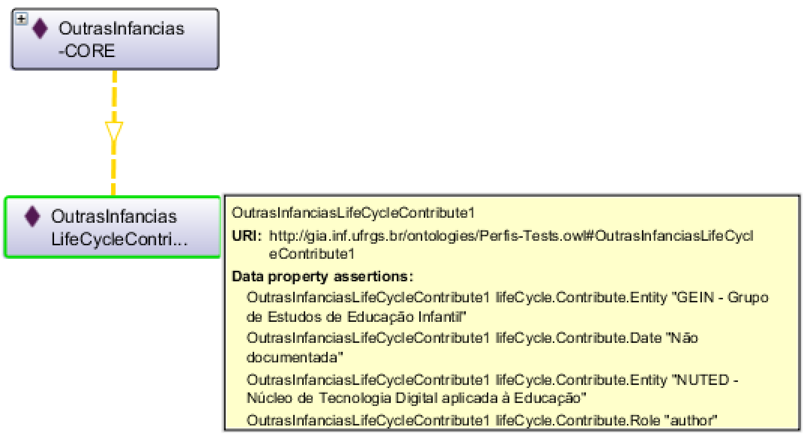

Figure 2. Properties related to the OutrasInfanciasLifeCycleContribute1 individual.

The properties will represent the learning object characteristics. The determined property range consists if the property was filled correctly. It is also possible to relate learning objects by object properties.

4.3. Cardinalities

The property cardinalities were defined according to the technical reports. Each cardinality is associated with the correspondent metadata, restricted by its property.

All the data and object property cardinalities were defined in superclass, aiming a code standard. For example, if a property has cardinality one, it is possible to restrict this cardinality both in superclass and in defining the property as functional. The Figure 3 shows the lifeCycle.Contribute.Role cardinality property and the inherited object property hasLifeCycleContribute.

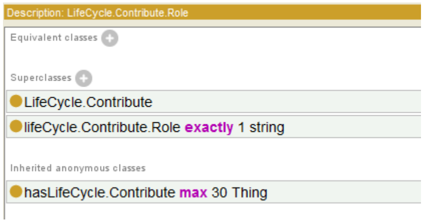

Figure 3. Cardinalities inherited to the LifeCycle.Contribute.Role class.

The cardinalities limit the number of properties that a learning object must have. So, if a learning object must have just one title, it will be restricted by cardinality.

4.4. Annotations and Documentation

It was used the enhanced annotation capabilities of OWL 2. Then, with OBAA, LOM, and IMS AccessForAll technical reports was possible to create annotations with the same tags of the reports. Also were created comments to the facts that could not be done, as cardinality problems.

Moreover, there is a Protégé plugin called OWL Doc[3] that generates a HMTL page containing all the documentation above mentioned. This allows to have an ontology overview even not having the Protégé tool working.

All the documentation was imported to a website. Thus, it is possible to access all the ontology semantic by its URI. Shadbolt et al. mention that associating a URI with a resource means that anyone can link to it, refer to it, or retrieve a representation of it [Shadbolt et al. 2006].

4.5. Individuals

Aiming the lowest ontology granularity, a minimum quantity of individuals should be created. Then, only the container metadata with cardinality greater than one will have an individual representation.

With an individual, it is possible maintain the relationship between the data properties of the container metadata and its maximum cardinality. But, it is necessary create an individual for the utilization of this object property always when the container appear in the metadata.

[3]http://www.co-ode.org/downloads/owldoc/

A whole learning object will be represented by one or more individuals. There will be a central individual representing the learning object and links the container representations above. This central individual will also handle the metadata elements that are in containers with cardinality equal to one by data properties.

Then, it will be possible consist this representation, verifying if a property is well-filled. It is also possible get inferences by the reasoning process.

5. Ontology Application

The following subsections show some applications of the OBAA ontology. This ontology would be integrated into recommendation systems, repositories, or a learning object authorship application.

5.1. Learning Object Representation

The learning object representation was made through the learning objects available at the OBAA portal[4]. Following the process above, the learning object Outras Infâncias is exemplified in Figure 4.

There is a main individual, named OutrasInfancias-CORE that is linked with other individuals by object properties. These individuals represent the metadata containers. There are also data properties that are hidden in this figure.

This approach is similar to performed by Gluz and Vicari [Gluz and Vicari 2011]. The difference is that metadata containers, with cardinality one, are not included in the learning object representation. For example, the Metadata individuals (md001, md002, ...) are not included in this work.

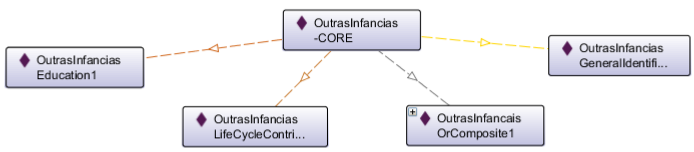

Figure 4. Individuals related to main individual OutrasInfancias-CORE.

In the end, all the individuals are declared as different. Because the reasoner do not assume same individuals when the cardinality is greater than the suggested.

5.2. Development of Application Profiles

Posteriorly, profile ontology was created to classify learning object individuals according some profiles. Technical and metadata profiles were defined. These profiles were defined as equivalent classes to be possible infer individuals as its members. The equivalent class is needed to specify the necessary and sufficient conditions to the reasoner inference.

In this ontology, property chains were created according to the profile. It is necessary to propagate the all the linked individual types to the main individual (the learning object). So, in the final of the inference, the main individual will be associated with the

[4] http://www.portalobaa.org/

profile and not the individuals that compose the learning object. This chain is also important as an access to the properties of the individuals that composes the whole learning object.

For example, to the PlatformSpecificFeatures node (illustrated in Figure 5), the chain would be compose of PlatformSpecificFeatures, SpecificRequirement, and SpecificOrComposite. Therefore, a chain property will be formed for each node way and level. In this case, an object property named as hasPlatformSpecificFeaturesChain with its chains was created, showed in Figure 6.

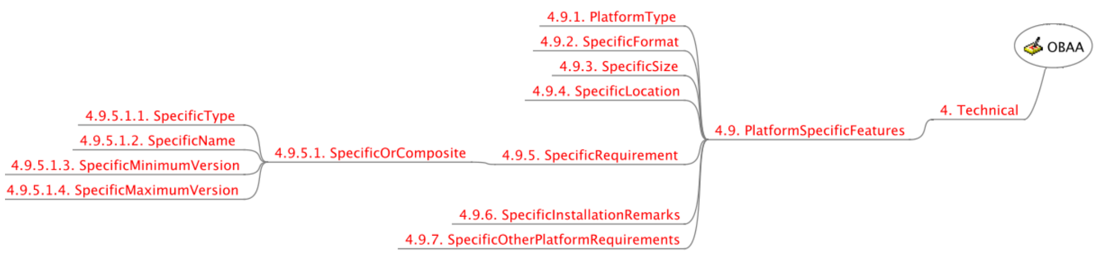

Figure 5. PlatformSpecificFeatures descendent nodes.

Figure 6. Object property chains to hasPlatformSpecificFeaturesChain.

With technical profiles, it is possible to classify determined learning object according its supported technology. Figure 7 exemplifies a learning object profile that supports the Ginga digital television technology. This example would have the Specific Name metadata (number 4.9.5.1.2) filled with the value "ginga" and the Language (1.3), for example, filled with "Português do Brasil".

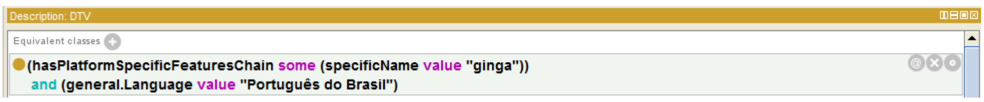

Figure 7. Learning object technical profile example for Ginga technology.

The metadata profiles aim verify if the learning object has or not a metadata filled, independent of which values were filled. The Figure 8 shows the OBAA-Lite profile, defined by Julia da Silva [da Silva 2011], as an ontology equivalent class.

6. Conclusion

This work presented how to transpose a standard metadata into an ontology. Further, a learning object was described as an individual member of this ontology and it is also possible to classify individuals from technical and metadata profiles.

Ontologies allow a discourse domain to be verified about its data consistency. It can be done through its axioms. It is also possible classify ontological representations of learning objects according predetermined profiles.

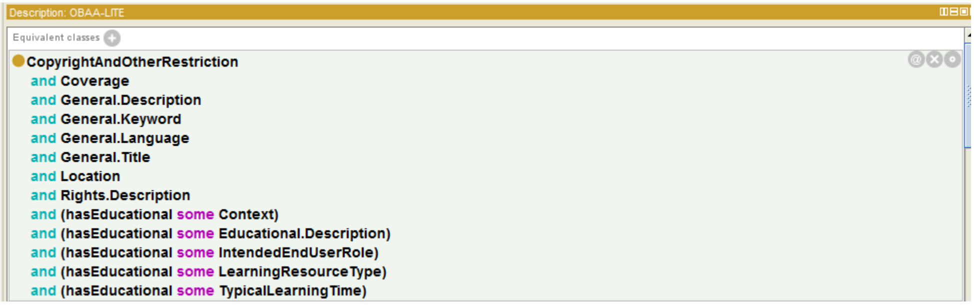

Figure 8. Equivalent class to OBAA-LITE profile.

After this experiment, it was noted that the task of create an ontology with a metadata standard for the ontology development is facilitated. The hierarchy classes, the properties, etc. just have to be transposed to the ontology. So, this task would be automatically done by an application.

This paper shows that is possible to construct ontologies with lower granularity than the related works. The OBAA ontology also can be described with the new features of the OWL 2. An OBAA ontology aims to contribute with the Semantic Web, providing a standard that allows a learning object description compatible with it.

As a future work, a tool that uses the OBAA ontology will be developed. With this tool, it will be possible that others applications uses it according with its domains. It can also be used together with learning objects repositories aiming to consist such data properly.

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