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Reusing ontologies in Competence Development programmes: RuleML and its capabilities

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Abstract: We want to solve several tasks with this paper - to show how different domain ontologies can be used in Learning Networks for Lifelong Competence Development (LN4LCD), to design experiments with reusing of a given domain ontology in different LN4LCD, to analyse the existing ontology languages in order to choose a suitable one (supporting the process of reuse of a domain ontology), and to show how how such ontology can be incorporated in different Learning Designs.

Keywords: ontology, taxonomies, production rules, SHOE, OWL, RuleML

Introduction

The name "ontology" comes from Greek philosophy and means "the study of the nature of being". The term is used in the domain of Knowledge Representation "to categorize the kinds of things existing". The aim is to fix a common vocabulary of terms able to describe as much knowledge about the world as possible from given domain, and to subdivide this knowledge in a coherent class hierarchy, so as to create a shared knowledge representation language. Usually an ontology is composed of (some of) the following: classes of objects, a vocabulary of terms (instances), and various relations between terms and classes.

In this paper we will show how different domain ontologies can be used in Learning Networks for Lifelong Competence Development (LN4LCD).

We will raise the question about the reuse of a given domain ontology in different LN4LCD. We will try to study this problem using one particular ontology, developed in a frame of one LN4LCD, and willing to use it in another LN4LCD.

We will try to analyse the existing ontology languages, and on the base of some existing methodologies, to choose the best one, supporting the process of reuse of an domain ontology.

At the end we will give some ideas how best such ontology can be incorporated in different Learning Designs.

Approach

Our approach is based on the following assumptions: (1) We have a Learning Network for Lifelong Competence Development (2) The Network is using the IMS LD standard (3) For some of the target domains of learning, appropriate ontology is available (4) Units of Learning available are indexed through IMS compliant metadata (eventually extended appropriately) (5) The information about Units of Learning relations and interdependency is formalised through the domain ontology, allowing to design abstract, simplified views of training domains.

Each Unit of Learning can be linked to some concepts and relations from the Domain ontology, for which this Unit of Learning can be used to learn them at some level of proficiency. This link is naturally represented by the metadata description of the corresponding Unit of Learning.

For each learner, using the Learning Network, first it will be identified what competencies in the domain of interest he posses (from the personal portfolio, personal information available, or using some standard assessment techniques like tests). The model of the personal competences can be mapped to the domain ontology, and as a result, a student model will be achieved, being some sub-set of the domain ontology.

Later on, knowing the competence level the learner wants to achieve, we can automatically derive a set of concepts and relations from the domain ontology, which represent the missing knowledge and skills for that learner. Using this model of the gaps in the learner knowledge and skills, as well as knowing what available Units of Learning we have in our knowledge repositories, we can create sets of various possible learning paths for the learner, which will lead to the competence level she/he is aiming. All these possible learning paths can be further analysed depending on different parameters (time needed, cost, quality, difficulty, etc.), and the best suitable learning path for the learner could be chosen.

In this approach, we need a system which is used both to represent the knowledge in a given domain, as well as to be able to reason (to make conclusions or to prove relations). Such a system can be further extended and adapted, so it will be able to select a particular set of topics from an ontology (representing the learner's gaps), and to arrange a personalised self-adaptive course about the chosen topics (personalisation on the base of Units of Learning available).

The main goal in our approach is to find the best way of separation between general learning design (expressed as IMS LD package) and domain knowledge (expressed in the domain ontology). This will guarantee the real interoperability of both the LD and the domain ontology in different settings and in different LD4LCD.

Computing ontology description

The case we will use to test our approach is the prototype [18], developed in the frame of DIOGENE project [19].

This prototype consists of one class (Computing Education field), a lot of instances (terms from the Computing domain), and a pre-defined set of three relations:

- *HP* (Has Part): *HP* $(x, y_1, y_2, ..., y_n)$ means that the concept x is composed of the concepts $y_1, y_2, ..., y_n$, or in other words: to learn x it is <u>necessary</u> to learn

y_1 and y_2, and, ..., and y_n.

- *R* (Requires): *R* (*x*, *y*) means that to learn *x* it is necessary to have already learnt *y*. This relation poses a constraint on the Domain Concepts' order in a given Learning Path.

- *SO* (Suggested Order): *SO* (*x, y*) means that it is *preferable* to learn *x* and *y* in this order. This relation also poses a constraint on the DCs' order, but now it is not necessary to learn *y* if we are interested only in *x*.

Relations between the instances are declared using "slots".

Some important features of the chosen relations are:

- Each concept can be split only by one Has Part relation
- The hierarchy defined by these three relations should not contain loops
- The lowest-level concepts are intended to be realised by corresponding Units of Learning, providing the conceptual link between the Ontology and underlying Metadata level

The more detailed description of the Computing Ontology is given in [18].
In summary, this prototype is based on the SHOE formalism, and expressed in Protégé editor. The main problem with such description is that the reasoning part of the ontology is hidden in the DIOGENE system, and as a result is not reusable. Another problem is linked with the existing relations, which actually poses not only domain knowledge, but also pedagogy knowledge. So we need also to re-design the existing ontology, separating the domain knowledge from the pedagogy knowledge, and to leave the pedagogy knowledge as part of the Learning Design. In order to make the ontology reusable in different settings, we need to use a language and tool, which combine the representation power with the inference engine, which can use both the domain knowledge with the knowledge available from the existing LD specifications.
We first fill give an extended classification of existing languages for ontology development, and on the base of existing methodology, will choose the languages and tools, which will be most suitable for solving our main goal – use (and reuse) of learning domain ontology in Learning Networks for Competence Development.

1. Ontology languages classification

Ontology languages are usually divided in two major groups: traditional and web based languages [1]. We will extend this classification with new type of languages: rule-based. Some traditional languages are Flogic, OCML and Ontolingua [17]. Other ontology languages like XOL, OIL, SHOE [8] are defined as web- based languages. The language RuleML [2] can be defined as a rule-based ontology language.
Of course, there are languages which can be defined in more than one group. Some of the traditional languages have been extended with additional, flexible and interactively updated information, making them very close to Web-based languages, like OWL [15]. Some other languages combine characteristics of web-based and rule-based languages, as SWRL [14].
On the other hand, we have languages, used mainly to physically code some ontology formalism, which are named representation languages. The most widespread such languages are XML, UML, RDF.
Other languages like PIF and KIF are used mainly for conversion between different ontology languages, supporting the process

of interchange between different ontology formalisms.
The extended classification of all types of ontology description languages, as explained above, is shown on Fig.1

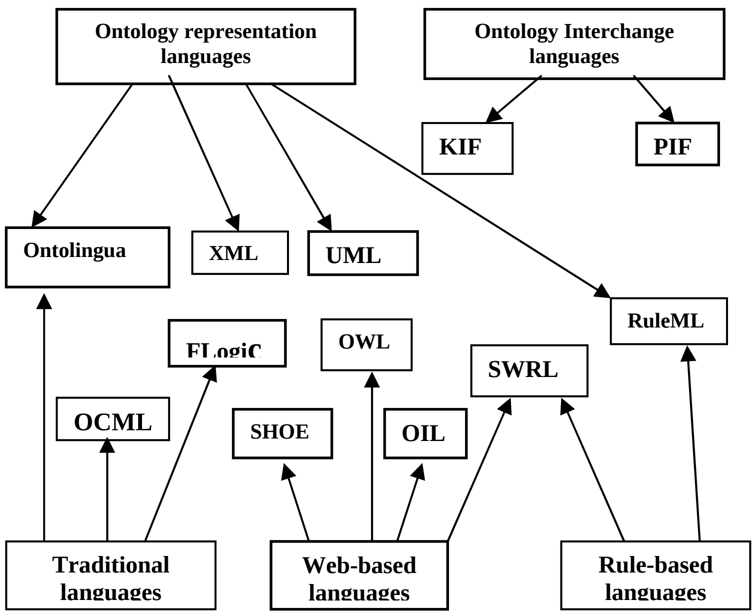

Fig.1 Ontology languages classifications

2. Selection of ontology description language

Below we will show a short classification of some of the most widespread ontology languages, using two main groups of criteria. First group organizes components of ontology like capabilities of language to describe ontology concepts, axioms, taxonomies and production rules [1]. Second group contains characteristics related to tools for ontology creation, validation, effective use and further development. [2]
WRL is a rule-based ontology language and it is derived from the ontology component of the Web Service Modeling Language (WSML), which provides a formal syntax and semantics for the Web Service Modeling Ontology (WSMO).

The Web Ontology Language OWL is a semantic markup language for publishing and sharing ontologies on the WWW.
SHOE is a knowledge representation language - super-set of HTML. It adds the tags necessary to embed arbitrary semantic data into web pages [8].
The Ontology Inference Layer (OIL) is ontology representation language, based on a multi-layer architecture. OIL's objective is to build on top of RDF Schema by adding modelling constructs for Description Logics.
FLogic integrates frame-based languages and first-order predicate calculus. FLogic has a model-theoretic semantics and a sound and complete resolution-based proof theory.
Loom defines a fundamental ontology for describing concepts, relations and other essential entities.
The OCML is a modelling language for defining ontologies and problem solving methods, supported by a large library of reusable models through the WebOnto editor. Ontolingua is a tool using a frame-based language for modeling ontologies.
Gathered information is summarized in Table 1.

	Characteristics	Traditional languages				Web-based languages			Rule-based language		
		Ontolingua	OCML	FLogic	LOOM	SHOE	OIL	OWL	RuleML	WRL	SWRL
Ontology elements	Concepts	+	+	+	+	+	+	+	+	+	+
	Taxonomy	+	+	+	+	-	-		+	/	/
	Relations	+	-	-	-	+	+		+	+	+
	Functions	+	/	+	-	-	+		/	-	-
	Axioms	+	-	+	+	+	/	+	+	+	+
	Instances	+	+	+	+	+	/	+	+	+	+
	Production rules	-	+	-	+	-	/	+	+	+	+
Tools	Queries	-	-	+	/	+	-	/	+	+	+
	Translators	-	/	/	+	+	+	+	+	/	+
	Engines	/	-	+	-	-	/	/	+	+	+
	Editors	+	+	-	+	+	+	+	+	+	+
	User Interfaces	+	+	/	+	+	+	+	+	+	+

Table 1 Ontology languages comparison

On the base of analysis of the data presented in Table 1, the main requirements and the tools available for each language, we choose rule-based languages as very promising and only conforming to all our needs. In particular, SWRL seems to be the best choice, as (1) it is supported by Protégé editor; (2) being based on OWL, it will be more easy to convert and reuse many type of ontologies; (3) it is in very close relation and conformance with the RuleML initiative.
Our next goal will be to investigate in more details the advantages of Rule-based languages, what additional features they will offer in relation to LN4LCD, and what other tasks will remain to be solved.

3. RuleML initiative

RuleML initiative is proposing rules as a natural language for the development of ontologies. Different languages are designed and can be used in different context, like RuleML, SWRL, RuleML Lite, Object-Oriented RuelML and others.
Most important advantages of RuleML initiative and all related languages are described by Harold Boley in [16], and are stated in several steps. Among them we can state briefly the possibilities for markup harmonization, rule syntaxes, rule modules and rule application to be described and properly used. It extends rule expressiveness and rule semantics, and allows RDF rules and ontology coupling to be used, rule validation and rule compilation. Other important features are the capabilities for XML stylesheets, semiformal rules and rule documents to be used.
The most important advantage is the ability to separate the knowledge and reasoning about given learning domain in one separate tool, to make this independent of the learning design description, logic and use, and in this way to allow real interoperability and reuse both of the Learning Design and the learning domain ontology.
The main research challenge will be how to combine the existing knowledge from the domain ontology, with the information and knowledge embedded in the Learning Design, in order to find the best possible learning path for a learner in LN4LCD. We have to experiment with the co-existence of the domain ontology with other ontologies (for LD or pedagogy).

4. Conclusion

In the paper we presented one specific approach for using learning domain ontologies in LN4LCD. We discussed the problems with the reuse of such ontology in different settings and different LN4LCD. We describe one particular case of such ontology – Computing ontology, and show how we are planning to further re-design and develop this ontology, in order to use it in new settings, and to be able further to easy reuse it in different LN4LCD. On the base of one existing classification for ontology languages we propose a suitable extension, and use it for the choice of best languages to be used as learning domain ontologies in LN4LCD, specifically stressing on the problems for their easy reusing.
Our future work is related to research and development of capabilities of this new type of languages and their implementation in ontology description for achievement of better expression power of reasoning and classification in regards to knowledge management and sharing, and in particular the best possible coexistence of such tools with standard tools supporting IMS LD specification, in a common framework – LN4LCD. We need to specify the proper set of rules and operations to be used for expressing the existent domain ontology in RuleML, and to use this as a recommendation for the use of domain ontologies in LN4LCD.

We also formulated one very interesting and important research question, which can be further investigated in the framework of the TENCompetence project [11]. We can also combine the work on this problem with other existing research activities related to the design and use of the IMS LD ontologies [20, 21].

Another important issue to be resolved is connected with the analysis of all possible problems related to the efficiency and performance.

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