Ontology Evaluation Functionalities of RDF(S), DAML+OIL, and OWL Parsers and Ontology Platforms

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Abstract

Before using ontologies in Semantic Web applications, ontology content and ontology tools (parsers, platforms, etc.) should be evaluated. In this paper we evaluate ontology evaluation functionalities of RDF(S), DAML+OIL, and OWL parsers and import services for such languages within ontology platforms. In recent years, some RDF(S), DAML+OIL, and OWL parsers have been created and several ontology platforms are able to import ontologies implemented in such languages. In this paper we present two experiments. The first one reveals that most RDF(S), DAML+OIL, and OWL parsers studied do not detect taxonomic problems, from a knowledge representation point of view, in ontologies implemented in such languages. So, if such ontologies are imported by ontology platforms, the question is: are they able to detect such problems? The second experiment presented in this paper reveals that most ontology platforms analyzed only detect a few of problems in concept taxonomies during ontology import.

1. Introduction

Ontology content evaluation as well as evaluation of the software used to build ontologies are critical activities to take into account before integrating ontologies in the Semantic Web. Content evaluation should be performed during the whole ontology life-cycle, and ontology tools should support this evaluation during the whole process.

Along with the increasing number of ontologies implemented in RDF(S) (1, 2), DAML+OIL (3), and OWL (4), specialized ontology parsers (Validating RDF Parser (5), RDF Validation Service (6), DAML Validator (7), DAML+OIL Ontology Checker (8), OWL Ontology Validator (9), and OWL Validator (10)) and import services within ontology platforms (OilEd (Bechhofer et al., 2001), OntoEdit (Sure et al., 2002), Protégé-2000 (Noy et al., 2000), and WebODE (Arpírez et al., 2003)) have been built. These ontology tools must be studied to analyze whether they detect taxonomic problems in ontologies from a knowledge representation point of view.

In this paper we have performed our experiments with 41 ontologies (7 on RDF(S), 17 on DAML+OIL, and 17 on OWL), which are well built from a syntactic point of view, according to the languages specifications, but have inconsistencies and redundancies in their concept taxonomies. In summary, we have used the following evaluation process: 1) We have parsed our ontologies with the previous parsers and we have discovered that, in most cases, these parsers do not detect the taxonomic problems identified in (Gómez-Pérez, 1996). 2) We have imported our ontologies into the previous ontology platforms using their import services or backends. We have found out that, in most cases, these platforms do not detect problems in concept taxonomies in RDF(S), DAML+OIL, and OWL.

This paper is organized as follows, section two presents possible anomalies that can appear in ontology taxonomies. Section three presents a brief description of the ontology parsers and platforms used. Section four includes the results of our two experiments. Finally, we conclude with further work on evaluation.

2. Taxonomic Knowledge in Ontologies

The primitives *rdfs:subClassOf* is used in RDF(S), DAML+OIL, and OWL to build concept taxonomies. Besides, DAML+OIL and OWL allow adding disjoint and exhaustive knowledge to concept taxonomies, which is used to create disjoint decompositions of classes, exhaustive decompositions of classes, and partitions of classes (that is, decompositions that are both disjoint and exhaustive). The primitives *daml:disjointUnionOf*, *daml:disjointWith*, *owl:disjointWith*, and *owl:unionOf* can be used for this purpose.

According to the different possibilities for defining concept taxonomies, Gómez-Pérez (1996) presents a set of potential problems that can appear when ontologists model taxonomic knowledge in ontologies.

In this paper we focus only on the automatic detection of inconsistencies (circularity issue and partition errors) and grammatical redundancy problems. We postpone the analysis of the other types of problems for further works.

3. Ontology Tools: Parsers and Platforms

The Validating RDF Parser (VRP) (11). This parser carries out a syntactic validation and a semantic validation for verifying constraints derived from RDFS.

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1 http://www.w3.org/TR/PR-rdf-schema

2 http://www.w3.org/TR/REC-rdf-syntax/

3 http://www.daml.org/2001/03/daml+oil-walkthru.html

4 http://www.w3.org/TR/owl-ref/

5 http://139.91.183.30:9090/RDF/VRP/

6 http://www.w3.org/RDF/Validator/

7 http://www.daml.org/validator/

8 http://potato.cs.man.ac.uk/oil/Checker

9 http://phoebus.cs.man.ac.uk:9999/OWL/Validator

10 http://owl.bbn.com/validator/

11 http://139.91.183.30:9090/RDF/VRP/

RDF Validation Service (12)**.** This service does syntactic validation, but it does not offer any semantic validation.

DAML Validator (13)**.** The validator checks the ontology for namespace problems, for existence of RDF resources, and for global domain and range constraints of predicates.

DAML+OIL Ontology Checker (14)**.** This tool carries out syntactic validation for checking missing definitions. And it verifies class hierarchy loops.

OWL Ontology Validator (15). This tool can be used to check if an ontology conforms to a specific OWL species, since it validates an OWL ontology.

OWL Validator (16). This tool is not a simple parser in the sense that it checks OWL ontologies not only for simple syntax problems, but also for other errors.

OilEd (17; Bechhofer et al., 2001) can import ontologies implemented in RDF(S), OIL, DAML+OIL, OWL, and the SHIQ XML format.

OntoEdit (18; Sure et al., 2002) Free can import ontologies from FLogic, RDF(S), DAML+OIL, and from directory structures and from Excel files.

Protégé-2000 (19; Noy et al., 2000) can import ontologies implemented in RDF(S), DAML+OIL, OWL, XML, XML Schema, and XMI.

WebODE (20; Arpírez et al., 2003) can import ontologies from XML, RDF(S), DAML+OIL, and OWL.

4. Comparative Study of Ontology Tools

As we can see in table 1, **circularity problems** are the only ones detected by some of the parsers studied. The VRP is able to detect circularity problems at any distance in RDF(S) ontologies. This parser indicates that there is a semantic error with the message '*loop detected*'. The DAML+OIL Ontology Checker discovers circularity problems at any distance in RDF(S) and DAML+OIL ontologies. This checker generates the warning '*cycles in class hierarchy*' for indicating the problem. None of the OWL parsers is able to detect circularity problems in concept taxonomies. Regarding **partition errors**, they have only been studied for DAML+OIL and for OWL, since they cannot be represented in RDF(S). None of the parsers studied have recognized partition errors in our ten ontologies. The same occurs with the **grammatical redundancy problems**, which are not detected by any of the parsers studied.

As table 2 shows, **circularity problems** at any distance are the only ones detected by most of the ontology platforms analyzed. However, OntoEdit Free does not discover, but it simply ignores circularity problems at distance zero in RDF(S) and DAML+OIL ontologies. WebODE is the only one that detects these anomalies in OWL ontologies, on account of this platform uses the ODEval (21) service. Regarding **partition errors**, only DAML+OIL and OWL ontologies have been studied

because this type of knowledge cannot be represented in RDF(S). Most ontology platforms used do not recognize partition errors in DAML+OIL and OWL ontologies. OilEd and Protégé-2000 allow the insertion of common classes in disjoint decompositions and partitions in OWL ontologies, but these platforms identifies these types of error when the ontology is verified. Only WebODE, using ODEval, detects some partition errors in DAML+OIL and OWL ontologies. **Grammatical problems** are not discovered either by most ontology platforms used. However, most of ontology platforms ignore direct redundancies of 'subclass-of' or 'instance-of' relations. Similar to the previous case, only WebODE recognizes, using ODEval, indirect redundancies of 'subclass-of' relations in RDF(S), DAML+OIL, and OWL ontologies.

5. Conclusions and Further Work

Taking into account the results of our experiments, we consider that it is necessary to check possible anomalies that can be made during ontology development. Therefore, it is important that ontology tools help the ontologist build ontologies without knowledge representation problems.

We consider that we need tools for giving support to the evaluation activity during the whole life-cycle of ontologies (conceptualization, implementation, import, export, etc.). These ontology tools should not only evaluate concept taxonomies, but also other ontology components, such as relations, axioms, instances, etc.

Acknowledgements

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12 http://www.w3.org/RDF/Validator/
13 http://www.daml.org/validator/
14 http://potato.cs.man.ac.uk/oil/Checker
15 http://phoebus.cs.man.ac.uk:9999/OWL/Validator
16 http://owl.bbn.com/validator/
17 http://oiled.man.ac.uk
18 http://www.ontoprise.de/com/start_downlo.htm
19 http://protege.stanford.edu/plugins.html
20 http://webode.dia.fi.upm.es/
21 http://minsky.dia.fi.upm.es/odeval

			Validating RDF Parser		RDF Validation Service		DAML Validator		DAML+OIL Ontology Checker		OWL Ontology Validator		OWL Validator	
			RDF(S)	DAML+OIL	RDF(S)	DAML+OIL	RDF(S)	DAML+OIL	RDF(S)	DAML+OIL	RDF(S)	OWL	RDF(S)	OWL
Inconsistency: Circularity Problems	At distance zero		✓	⊘	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗
	At distance one		✓	⊘	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗
	At distance n		✓	⊘	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗
Inconsistency: Partition Errors	Common classes in disjoint decompositions	Direct	--	⊘	--	✗	--	✗	--	✗	--	✗	--	✗
		Indirect	--	⊘	--	✗	--	✗	--	✗	--	✗	--	✗
	Common classes in partitions		--	⊘	--	✗	--	✗	--	✗	--	✗	--	✗
	Common instances in disjoint decompositions	Direct	--	⊘	--	✗	--	✗	--	✗	--	✗	--	✗
		Indirect	--	⊘	--	✗	--	✗	--	✗	--	✗	--	✗
	Common instances in partitions		--	⊘	--	✗	--	✗	--	✗	--	✗	--	✗
	External classes in exhaustive decompositions		--	⊘	--	✗	--	✗	--	✗	--	✗	--	✗
	External classes in partitions		--	⊘	--	✗	--	✗	--	✗	--	✗	--	✗
	External instances in exhaustive decompositions		--	⊘	--	✗	--	✗	--	✗	--	✗	--	✗
	External instances in partitions		--	⊘	--	✗	--	✗	--	✗	--	✗	--	✗
Redundancy: Grammatical Problems	Redundancies of 'subclass-of' relations	Direct	✗	⊘	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
		Indirect	✗	⊘	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
	Redundancies of 'instance-of' relations	Direct	✗	⊘	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
		Indirect	✗	⊘	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗

Table 1: Results of the analysis of the RDF(S), DAML+OIL, and OWL parsers (22)

22 ✓: The parser detects the problem in this language   ⊘: The parser does not accept files written in this language
   ✗: The parser does not detect the problem in this language   --: The problem cannot be represented in this language

			OilEd			OntoEdit Free			Protégé-2000			WebODE		
			RDF(S)	DAML+ OIL	OWL	RDF(S)	DAML+ OIL	OWL	RDF(S)	DAML+ OIL	OWL	RDF(S)	DAML+ OIL	OWL
Inconsistency: Circularity Problems	At distance zero		✓	✓	✗	✗	✗	⊘	✓	✓	✗	✓	✓	✓
	At distance one		✓	✓	✗	✓	✓	⊘	✓	✓	✗	✓	✓	✓
	At distance n		✓	✓	✗	✓	✓	⊘	✓	✓	✗	✓	✓	✓
Inconsistency: Partition Errors	Common classes in disjoint decompositions	Direct	--	✗	☑	--	✗	⊘	--	✗	☑	--	✓	✓
		Indirect	--	✗	☑	--	✗	⊘	--	✗	☑	--	✓	✓
	Common classes in partitions		--	✗	☑	--	☺	⊘	--	✗	☑	--	✓	✓
	Common instances in disjoint decompositions	Direct	--	✗	✗	--	✗	⊘	--	☺	✗	--	☺	✓
		Indirect	--	✗	✗	--	✗	⊘	--	☺	✗	--	☺	✓
	Common instances in partitions		--	✗	✗	--	☺	⊘	--	☺	✗	--	☺	✓
	External classes in exhaustive decompositions		--	✗	✗	--	☺	⊘	--	✗	✗	--	☺	✗
	External classes in partitions		--	✗	✗	--	☺	⊘	--	✗	✗	--	✓	✗
	External instances in exhaustive decompositions		--	✗	✗	--	☺	⊘	--	✗	✗	--	☺	✗
	External instances in partitions		--	✗	✗	--	☺	⊘	--	✗	✗	--	✓	✗
Redundancy: Grammatical Problems	Redundancies of 'subclass-of' relations	Direct	✗	✗	✗	✗	✗	⊘	✗	✗	✗	✗	✗	✗
		Indirect	✗	✗	✗	✗	✗	⊘	✗	✗	✗	✓	✓	✓
	Redundancies of 'instance-of' relations	Direct	✗	✗	✗	✗	✗	⊘	✗	☺	✗	☺	☺	✗
		Indirect	✗	✗	✗	✗	✗	⊘	☺	☺	✗	☺	☺	✗

Table 2: Results of the analysis of the RDF(S), DAML+OIL , and OWL ontology import (23)

23 ✓: The ontology platform detects the problem
  ✗: The ontology platform does not detect the problem
  --: The problem cannot be represented in this language

☺: The ontology platform does not allow representing this type of problem
☑: The ontology platform allows inserting the problem, which is only detected when the ontology is verified
⊘: OntoEdit OWL plug-ins are being currently developed in Ontoprise