Ontology Languages & Reasoning

Introduction

Representation languages are a cornerstone of the Semantic Web. The existence of *standard* languages is important in ensuring wide-scale takeup and implementation of the Semantic Web. Standards facilitate interoperation and sharing of data and provide a grounding for the machine readability which is a cornerstone of the Semantic Web.

The World Wide Web Consortium's (W3C) Recommendation for an Web Ontology Language OWL has seen rapid uptake in both industrial and academic contexts since its publication in 2004.

Work in language design does not finish with OWL, however. This briefing highlights work undertaken by members of the KnowledgeWeb network in the investigation and design of language extensions. The work is driven by use cases drawn from both industry and academia.

Extending OWL

OWL DL (one of the three "subspecies" of OWL) is, by design, limited in its expressivity. This is primarily to ensure that, in line with known theoretical results, automated inference with OWL DL is both feasible and practical. However, there are applications and use cases that require extensions to the existing languages.

A number of use cases contributed requirements to this activity. In particular, Health Care and Life Sciences applications (e.g. modelling of Protein Data or Brain Anatomy) have needs for extended cardinalities or dependencies between properties, such as the interaction between partonomic and locative relations. The limited facilities for metamodelling and annotation in OWL have also been seen as an issue.

Recent work has produced a concrete proposal for a more expressive ontology language, known as OWL 1.1. Key aspects of the extensions are:

- A richer set of property characteristics such as reflexivity and asymmetry;
- Facilities for describing interactions between property chains;
- User defined datatypes;
- Metamodelling and annotations.

OWL 1.1's expressivity has been carefully chose in order to preserve the desirable characteristics present in OWL DL (e.g. decidability of key inference problems such as satisfiability). Extensions are built on recent theoretical results (for example, an understanding of reasoning problems in the logic $\mathcal{SROIQ}$).

The development of a mapping between the Open Biological Ontologies (OBO) format and OWL 1.1 will also facilitate wider-scale uptake and interest in the extended language.

This proposal has now gained sufficient critical mass for standardisation activity to begin, and a new W3C working group started in October 2007 to standardise the proposal. Support for OWL 1.1 extensions is also already available in popular tools such as editors and reasoners.

Fuzzy OWL

Description Logic based languages like OWL are traditionally strong at definitive *yes/no* reasoning. Many classification problems, however, are imprecise by their nature: for example *tall* vs. *short* or whether an area is considered to be a flood plain. "Fuzzy" reasoning approaches allow us to introduce measures of uncertainty that facilitate modelling of vagueness or imprecision.

Within KnowledgeWeb, proposals for Fuzzy extensions to OWL have been developed. The work includes a rigorous theoretical framework for reasoning about fuzzy knowledge in Description Logic ontologies, along with practical reasoning algorithms and a prototype implementation of a reasoner.

This work has been driven by needs from use cases concerning annotation of multimedia content (taken from the aceMedia project), where ambiguity is an integral aspect of the domain.

Rough Description Logics

In some domains, concepts cannot be precisely defined, but instead are restricted by approximations. An approach known as Rough Description Logics (Rough DL) addresses these issues through an extension of the classical DL approach. A syntax and semantics has been defined, with reasoning tasks supported through classical DL reasoning.

The approach has been demonstrated in a proof of concept example modelling Sepsis in Clinical Trials using data

taken from the Dutch National Intensive Care Evaluation. In this example, it is difficult to provide criteria that characterise precisely when sepsis is present, and different clinical trials used different entry criteria for patient selection. However, upper and lower approximations can be given, allowing a comparison between trials, potentially spotting discrepancies or inconsistencies bewteen the selections.

Approximation

The move to web-size quantities of data puts new requirements on representation languages, and scalability becomes a key issue. Approximate reasoning is seen as one possible solution, with correctness of reasoning being sacrificed in order to obtain better performance. This must, of course, be done in a controlled and well-understood way.

For example, query rewriting can replace an inference problem with a simpler problem in such a way that the soundness or completeness of the result is preserved (but not both). The solution to the simpler problem can be seen as an approximation to the original problem.

When insufficient results are obtained from a query, query relaxation can be used to rewrite to a less restrictive query, potentially using user preferences or context. This has been explored within the context of a use case concerning Human Resources and job recruitment.

Query Languages

Standardisation activity relating to Query Languages for the Semantic Web is ongoing, and members of KnowledgeWeb have been active within this domain through involvement in the W3C's Data Access Working Group (DAWG) which is producing the SPARQL query language. In particular, KnowledgeWeb members have made key contributions to ensure that the formal underpinnings of SPARQL are sound.

Rules

The addition of rules to OWL is another direction under investigation. Standardisation activity is focused around W3C's Rule Interchange Format (RIF) Working Group. This is a large, hetereogenous group with many different requirements, and progress towards a standard is slow. However, KnowledgeWeb members continue to advance investigations into the interaction between rules and ontology languages.

Publications & Resources

KnowledgeWeb Deliverable D2.5.4: *Analysis of Requirements for Further Language Extensions*

I. Horrocks, O. Kutz, U. Sattler: *The Even More Irresistable SROIQ*, In Proceedings of KR 2006, 2006.

W3C OWL Working Group
http://www.w3.org/2007/10

G. Stoilos, N. Simou, G. Stamou and S. Kollias *Uncertainty and the Semantic Web* IEEE Intelligent Systems, 21(5), p. 84-87, 2006

S. Schlobach, M. Klein, L. Peelen *Description Logics with Approximate Definitions - Precise Modeling of Vague Concepts* in Proceedings of IJCAI'07, 2007

M. Mochol, H. Wache and L. Nixon. *Improving the accuracy of job search with semantic techniques* Proceedings of BIS2007, 2007.

E. Franconi and S. Tessaris. *The logic of RDF and SPARQL: a preliminary report*. Technical Report, KRDB Research Centre, Free University of Bozen-Bolzano, 2006.

B. Motik, U. Sattler and R. Studer *Query Answering for OWL-DL with rules*. Journal of Web Semantics 3(1), 2005.

Contact

For more information about the results presented here or the KnowledgeWeb Network of Excellence, please see the project web site

http://knowledgeweb.semanticweb.org

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