Lightweight Rule Extended Ontology Languages

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1 Research Problem

The combination of ontologies and rules is considered to be an important step forward for the Semantic Web. The OWL Web Ontology Language is the current W3C recommendation for representing ontologies on the Semantic Web. However, many applications require expressivity beyond that which OWL provides, e.g., to express constraints or to reason about closed-world knowledge. Logic programming rules can provide such expressivity and consequently, their combination with OWL DL is an active research area. Furthermore, the World Wide Web Consortium (W3C) have set up a Rule Interchange Format (RIF) Working Group to standardise the exchange of rules on the Web.

Combining OWL DL with rules is not a straight-forward task. Simply extending OWL DL with arbitrary rules leads to undecidability of certain core reasoning tasks. Additionally, efficiency and scalability are crucial for practical use of rule extended ontology languages in real world, large scale applications. Unfortunately, the reasoning tasks of OWL DL alone have a high complexity, resulting in intractability and are therefore often not are scalable enough for practical applications.

For OWL DL, there are generally two approaches to achieve scalable reasoning. The first, is to use a lightweight ontology language (such as DL-Lite [2], EL++ [1] or DLP [4]) that is tractable for the desired reasoning tasks. The second, is to use approximation methods [6, 13] to reduce reasoning tasks over the OWL DL ontology to that of a lightweight ontology language.

In this paper we outline our approach provide an expressive rule extended ontology language to users, while still allowing scalable and efficient reasoning.

The remainder of this paper is organised as follows. Section 2 gives details on the related work, Section 3 outlines our approach, Section 4 presents the methodology will be used and finally we conclude in Section 5.

2 Related Work

Currently, there is a wide range of proposed approaches for extending OWL DL with rules. However, as identified in [3], the availability scalable and efficient implementations is still of concern. In this section, we outline a number of these approaches, beginning with scalable approaches for reasoning in OWL DL.

The recent OWL 2 draft specification[1] defines a number tractable fragments, called Profiles. The OWL 2 Profiles document[2] comprises of three profiles (OWL 2 EL, OWL 2 QL and OWL 2 RL) defined by restrictions to the full OWL 2 DL language. These restrictions result in tractable sub-languages, tailored for efficient reasoning in particular situations.

Semantic Approximation [13] has been proposed to provide efficient reasoning for OWL DL ontologies while allowing users the freedom to define ontologies in the full language. In this approach, OWL DL ontologies are approximated to DL-Lite (the basis for the OWL 2 QL profile) which provides scalable query answering for ontologies with a large number of individuals.

SWRL [8] is defined by the unrestricted combination of OWL DL and rules. While this combination very expressive, reasoning in SWRL is undecidable. In [12], Motik et al propose DL-safe rules, a decidable combination of OWL DL and rules. In this approach the interaction between the rules and ontology is restricted so that the rules may only reference named individuals in the ontology. However, even with the added restriction of DL-safe rules, the combination still remains intractable.

DLP [4] is defined by the intersection of OWL DL and Horn rules. Furthermore, the draft OWL 2 RL profile has been inspired by this approach. DLP is intended for ease of implementation in rule languages, additionally allowing for certain rules to be built on top of the ontology language. However, while this approach is tractable, it does not result in an especially expressive language. Therefore an interesting question remains open regarding the amount expressivity required by rule extended ontology languages for the Semantic Web.

The Description Logic Rules approach [11] describes certain rules that can be transformed to the underlying description logic of OWL 2; allowing the user to make use of the often simpler rule-based presentation. This approach also identifies extensions to both DLP and EL++, using features from OWL 2. This approach however, does not add expressivity to the OWL 2 DL language.

Recently the language ELP [10] has been proposed as a both expressive and tractable combination of OWL 2 DL and rules. ELP is the extension of OWL 2 EL with Description Logic Rules, a generalisation of DL-safe rules and role conjunction; resulting in a super-language of both OWL 2 EL an OWL 2 QL. In common with DLP and OWL 2 RL, ELP can be implemented using a Datalog engine. An interesting next step would be to to carry out evaluations of this combination in a practical application scenario.

Standards are key for widespread uptake of new technologies on the Web and in other areas. While the OWL standard is mature, at this time no such standard exists for rules on the Web. The Rule Interchange Format (RIF)[3] working group are currently working toward providing such a standard. RIF aims to provide both a level of interoperability between different rule systems and compatibility

[1] http://www.w3.org/2007/OWL/
[2] http://www.w3.org/TR/owl2-profiles/
[3] http://www.w3.org/2005/rules/

with key Semantic Web standards such as RDF and OWL. This standard looks to be the future basis for rule exchange on the Web.

3 Proposed Approach

The main objective of my research is to provide scalable reasoning services for rule extended ontology languages. Based on the related work described in Section 2, we propose to provide an expressive rule extended ontology language to users, which can be approximated to a lightweight, tractable language to facilitate scalable and efficient reasoning. We propose to base this *expressive language* on OWL DL, extended with a useful set of rules. The *lightweight language* is to be based on OWL 2 RL, to provide a platform for rule extension and efficient reasoning.

3.1 Expressive Language

Providing users with the full expressivity of OWL DL, plus a rule extension, should ensure that our approach is applicable to a wide range of the ontologies in use on the Semantic Web. Furthermore, targeting OWL DL as a basis for this language will provide users with the freedom of a highly expressive rule extended ontology language, without having to worry about a complicated set of restrictions. Since this expressive language is likely to be be highly intractable, we intend to investigate approximation techniques to provide scalable reasoning. However, the Semantic Approximation approach presented in [13] requires a reasoner for the full source language in order to compute the approximation. This issue will be considered when choosing the particular rule extended ontology language and approximation approach.

3.2 Lightweight Language

A key characteristic of OWL 2 RL is that reasoners can be implemented using a Datalog engine, which can provide both efficiency and a natural platform for rule extension. The recently proposed ELP language is a tractable sub-language of SWR and can be implemented using similar techniques to OWL 2 RL. This language could provide an appropriate candidate for our lightweight language. An additional consideration is that this language should be suitable for an approximation process that does not sacrifice too much in terms of soundness or completeness. The main goal of this component of our approach is to find advantages over existing logic programming based reasoners (such as KAON2 [7], Oracle 11g[4] and OWLIM [9]).

4 Methodology

In this section we present our methodology to address three main areas of our approach.

[4] http://www.oracle.com/technology/products/database/oracle11g/index.html

4.1 Expressive Language

We are investigating possible approximation methods to provide an expressive rule extended language to users. The first task is to determine the appropriate approximation technique for this language. We have chosen to first target the Semantic Approximation of DL-safe SWRL. This choice of language is based on the availability of existing SWRL reasoners[5], required for the Semantic Approximation approach. However, at this stage, the specific choice of expressive language and approximation method are not yet fixed.

4.2 Lightweight Language

The first task is to determine which logic programming systems can provide a scalable platform for a logic programming based reasoner. Our approach is to implement the OWL 2 RL inference rules in RIF, a basic RIF translator can then be used to translate the inference rules to number of rule languages for comparison and evaluation. Since an OWL 2 RL reasoner is intended to be straight-forward to implement, preliminary results should be available quite quickly. The second task is to decide upon an appropriate lightweight language as the target of the approximation, our approach is to first target existing lightweight languages such as OWL 2 RL and ELP and then investigate further extensions if necessary.

4.3 Evaluation

Evaluating the usefulness of our rule extended ontology languages in practical applications is an important issue. A possible evaluation could be to make used of Linked Open Data (LOD)[6] in the context of a Semantic Web mashup application[7]. In this context, our rule extended ontology language could be used derive further information from the LOD datasets which cannot be derived using standard DL-based reasoning techniques. Furthermore, this large dataset could be use to form the basis of a scalability benchmark, in the style of the widely used Lehigh University Benchmark [5].

5 Conclusion

Rule extended ontology languages are desirable for the Semantic Web. However, there are currently no sufficiently expressive and scalable reasoners available that support OWL DL extended with rules. In this paper we have proposed an approach to extend OWL DL with rules, making use of approximation techniques to provide an expressive language to users, while allowing them to enjoy the scalable reasoning associated with lightweight languages. We have also presented our preliminary methodology to develop a useful and scalable rule extended ontology language reasoner for the Semantic Web.

[5] Both Pellet and KAON2 provide some support for DL-safe SWRL
[6] http://linkeddata.org/
[7] http://www.musicmash.org/ is a Semantic Mashup application developed at the University of Aberdeen

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