Chapter XXII
Using the Semantic Web Rule Language in the Development of Ontology-Driven Applications

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ABSTRACT

The Semantic Web Rule Language (SWRL) is an expressive OWL-based rule language. SWRL allows users to write Horn-like rules that can be expressed in terms of OWL concepts to provide more powerful deductive reasoning capabilities than OWL alone. Semantically, SWRL is built on the same description logic foundation as OWL and provides similar strong formal guarantees when performing inference. Due to its description logics foundation, rule-based applications developed using SWRL have a number of relatively novel characteristics. For example, SWRL shares OWL's open world assumption so certain types of rules that assume a closed world may be difficult or impossible to write in SWRL. In addition, all inference in SWRL is monotonic so deductions cannot be updated or retracted. These formal characteristic have a strong influence on the development and use of SWRL rules in ontology-driven applications. In this chapter, we describe the primary features of SWRL and outline how, despite some limitations, SWRL can be used to dramatically increase amount of knowledge that be represented in OWL ontologies.

INTRODUCTION

The Semantic Web project is a shared research plan that aims to provide explicit semantic meaning to data and knowledge on the World Wide Web (Berners-Lee et al., 2001). One of the goals of the Semantic Web is to enable applications to integrate data and knowledge automatically through the use of standardized languages that describe the content of Web-accessible resources. The Web Ontology Language (OWL; OWL, 2004) is emerging as a core Semantic Web language. OWL provides a language for constructing ontologies that provide high-level descriptions of Web content. This language is built on a description logic foundation and provides strong formal consistency guarantees when checking ontologies for inconsistencies and when deducing new knowledge. OWL has three sublanguages—OWL Lite, OWL-DL, OWL Full—that provide varying levels of expressive power. An important characteristic of OWL-DL is that it provides strong *decidablilty* guarantees – that is, the consistency checking and inference processes are guaranteed to terminate with definite conclusions no matter how large or complex the underlying ontologies.

OWL-DL's formal underpinnings also limit its expressive power. While it provides a rich set of modeling constructs, it restricts those constructs to the set that meet its decidability guarantees. As a result, certain concepts can not be expressed in OWL-DL. In particular, OWL-DL has poor support for reasoning with data values and certain types of interrelationships between multiple entities in an ontology can not be represented. OWL Full, which is slightly more expressive than OWL DL, shares these limitations. The proposed OWL 2 standard (OWL 2, 2008) addresses some, though not all, of the limitations.

Some researchers have proposed adding rules to OWL to expand its expressiveness. The Semantic Web Rule Language (SWRL; Horrocks et al., 2004) is one of the primary results of these activities. Semantically, SWRL is built on the same description logic foundation as OWL and provides strong formal guarantees when performing inference. SWRL provides considerably more expressive power than OWL alone, particularly when dealing with complex interrelationships between OWL individuals, or when reasoning with data values. It is rapidly become the *de facto* OWL rule language.

Background

Rule-bases developed using SWRL have a number of relatively novel characteristics. Instead being a standalone rule language, SWRL can be considered as a formal extension of the OWL language. Each SWRL rule is a sort of OWL axiom that is added to and interacts with existing OWL axioms in an ontology. That is, SWRL rules are formal logical statements about entities in an OWL ontology. This logical underpinning has significant consequences for rule development. A major consequence is that SWRL rules cannot be considered independently from OWL axioms during inference: SWRL rules and standard OWL axioms must be reasoned with together, which can make the reasoning process computationally expensive. This interdependence is such that a serial reasoning with OWL axioms followed by inference with SWRL rules does not guarantee completeness (Motik at al., 2005). As a result, OWL reasoners have to be extended to support SWRL, which is not a trivial undertaking.

As a practical consequence, SWRL rule development is deeply intertwined with the development of the associated OWL ontology. Since a SWRL rule may potentially interact with any OWL axiom in an ontology care must be taken to ensure that they do not conflict. Fortunately, these conflicts can be identified by a SWRL-aware OWL reasoner. An important further consequence is that SWRL rules bases cannot be considered independently of their associated OWL ontology.

The formal underpinnings of SWRL also results in some unexpected expressive limitations when writing rules, which has important consequence for rule development. SWRL rules are not as free form as many rule languages and many common rule constructs are not allowed. Techniques to work around these limitations may be required for many applications.

In this chapter, we explore some of SWRL's idiosyncrasies and show that despite them SWRL

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