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Interpreting SWRL Rules in RDF Graphs [1]

Jing Mei [2]

Department of Information Science
Peking University
Beijing 100871, China

Harold Boley [3]

Institute for Information Technology - e-Business
National Research Council of Canada
Fredericton, NB, E3B 9W4, Canada

Abstract

An unresolved issue in SWRL (the Semantic Web Rule Language) is whether the intended semantics of its RDF representation can be described as an extension of the W3C RDF semantics. In this paper we propose to make the model-theoretic semantics of SWRL compatible with RDF by interpreting SWRL rules in RDF graphs. For dealing with SWRL/RDF rules, we regard 'Implies' as an OWL class, and extract all 'Implies' rules from an RDF database that represents a SWRL knowledge base. Each 'Implies' rule is grounded through mappings built into the semantic conditions of the model theory. Based on the fixpoint semantics, a bottom-up strategy is employed to compute the least Herbrand models.

Keywords: SWRL rules, RDF graphs,
model theory, fixpoint semantics, bottom-up strategy.

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[2] Email: `mayyam AT is.pku.edu.cn`

[3] Email: `Harold.Boley AT nrc.gc.ca`

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1 Introduction

The Semantic Web Rule Language (SWRL) is based on a combination of the Web Ontology Language [19] with the Rule Markup Language [4]. The SWRL issues dealt with in the current paper are in part responding to the W3C team comment on the SWRL submission [16], which emphasized: "We greatly hope the path forward for SWRL includes an RDF encoding with full and correct RDF semantics, and an eye towards real user applications". Since universal variables in SWRL rules go beyond the RDF semantics [9], it has been questioned in [12] whether the intended semantics of the resultant RDF graphs can be described as a semantic extension of RDF.

In this paper we propose an RDF-compatible model-theoretic semantics of SWRL, interpreting SWRL rules in the framework of RDF graphs. This differs from the direct model-theoretic semantics of SWRL [19], whose basic idea is the definition of bindings as extensions of OWL interpretations that map variables to elements of the domain: while the mapping in [19] is s.t. a given variable appearing in different rules would assume the same value for an entire SWRL ontology, our mapping introduces rule names to permit different values for the same variable in different rules. To keep the RDF semantics of non-rule SWRL parts unchanged, we make use of an RDF resource for interpreting a variable, which will be mapped to a constant (i.e., an OWL individual or a literal value).

Moreover, since the RDF semantics permits variables as predicates, our SWRL interpretation comes in two variants, namely SWRL Full and SWRL non-Full. The former one conforms to OWL Full, while the latter one emphasizes a separation of the domain of discourse into disjoint parts (in particular, into classes, properties, individuals and variables), which makes sure that the SWRL portion, uniting OWL-DL and Datalog, preserves the standard first-order semantics. Also, a correspondence between SWRL non-Full triples and certain abstract syntax SWRL ontology "directives" (here, axioms or facts) is established. On top of that, SWRL DL-safe rules can also be achieved by restricting the universe of variables to explicitly named resources, which has been proved to be a decidable combination of OWL-DL and rules [18].

However, it should be pointed out that there is as of yet no known practical complete algorithm for reasoning in OWL-DL or OWL-Full (only OWL-Lite is more practical in this regard). Hence, our prototype system focuses on SWRL rules over RDF triples, extracting desired ground instantiations from a relational database, and computing their least Herbrand model via a bottom-up Datalog evaluation strategy. Our SWRL engine is thus available for inheritance reasoning on RDF Schema taxonomies, and we keep open an extension path towards OWL reasoning beyond RDF Schema inheritance.