RIF: A Standard Rules Language for the Semantic Web

Jos de Bruijn

Faculty of Computer Science
Free University of Bozen-Bolzano, Italy
`debruijn AT inf.unibz.it`

Ontolog Conference Call – 26 June 2008

(Semantic) Web Languages (I)

Data Language

- Resource Description Framework (RDF)
  - *subject – predicate – object*
  - `a rdf:type c`, `a p b`

Ontology Languages

- RDF Schema
  - Semantically extends RDF, defining semantics for `subClassOf`, `subPropertyOf`, `domain`, `range`
- OWL Full
  - Semantically extends RDFS, defining semantics for `intersectionOf`, `unionOf`, etc.
- OWL Lite/DL
  - Syntactical subsets of RDF, different semantics
  - Semantics defined in terms of *abstract syntax*

(Semantic) Web Languages (II)

Web Rule Language

- Rule Interchange Format (RIF) BLD (Basic Logic Dialect)
  - Horn rules with equality for the Web
  - *Not* based on RDF or OWL

Rules, Ontologies, and Data

- RDF graphs as data sets for rules
- RDFS/OWL ontologies as data models for rules
- Rules as extension to RDFS or OWL ontologies
- Solution: define interoperation between RIF, RDF, and OWL by connecting their semantics

Contents

Importing RDF/OWL

A RIF document (ruleset) R may reference (*Import*) RDF/OWL documents S_i:
`Import(`*`graphLocation profile`*`)`

- *`graphLocation`*: location of the RDF graph
- *`profile`*: how to interpret RDF graph (cf. entailment regime)
  - e.g., simple entailment, RDFS, OWL DL
  - Determines semantic notions to be used, model, satisfiability, entailment

A *RIF-RDF combination* is a tuple $C = \langle R, \{S_1, \ldots, S_n\} \rangle$
A *RIF-OWL DL combination* is a tuple $C = \langle R, \{O_1, \ldots, O_n\} \rangle$, where $O_1, \ldots, O_n$ are OWL ontologies in abstract syntax form; R does not have variables in class/property positions.

Statements in RIF versus Statements in RDF/OWL

RDF/OWL symbol		RIF symbol	
IRI	`<http:/...>`	IRI	`"http:/..."^^rif:iri`
Literal w/o language tag	`"abcde"`	String	`"abcde"^^xs:string`
Literal w language tag	`"abcde"@en`	`rif:text` constant	`"abcde@en"^^rif:text`
Typed literal	`"1"^^xs:int`	Constant	`"1"^^xs:int`
Blank node	`_:x`	Existential variable (in rule body)	`?x`

RDF/OWL statement		RIF statement	
RDF Triple	`s p o`	Frame formula	`s[p -> o]`
OWL class membership	`a type(C)`	Frame	`a[rdf:type -> C]`
OWL property value	`a value(p b)`	Frame	`a[p -> b]`

Example

Consider the RDF graph S:

```
ex:john   ex:brotherOf   _:x .
_:x       ex:parentOf    ex:mary .
```

And the ruleset R:

```
Forall ?x, ?y, ?z (?x[ex:uncleOf -> ?z] :-
  And(?x[ex:brotherOf -> ?y] ?y[ex:parentOf -> ?z]))
```

From the combination $\langle R, \{S\} \rangle$ we can derive the frame formula

`ex:john[ex:uncleOf -> ex:mary]`

But also the triple

`ex:john ex:uncleOf ex:mary`

Semantics of Combinations (I)

- Three model theories: RIF, RDF, and OWL DL
  - RDF model theory has several notions of *interpretation* (and satisfiability, entailment): simple, RDF, RDFS, D, OWL Full
  - Semantics of combination accommodates all these notions; selection of notion based on $\mathit{profile}$
- Semantics of combination based on *connection* of model theories
  - RIF interpretations interpret rule sets
  - RDF interpretations interpret RDF graphs
  - OWL interpretations interpret OWL ontologies
  - Connection of model theories through *conditions* on interpretations

Semantics of Combinations (II)

- A common-rif-rdf-interpretation is a pair (**I**, I), where **I** is an RIF interpretation, I is an RDF interpretation, such that a number of conditions hold, e.g.:
  - Domains of interpretation are the same
  - Interpretation of IRIs and well-typed literals is the same
  - Interpretation of triples corresponds with interpretation of frame formulas
- (**I**, I) satisfies a combination $C = \langle R, \{S_1, \ldots, S_n\} \rangle$ if **I** satisfies R and I satisfies all $S_1, \ldots, S_n$
  - (**I**, I) rdfs-satisfies C if I is an rdfs-interpretation
  - (**I**, I) D-satisfies C if I is a D-interpretation
  - (**I**, I) OWL-Full-satisfies C if I is an OWL-Full-interpretation
- C entails a graph T if for every (**I**, I) that satisfies C, I satisfies T
- C entails a RIF condition formula ϕ if for every (**I**, I) that satisfies C, **I** satisfies ϕ

Embedding RIF-RDF combinations

- Simple, RDF, and RDFS entailment for combinations may be embedded into RIF
- Given a combination $C = \langle R, \{S_1, \ldots, S_n\} \rangle$, RIF condition ϕ, and graph T
  - Embed S_i as sets of facts, Skolemizing blank nodes ($tr_R(S_i)$)
  - Embed R as R
  - Axiomatize profile ($R^{simple}, R^{RDF}, R^{RDFS}$)
  - Embed ϕ as ϕ
  - Embed T as conjunction of frame formulas, with blank nodes as existentially quantified variables ($tr_Q(t)$)
- Then,
  - C rdfs-entails ϕ iff $R \cup R^{RDFS} \cup tr_R(S_1) \cup \cdots \cup tr_R(S_n)$ entails ϕ and
  - C rdfs-entails T iff $R \cup R^{RDFS} \cup tr_R(S_1) \cup \cdots \cup tr_R(S_n)$ entails $tr_Q(T)$

Example

Consider the combination $C = \langle R, \{S\} \rangle$, with S:

```
ex:john      ex:memberOf      ex:studentCouncil .
ex:Student   rdfs:subClassOf  ex:Person .
```

and R:

```
Forall ?x (?x[rdf:type -> ex:Student] :-
  ?x[ex:memberOf -> ex:studentCouncil]))
```

and the graph T:

```
_:x rdf:type ex:Person
```

Example (cont'd)

$tr_R(S)$:

```
ex:john[ex:memberOf -> ex:studentCouncil]
ex:Student[rdfs:subClassOf -> ex:Person]
```

R^{RDFS} includes:

```
Forall ?x ?y ?z (?z[rdf:type -> ?y] :-
 And (?x[rdfs:subClassOf -> ?y] ?z[rdf:type -> ?x])),
```

$tr_Q(T)$:

```
Exists ?x (?x[rdf:type -> ex:Person])
```

As expected, $R \cup R^{RDFS} \cup tr_R(S)$ entails $tr_Q(T)$

Bibliography

- RIF Basic Logic Dialect, H. Boley, M. Kifer, eds. Latest version available at `http://www.w3.org/TR/rif-bld/`.
- RIF RDF and OWL compatibility, J. de Bruijn, ed. Latest version available at `http://www.w3.org/TR/rif-rdf-owl/`.
- RDF Semantics, P. Hayes, Editor. Latest version available at `http://www.w3.org/TR/rdf-mt/`.
- OWL Web Ontology Language Semantics and Abstract Syntax, P. F. Patel-Schneider, P. Hayes, I. Horrocks, Editors. Latest version available at `http://www.w3.org/TR/owl-semantics/`.