

Relation between OWL & First-Order Logics

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Recuperación de la Información – MTISI

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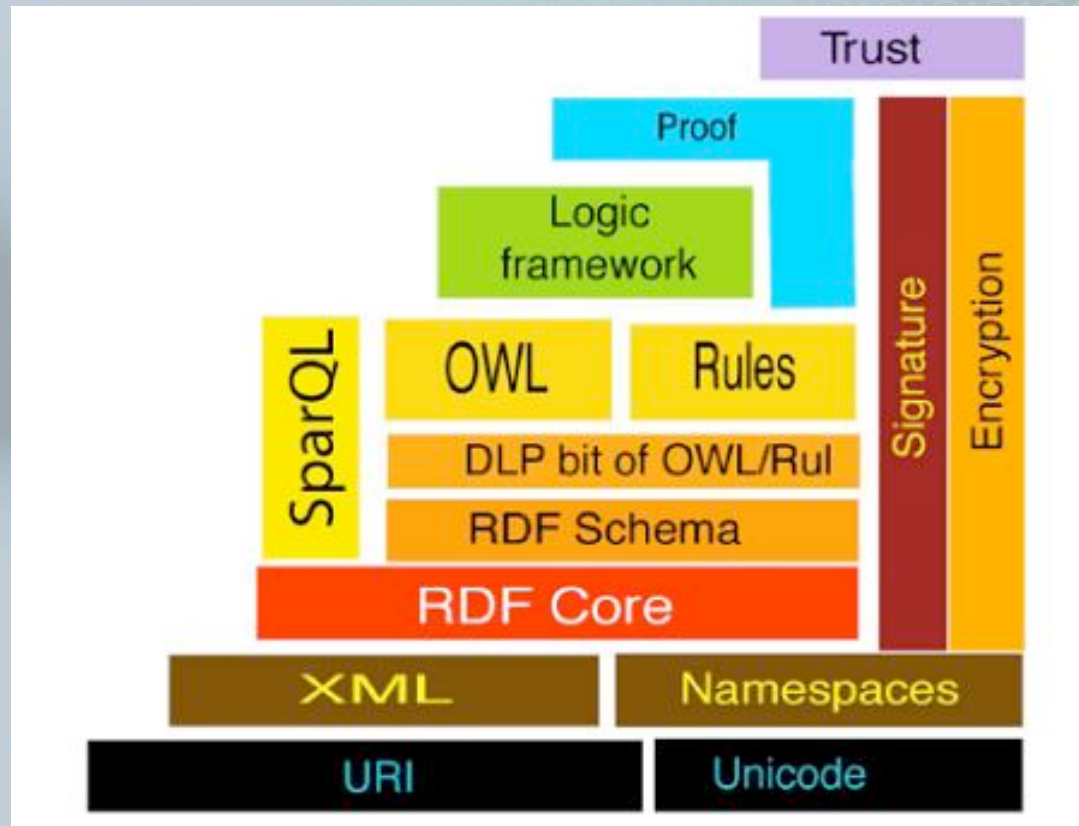
Introduction

- Objective: revision of the existing relationship between OWL (Web Ontology Language) and First Order Logics.
- Procedure: revision and compilation of information in existing papers and RDF and OWL W3C Primers and Recommendations.

OWL Introduction

- OWL is intended to provide a language that can be used to describe the classes and relations between them that are inherent in Web documents and applications (W3C).
- The final aim for using OWL is:
 - formalize a domain by defining classes and properties of those classes,
 - define individuals and assert properties about them, and
 - reason about these classes and individuals in order to derive logical consequences (facts not literally present in the ontology, but *entailed* by the semantics).

Semantic Web Architecture



source: <http://www.w3.org/2005/Talks/1110-iswc-tbl/>

Semantic Web is aimed to make web resources (data and services) more readily accessible to automated processes.

OWL Introduction

Species of OWL

- *OWL Lite*:
 - Basic support, e.g. classification hierarchy and simple constraint features (cardinality values of 0 or 1).
- *OWL DL*:
 - Maximum expressiveness without losing computational completeness, but still having some semantic restrictions.
- *OWL Full*:
 - Maximum expressiveness and the syntactic freedom of RDF with no computational guarantees

Syntax and Semantics

- OWL is a vocabulary extension of RDF, e.g.

```
<owl:Class>  
  <owl:intersectionOf>  
    <owl:Restriction>  
      <owl:onProperty rdf:resource="#worksFor" />  
      <owl:hasValue rdf:resource="http:www.accenture.com" />  
    </owl:Restriction>  
  <owl:Class rdf:about="#Consultant" />  
</owl:intersectionOf>  
<owl:subclassOf rdf:about="" rdf:resource="#CRMExpert"/>  
</owl:Class>
```

- Some built-in constructors:

owl:sameAs, owl:differentFrom, owl:cardinality,
owl:equivalentClass, owl:equivalentProperty,
owl:TransitiveProperty, owl:InverseFunctionalProperty...

Description Logics

- Description Logics are a subset of First Order Logics rules which can be used to represent a domain in a structured and formally well-understood way.
- Syntax of Description Logics consists of:
 - A set of unary predicate symbols that are used to denote *concept names*;
 - A set of binary relations that are used to denote *role names*;
 - A recursive definition for defining concept terms from concept names and role names using constructors.
- Description Logic is a very good way for representing and inferring relationships and values from known relationships.

OWL & Description Logics

- Entailment in OWL DL and OWL Lite can be reduced to Knowledge Base Satisfiability in the $SHOIN^{(D)}$ and $SHIF^{(D)}$ description logics domains respectively.
- Computing ontology entailment in OWL DL with respect to OWL Lite has the same complexity as computing knowledge base satisfiability in $SHOIN^{(D)}$ with respect to $SHIF^{(D)}$
- Description Logic algorithms and implementations for $SHIF^{(D)}$ can be used to provide reasoning services for OWL Lite in exponential time.
- Most problems in $SHOIN^{(D)}$, including satisfiability, are in N-exponential time. Further, there are as yet no known optimized inference algorithms or implemented systems for $SHOIN(D)$.

OWL Example

- One of the most widely used examples for OWLs is the wine ontology. There is a really good wine ontology referenced by W3C.
- There is also a wine agent associated to this ontology that performs OWL queries using a web-based ontological mark-up language. That is, by combining a logical reasoner with an OWL ontology.
- The agent's operation can be described in three parts: consulting the ontology, performing queries and outputting results.

OWL Example

Wine Agent

Wine Agent (version 1.0) - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://loris.stanford.edu:8080/wine/index.jsp

Wine Agent 1.0

[How does it work?](#)

Please select a type of course:

SEAFOOD <ul style="list-style-type: none">Fish<ul style="list-style-type: none">• Mixed fish• flavorful fish• shellfish<ul style="list-style-type: none">• oysters• other shellfish	RED MEAT <ul style="list-style-type: none">• regular red meat• spicy red meat	PASTA <ul style="list-style-type: none">• pasta w/regular red sauce• pasta w/spicy red sauce• pasta w/light cream sauce• pasta w/heavy cream sauce	DESSERT <ul style="list-style-type: none">• sweets• nuts and cheese
	WHITE MEAT <ul style="list-style-type: none">• traditional food• Louisiana food	TOMATO-BASED FOOD	FRUIT <ul style="list-style-type: none">• sweet fruit• unsweet fruit

Or, select a specific item from the sample menu:

Staters: Dozen clams • Dozen oysters • Dozen mussels • Personal cheese pizza

Poultry: Roast turkey • Roast duck • Roast goose • Roast turkey

Meat: Grilled T-bone steak • 10 oz. Prime rib • Grubby roast • Branded beef • Grilled veal chops • Grilled pork chops • Lamb curry

Pasta: Spaghetti with tomato sauce • Petterone Alce Jo • Piza Divola • Linguine with white clam sauce

Seafood: Grilled tuna • Baked flounder • Grilled salmon fish • Grilled halibut • Broiled sole • Maine lobster • White Tangaroon crab

Dessert: Double chocolate cake • Fresh fruit • Fruit plate • Puke Lunche • King of Pouter • Peach cobbler • Assorted nuts & assorted cheeses

OWL Example

Results from Reasoner

Wine Agent (version 1.0) - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites

Address http://onto.stanford.edu:2020/wine/index.jsp?tagstring=NON-OYSTER-SHELLFISH

Course Type: NON-OYSTER-SHELLFISH

"Pairs well with *dry* white varieties. Full-bodied wines match especially well."

The local knowledge base particularly recommends the following

- CORBANS PRIVATE BIN SAUVIGNON BLANC
- CORTON MONTRACHET WHITE BURGUNDY
 - MOUNTADAM CHARDONNAY
- CHATEAU DE MEURSAULT MEURSAULT
 - KALIN CELLARS SEMILLON
 - FORMAN CHARDONNAY
 - FOXEN CHENIN BLANC

The recommended wines can be found below, along with some comparable selections:

[Web Inventory Search](#)

Alternatively, the following varieties include many suitable matches:

- [PINOT-BLANC](#)
- [CHENIN-BLANC](#)
 - [RIESLING](#)
- [SAUVIGNON-BLANC](#)
- [WHITE-BURGUNDY](#)
- [WHITE-BORDEAUX](#)
 - [SEMILLON](#)

Please select a type of course:

Local intranet

OWL Example

Wine Ontology

```
<rdfs:Class rdf:ID="NON-OYSTER-SHELLFISH-COURSE">
  <rdfs:subClassOf rdf:resource="#DRINK-HAS-DRY-SUGAR-TO-CLASS-RESTRICTION"/>
</rdfs:Class rdf:ID="NON-OYSTER-SHELLFISH">
  <rdfs:subClassOf rdf:resource="#SHELLFISH"/>
  <daml:disjointWith rdf:resource="#OYSTER-SHELLFISH"/>
</rdfs:Class>
[...]
```

```
<rdfs:Class rdf:ID="SHELLFISH-COURSE">
  <rdfs:subClassOf rdf:resource="#DRINK-HAS-MODERATE-OR-STRONG-FLAVOR-TO-CLASS-RESTRICTION"/>
  <rdfs:subClassOf rdf:resource="#DRINK-HAS-FULL-BODY-TO-CLASS-RESTRICTION"/>
</rdfs:Class>
[...]
```

```
<rdfs:Class rdf:ID="SEMILLON-OR-SAUVIGNON-BLANC">
  <rdfs:subClassOf rdf:resource="#WHITE-COLOR-RESTRICTION"/>
  <rdfs:subClassOf rdf:resource="#MEDIUM-OR-FULL-BODY-TO-CLASS-RESTRICTION"/>
  <daml:intersectionOf rdf:parseType="daml:collection">
    <daml:Restriction rdf:about="#SEMILLON-INDIVIDUAL-OR-SAUVIGNON-BLANC-INDIVIDUAL-GRAPE-SLOT-
HAS-CLASS-RESTRICTION"/>
    <rdfs:Class rdf:about="#WINE"/>
  </daml:intersectionOf>
  <rdfs:subClassOf rdf:resource="#SEMILLON-INDIVIDUAL-OR-SAUVIGNON-BLANC-INDIVIDUAL-GRAPE-SLOT-TO-
CLASS-RESTRICTION"/>
</rdfs:Class>
[...]
```


```
<rdf:Description rdf:ID="CORBANS-PRIVATE-BIN-SAUVIGNON-BLANC">
  <rdf:type rdf:resource="#SAUVIGNON-BLANC" />
  <REGION rdf:resource="#NEW-ZEALAND"/>
  <MAKER rdf:resource="#CORBANS"/>
  <SUGAR rdf:resource="#DRY" />
  <FLAVOR rdf:resource="#STRONG" />
  <BODY rdf:resource="#FULL" />
</rdf:Description>
```

Conclusions

- Computing ontology entailment in OWL DL and OWL Lite is in N-Exp and Exp time respectively.
- The mapping of OWL Lite to $SHIF^{(D)}$ means that already-known practical reasoning algorithms for $SHIF^{(D)}$ can be used in OWL Lite.
- The mapping from OWL DL to $SHOIN^{(D)}$ can provide reasoning services for a large part of OWL DL. But the design of “practical” algorithms for $SHOIN^{(D)}$ is still an open problem.
- Extensions to OWL/RDFS (complex rules languages) are currently under development by W3C.
- Deep domain-specific knowledge is required to define a proper ontology, but that’s just the first time...

References

- Horrocks, I., Patel-Schneider, P.F., *Reducing OWL Entailment to Description Logic Satisfiability*. In Proc. of the 2nd International Semantic Web Conference (ISWC), 2003.
<http://www.cs.man.ac.uk/~horrocks/Publications/download/2003/HoPa03c.pdf>
- Baader, F., Calvanese, D., McGuinness, D. L., Nardi, D., and Patel-Schneider, P. F., editors (2003). *The Description Logic Handbook*. Cambridge University Press.
- W3C RDF Primer. <http://www.w3.org/TR/rdf-primer/>
- W3C OWL Primer. <http://www.w3.org/TR/owl-guide/>
- Polleres, A., *OWL and Semantic Web Slides*. Recuperación de la Información. URJC. 2007.
<http://platon.escet.urjc.es/~axel/teaching/ri2007/>
- Wikipedia, The Free Encyclopedia. <http://en.wikipedia.org/>
- W3C Recommendation: OWL Semantics and Abstract Syntax. <http://www.w3.org/TR/2004/REC-owl-semantics-20040210/>
- Wine Ontology. <http://www.daml.org/ontologies/76>
- Wine Agent.
<http://www.ksl.stanford.edu/people/dlm/webont/wineAgent/>



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