Relation between OWL & First-Order Logics

Alejandro Prieto Torres

Recuperación de la Información – MTISI

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Contents

Introduction

- Objective: revision of the existing relationship between OWL (Web Ontology Language) and First Order Logics.

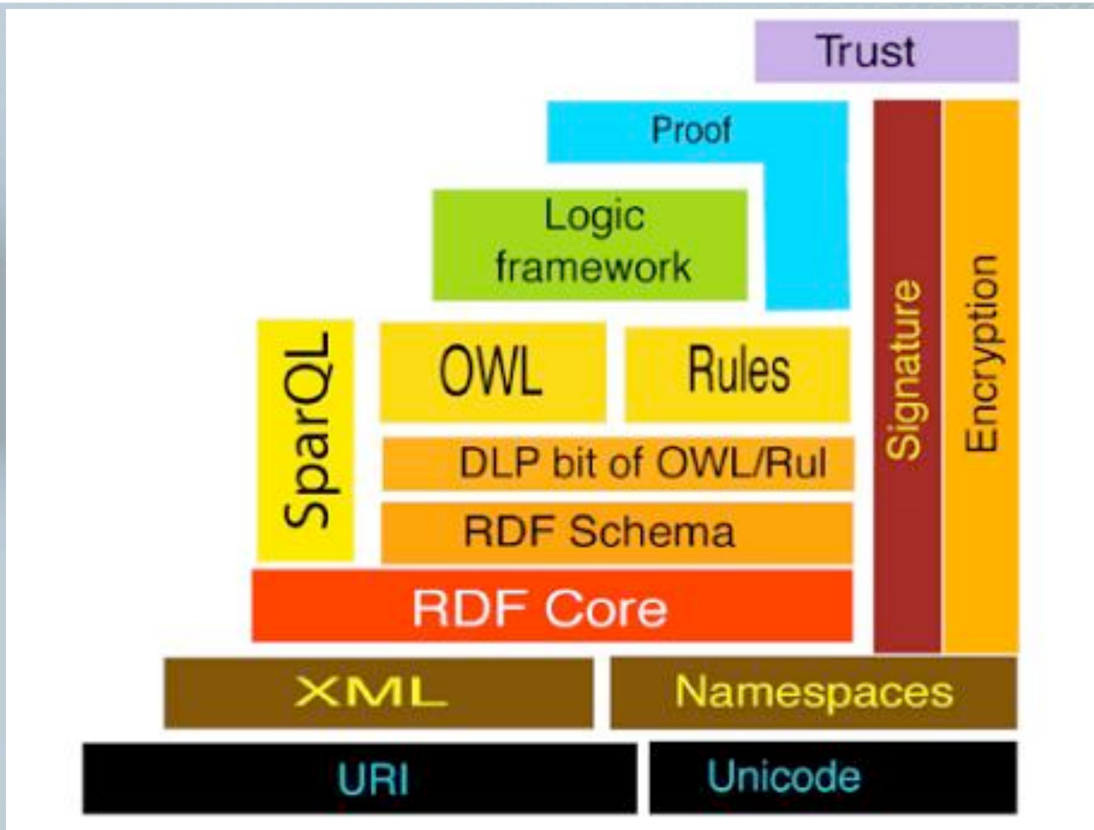
- Procedure: revision and compilation of information in existing papers and RDF and OWL W3C Primers and Recommendations.

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.

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

OWL Introduction

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 $\mathcal{SHOIN}^{(\mathcal{D})}$ and $\mathcal{SHIF}^{(\mathcal{D})}$ 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 $\mathcal{SHOIN}^{(\mathcal{D})}$ with respect to $\mathcal{SHIF}^{(\mathcal{D})}$

- Description Logic algorithms and implementations for $\mathcal{SHIF}^{(\mathcal{D})}$ can be used to provide reasoning services for OWL Lite in exponential time.

- Most problems in $\mathcal{SHOIN}^{(\mathcal{D})}$, including satisfiability, are in N-exponential time. Further, there are as yet no known optimized inference algorithms or implemented systems for $\mathcal{SHOIN}(\mathcal{D})$.

OWL Example

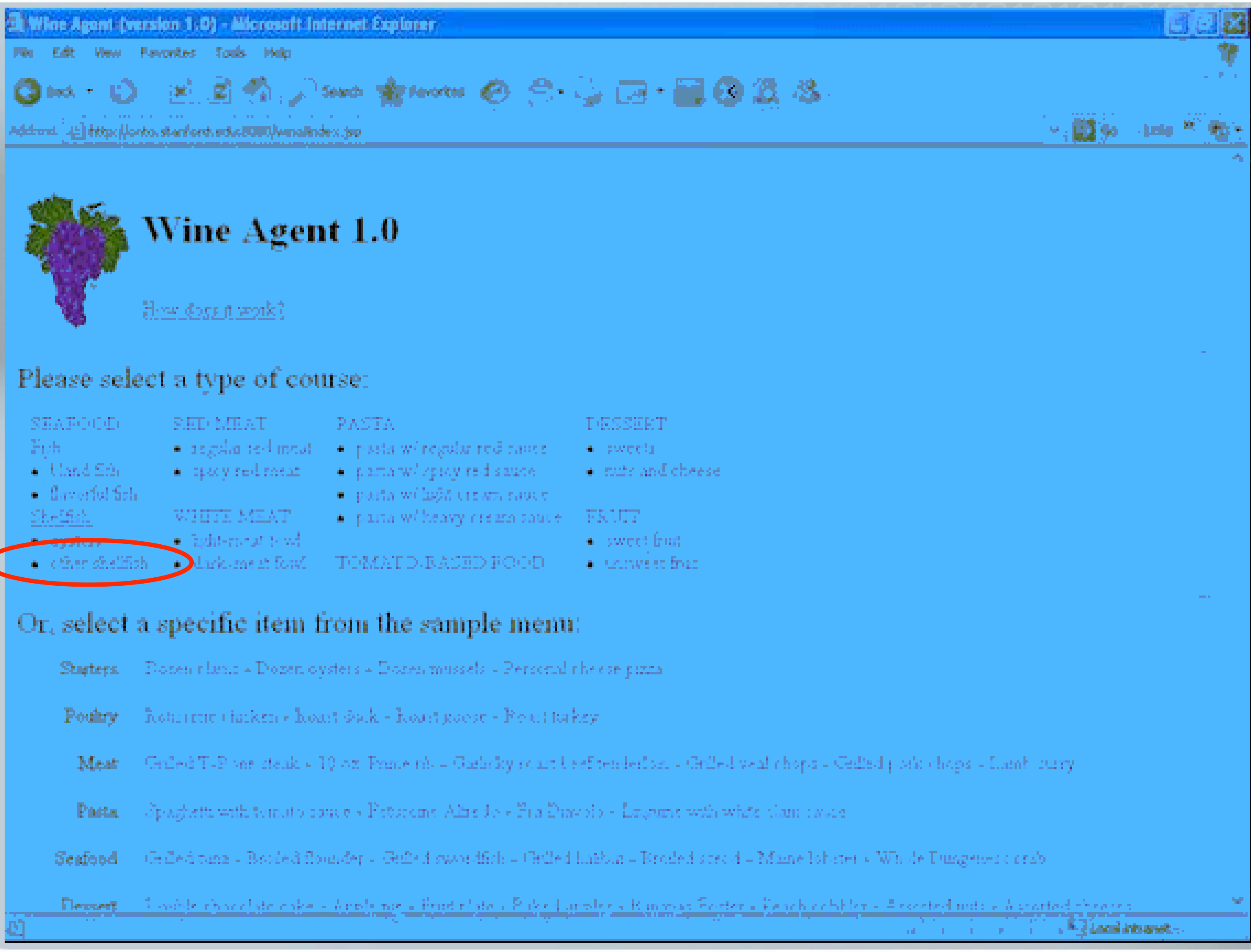
- One of the most widely used examples for OWLs is the wine ontology. There is a really good wine ontology referenced by W3C.

- 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.

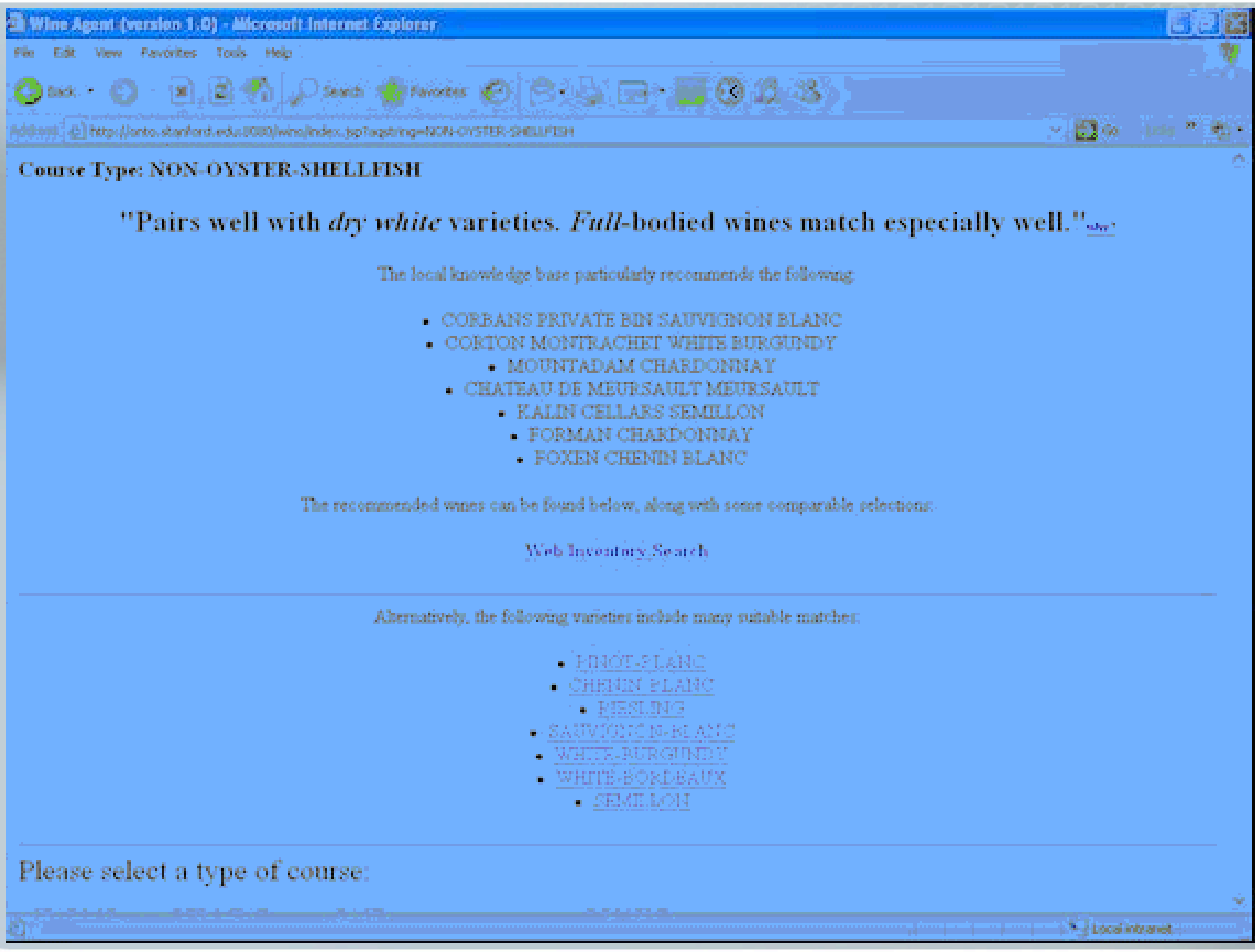
OWL Example

Wine Agent



OWL Example

Results from Reasoner



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 $\mathcal{SHIF}^{(\mathcal{D})}$ means that already-known practical reasoning algorithms for $\mathcal{SHIF}^{(\mathcal{D})}$ can be used in OWL Lite.
- The mapping from OWL DL to $\mathcal{SHOIN}^{(\mathcal{D})}$ can provide reasoning services for a large part of OWL DL. But the design of "practical" algorithms for $\mathcal{SHOIN}^{(\mathcal{D})}$ 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

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