Semantic Web - OWL

CS 431 – April 7, 2008

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Acknowledgements for various slides and ideas

- Ian Horrocks (Manchester U.K.)
- Eric Miller (W3C)
- Dieter Fensel (Berlin)
- Volker Haarslev (Montreal)

OWL Lite Summary

RDF Schema Features:

- Class (Thing, Nothing)
- rdfs:subClassOf
- rdf:Property
- rdfs:subPropertyOf
- rdfs:domain
- rdfs:range
- Individual

(In)Equality:

- equivalentClass
- equivalentProperty
- sameAs
- differentFrom
- AllDifferent
- distinctMembers

Property Characteristics:

- ObjectProperty
- DatatypeProperty
- inverseOf
- TransitiveProperty
- SymmetricProperty
- FunctionalProperty
- InverseFunctionalProperty

Property Restrictions:

- Restriction
- onProperty
- allValuesFrom
- someValuesFrom

Restricted Cardinality:

- minCardinality (only 0 or 1)
- maxCardinality (only 0 or 1)
- cardinality (only 0 or 1)

Header Information:

- Ontology
- imports

Class Intersection:

- intersectionOf

Datatypes

- xsd datatypes

Versioning:

- versionInfo
- priorVersion
- backwardCompatibleWith
- incompatibleWith
- DeprecatedClass
- DeprecatedProperty

Annotation Properties:

- rdfs:label
- rdfs:comment
- rdfs:seeAlso
- rdfs:isDefinedBy
- AnnotationProperty
- OntologyProperty

OWL DL and Full Summary

Class Axioms:

- *oneOf, dataRange*
- *disjointWith*
- *equivalentClass* (applied to class expressions)
- *rdfs:subClassOf* (applied to class expressions)

Boolean Combinations of Class Expressions:

- *unionOf*
- *complementOf*
- *intersectionOf*

Arbitrary Cardinality:

- *minCardinality*
- *maxCardinality*
- *cardinality*

Filler Information:

- *hasValue*

OWL DL vs. OWL-Full

- Same vocabulary
- OWL DL restrictions
  - Type separation
    - Class can not also be an individual or property
    - Property can not also be an individual or class
  - Separation of ObjectProperties and DatatypeProperties

Class/Property Example

```
<?xml version="1.0"?>
<rdf:RDF xmlns="http://www.co-ode.org/ontologies/wine/2005/10/18/wine.owl#"
  xml:base="http://www.co-ode.org/ontologies/wine/2005/10/18/wine.owl"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#" xmlns:dc="http://purl.org/dc/elements/1.1/"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:owl="http://www.w3.org/2002/07/owl#">
  <owl:class rdf:ID="PotableLiquid"/>
  <owl:Class rdf:ID="Wine">
    <rdfs:subClassOf rdf:resource="#PotableLiquid"/>
    <rdfs:label xml:lang="en">wine</rdfs:label>
    <rdfs:label xml:lang="fr">vin</rdfs:label>
  </owl:Class>
  <owl:DatatypeProperty rdf:ID="color">
    <rdfs:domain rdf:resource="#Wine"/>
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema/string"/>
  </owl:DatatypeProperty>
  <owl:Class rdf:ID="Appellation"/>
  <owl:ObjectProperty rdf:ID="hasAppellation">
    <rdfs:domain rdf:resource="#Wine"/>
    <rdfs:range rdf:resource="#Appellation"/>
  </owl:ObjectProperty>
  <owl:ObjectProperty rdf:ID="producesWine">
    <rdfs:range rdf:resource="#Wine"/>
    <rdfs:domain rdf:resource="#Appellation"/>
    <owl:inverseOf rdf:resource="#hasAppellation"/>
  </owl:ObjectProperty>
</rdf:RDF>
```

Demonstrating RDF, OWL, and Inferences

- RDQLPlus - http://rdqlplus.sourceforge.net/doc/ridiql.html

Language Comparison

	DTD	XSD	RDF(S)	OWL
Bounded lists (“X is known to have exactly 5 children”)				X
Cardinality constraints (Kleene operators)	X	X		X
Class expressions (unionOf, complementOf)				X
Data types		X		X
Enumerations	X	X		X
Equivalence (properties, classes, instances)				X
Formal semantics (model-theoretic & axiomatic)				X
Inheritance			X	X
Inference (transitivity, inverse)				X
Qualified contraints (“all children are of type person”				X
Reification			X	X

Storing and querying RDF-based models

- Persistent storage implementations
  - Jena - http://jena.sourceforge.net/
    - Relational databases (mysql , postgres, oracle)
  - Mulgara – http://www.mulgara.org/
    - Mapped files
  - Sesame- http://www.openrdf.org/
    - Relational databases (mysql, postgres, oracle)
- Query languages
  - RDQL (Mulgara)
  - SPARQL (Jena)
    - W3C recommendation
    - http://www.w3.org/TR/rdf-sparql-query/

RDQL-by-example

- RDF source
  - vc-db-3.rdf
- Queries
  - vc-q1
  - vc-q2
  - vc-q3
  - vc-q4
  - vc-q5
  - vc-q6
  - vc-q7
  - vc-q8

What is an *Ontology*?

- A formal specification of conceptualization shared in a community
- Vocabulary for defining a set of things that exist in a world view
- Formalization allows communication across application systems and extension
- Parallel concepts in other areas:
  - *Domains:* database theory
  - *Types*: AI
  - *Classes*: OO systems
  - *Types/Sorts*: Logic
- Global vs. Domain-specific

XML and RDF are *ontologically neutral*

- No standard vocabulary just primitives
  - Resource, Class, Property, Statement, etc.
- Compare to classic first order logic
  - Conjunction, disjunction, implication, existential, universal quantifier

Components of an Ontology

- Vocabulary (concepts)
- Structure (attributes of concepts and hierarchy)
- Relationships between concepts
- Logical characteristics of relationships
  - Domain and range restrictions
  - Properties of relations (symmetry, transitivity)
  - Cardinality of relations
  - etc.

Wordnet

- On-line lexical reference system, domain-independent
- >100,000 word meanings organized in a taxonomy with semantic relationships
  - Synonymy, meronymy, hyponymy, hypernymy
- Useful for text retrieval, etc.
- http://www.cogsci.princeton.edu/~wn/online/

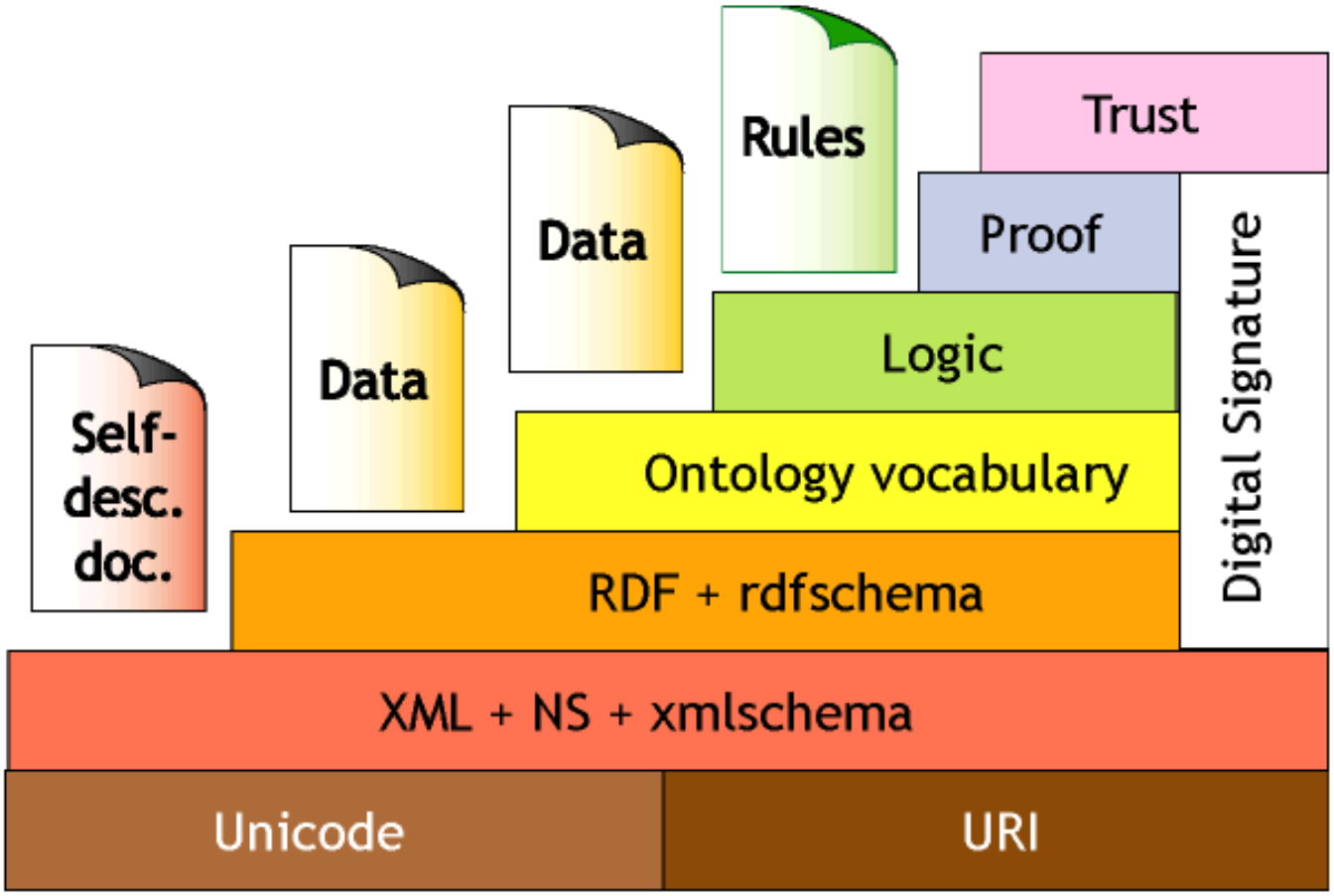
CYC

- Effort in AI community to accommodate all of human knowledge!!!
- Formalizes concepts with logical axioms specifying constraints on objects and classes
- Associated reasoning tools
- Contents are proprietary but there is OpenCyc
  - http://www.opencyc.org/

So why re-invent ontologies for the Web

- Not re-invention
  - Same underlying formalisms (frames, slots, description logic)
- But new factors
  - Massive scale
    - Tractability
    - Knowledge expressiveness must be limited or reasoning must be incomplete
  - Lack of central control
    - Need for federation
    - Inconsistency, lies, re-interpretations, duplications
    - New facts appear and modify constantly
  - Open world vs. Close world assumptions
    - Contrast to most reasoning systems that assume anything absent from knowledge base is not true
    - Need to maintain monotonicity with tolerance for contradictions
  - Need to build on existing standards
    - URI, XML, RDF

Components of the Semantic Web



Protégé and Pellet– tools for building, manipulating and reasoning over ontologies

- Protégé - http://protege.stanford.edu/
  - Use the 3.x version
  - Multiple plug-ins are available, you should install with all plugins
- Protégé OWL plug-in
  - http://protege.stanford.edu/plugins/owl/
- Other semantic web related plug-ins
  - http://protege.cim3.net/cgi-bin/wiki.pl?ProtegePluginsLibraryByTopic#nid349
- Pellet
  - Open Source Description Logic based reasoning engine
  - Server-based
  - Integrates with Protégé-OWL
  - http://pellet.owldl.com/