

Intelligent Autonomous Agents ICS606/EE606 Fall 2011

Nancy E. Reed

nreed@hawaii.edu

Lecture #6 Understanding Each Other and The Semantic Web

- A vision of a semantic web
- Markup languages, XML
- Data model, RDF
- Ontology sharing, DAML+OIL
- OWL -- The Web Ontology Language
- KIF -- Ontologies in First-Order Logic
- Constructing an Ontology
- Software Tools for Ontologies
- Reference
 - Wooldridge MAS Ch. 6
 - Semantic web references

Ontologies

“An ontology is a formal definition of a body of knowledge. The most typical type of ontology used in building agents involves a structural component. Essentially a taxonomy of class and subclass relations coupled with definitions of the relationships between these things”
-- Jim Hendler

From Ontologies to the Semantic Web

- Semantic Web was the motivation for renewed focus on ontologies
- Ontology spectrum from
 - Informal and less expressive up to
 - Formal and very expressive
- Ontology hierarchy: from
 - Very general (and reusable) on the bottom to
 - Very specific (not as reusable) at the top

eXtensible Markup Language (XML)

- HTML describes document structure and presentation
- XML is meta-language used to define other domain or industry specific information
- XML addresses “structuring” of **data** rather than documents
- Separation of **content** from **presentation**

XML and Semantics

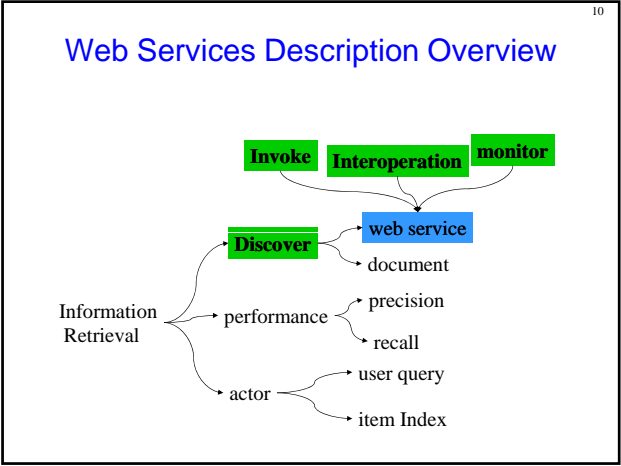
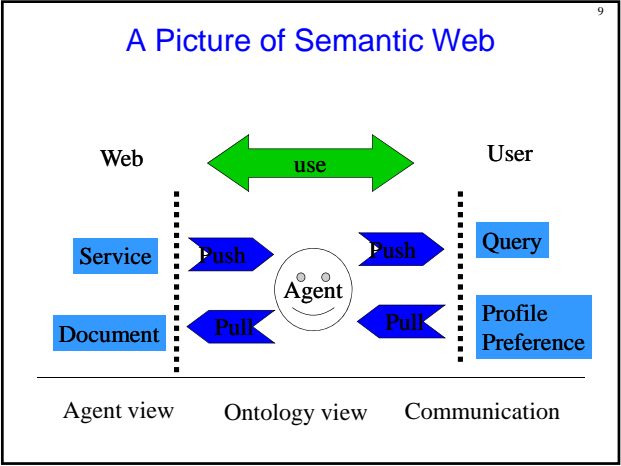
- **XML documents do not have semantics built-in**
- XML documents can have semantics **only by convention**
- Convention is an implicit semantic agreement on paper within a community of users for a particular domain’s data

Web Evolution

- 1st generation Internet -- enabled disparate machines to exchange data
- 2nd generation – WWW, new applications, enormous amounts of information available, revolution in new applications B2C (business to consumer)
- The next generation -- “agent-enabled” (Semantic Web) -- makes information available in machine-readable and understandable form
- enabling “agent” communication at a Web-wide scale

Semantic Web

- The Semantic Web is a vision: the idea of having data on the web defined and linked in a way that it **can be used by machines**
- The Semantic Web
 - proposes languages for expressing information and the relationships between information. ...
 - will accommodate additional formal systems techniques for verification of logical consistency and for reasoning
- W3C Semantic Web Activity Statement



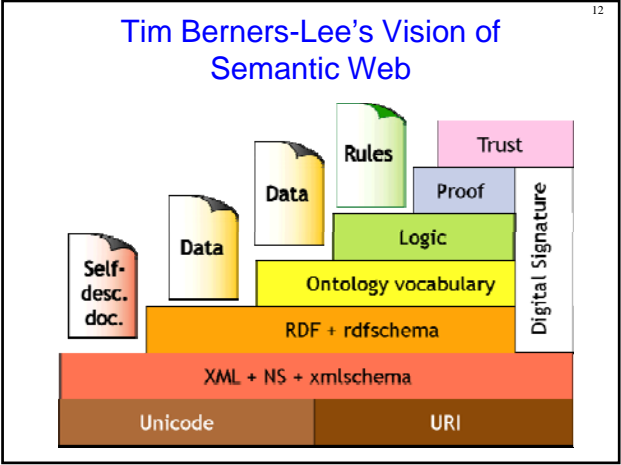
Tim Berners-Lee's Semantic Web

“... a universe of network-accessible information,

- a means of human-to-human communication, and
- a space in which software agents can, though access to a vast amount of everything which is society, science and its problems, become tools to work with us.”

Web Architecture from 50,000 feet
<http://www.w3.org/DesignIssues/Architecture.html>

From Machine Readable
 to
 Machine understandable



Semantic Web 13


- **Logic**
 - Jo is an employee of UMBC.
 - UMBC is a member of W3C.
 - UMBC has GET access to <http://www.w3.org/Member/>.
 - Jo (therefore) has access to <http://www.w3.org/Member/>.
- **Proof**
 - UMBC's document employList lists Jo as an employee.
 - W3C's member list includes UMBC.
 - The ACLs for <http://www.w3.org/Member/> assert that employees of members have GET access.
- **Trust**
 - UMBC's document employList is signed by a private key that W3C trusts to make such assertions.
 - W3C's member list is trusted by the access control mechanism.
 - The ACLs for <http://www.w3.org/Member/> were set by an agent trusted by the access control mechanism.
- Making the **simple stuff simple** and the **complex stuff possible**

Resource Description Frameworks 14

- The RDF Model and Syntax Specification defines the RDF data model and an XML-based serialization syntax.
- Uses XML to exchange descriptions of Web resources (meanings) but the resources being described can be of any type
 - XML or non-XML resources
- XML syntax is just one possible syntax for RDF

A Simple Example of an RDF model 15

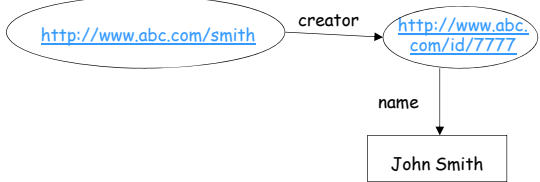
- John Smith is the creator of the resource <http://www.abc.com/smith>



Subject (Resource)	http://www.abc.com/smith
Predicated (Property)	Creator
Object (literal)	John Smith

Example (cont.) 16

- There is a unique employee ID for each employee in <http://www.abc.com>, and the ID is defined by a URI:



RDF Schema (RDFS) 17

- Defines the terms that will be used in RDF statements
- Provides means to define property domains and ranges, and class and subclass hierarchies
- More about RDF Schema:
 - RDF Schema Specification 1.0, <http://www.w3.org/TR/2000/CR-rdf-schema-20000327/>

RDFS Example 18

```

<rdf:Class ID="ResourceAccessRule">
  <rdf:label xml:lang="en">Access Rule</rdf:label>
  <rdf:comment>An assertion of access privileges to a resource.</rdf:comment>
  <rdf:isDefinedBy resource="http://www.w3.org/2001/02/acis/ns#" />
</rdf:Class>

<rdf:Property ID="hasAccessTo">
  <rdf:label xml:lang="en">has access to</rdf:label>
  <rdf:comment>Relates an Access Rule to the resources to which the rule applies. The inverse relation is 'accessedBy'.</rdf:comment>
  <rdf:range rdf:resource="http://www.w3.org/2000/01/rdf-schema#Resource" />
  <rdf:domain rdf:resource="#ResourceAccessRule" />
  <rdf:isDefinedBy resource="http://www.w3.org/2001/02/acis/ns#" />
</rdf:Property>
    
```

Practical uses of RDF

19

- Intelligent software agents to facilitate knowledge sharing and exchange
- Cataloging: for describing the content and content relationships available at a particular Web site, page or digital library.
- Describe collections of pages that represent a single logical “document”

Practical uses of RDF (cont.)

20

- Describing intellectual property rights of Web pages
- Digital signature: RDF may express information regarding what you are signing, what the significance of the signature is, the dates that the signature is valid.

Why RDF Is Not Enough

21

- Expressive inadequacy
 - Only range/domain constraints (on properties)
 - No properties of properties (unique, transitive, inverse etc.)
 - No equivalence, disjointness, coverings etc.
 - No necessary and sufficient conditions (for class membership)
- Poorly (un) defined semantics

Missing: Ontology Layer

22

- A common vocabulary with agreed upon meanings to describe a subject domain
- Widens interoperability & inter-conversion
- More meta-information such as
 - Transitive property
 - Unique, unambiguous, cardinality etc.
- More Semantically Rich

Describing and Exchanging Ontologies

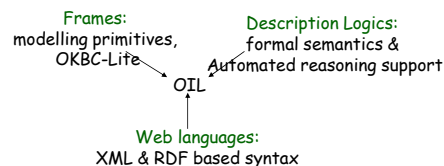
23

- To reuse an ontology we need to share it with others in the community
- Exchanging ontologies requires a language with:
 - common syntax
 - clear and explicit shared meaning
- Tools for parsing, delivery, visualizing etc.

OIL: Ontology Inference Layer

24

- Formally known as Ontology Interchange Language



- Extends XOL (some current restrictions)
- Gives a semantics to RDF-Schema
- <http://www.ontoknowledge.org/>
- A knowledge representation language and inference mechanism for the web

25

OIL Extensibility Model

Concrete domains (integers, strings) are on their way to the core...

26

Design Goals - OIL and DAML (DARPA Agent Markup Language)

- **Well *designed***
 - Intuitive to (human) users
 - Adequate expressive power
 - Support machine understanding/reasoning
- **Well *defined***
 - Clearly specified syntax (obviously)
 - Formal semantics (equally important)
- ***Extend*** existing web standards
 - DAML+OIL is built on top of RDF(S)

27

DAML+OIL Example

```
<rdf:Property ID="memberOf">
  <rdf:type rdf:resource="http://www.
  ontoknowledge.org/oil/rdf-
  schema/2000/11/10-oil-
  standard#TransitiveProperty"/>
  <rdfs:label xml:lang="en">member of<
  /rdfs:label>
  <rdfs:comment>The relationship of a
  member of a group
  to that group.</rdfs:comment>
  <rdfs:range rdf:resource="#Group"/>
  <rdfs:domain rdf:resource="#Principle"
  />
  <rdfs:isDefinedBy
  resource="http://www.w3.org/2001/02/ac
  ls/ns#" />
</rdf:Property>
```

28

How DAML+OIL Build ON RDF

- **Extends expressive power**
 - Constraints (restrictions) on properties of classes (existential/universal/cardinality)
 - Boolean combinations of classes and restrictions
 - Equivalence, disjointness, coverings
 - Necessary and sufficient conditions
 - Constraints on properties

29

DAML+OIL ↔ RDF

- DAML+OIL ontology is a set of RDF statements
- DAML+OIL defines semantics for certain statements
- Does **NOT** restrict what can be said
 - Ontology can include arbitrary RDF
- But no semantics for non-DAML+OIL statements

30

DAML+OIL Summary

- **Ontology language for Semantic Web**
- **Extends RDF**
 - More expressive power
 - Well defined semantics
- **Implementable**
 - Decidable and tractable reasoning
 - Cost is some restriction on expressive power
- **Extensible**
 - Cost may be loss of (some of) above properties

Conclusion

31

- The full potential of the web can only be reached with sharing and automating, by both tools and people
- The idea of a Semantic Web can help to reach this potential
- Languages (RDF, OIL, DAML) are still under development
- Hard to fully implement a Semantic Web in a short time - a long-term project

Acknowledgements

32

- Carole Goble, Ian Horrocks, University of Manchester and The OIL Consortium
- Tim Berners-Lee Presentation
- W3C Semantic Web Activity
- Eric Prudhommeaus
- Iris Ngai, mngai@cpsc.ucalgary.ca

Acknowledgements, cont. (OIL)

33

- Ian Horrocks and Carole Goble, Department of Computer Science, University of Manchester, UK
- Dieter Fensel, Michel Klein, Frank van Harmelen, Ying Ding, Rainer Faulstich, Borys Omelayenko and Hans Akkermans, Vrije Universiteit Amsterdam, Nederland
- Jeen Broekstra, Frank van Harmelen, Jos van der Meer and Christiaan Fluit, Administrator, Nederland
- Guus Schreiber, SWI, University of Amsterdam, Nederland
- Enrico Motta, Knowledge Media Institute, Open University, UK
- Deborah McGuinness, Stefan Decker, Stanford University, USA
- Michael Erdmann, Stefan Staab, Alexander Maedche and Rudi Studer, Institute AIFB, University of Karlsruhe, Germany
- Peter Karp, SRI International's Artificial Intelligence Center, USA
- Monika Crubezy, Stefan Decker, William Grosso, and Mark Musen, Knowledge Modeling Group at Stanford Medical Informatics, Stanford University, USA
- Heiner Stuckenschmidt, University of Bremen, Germany
- Robin McEntire, SmithKline Beecham
- John Davis, John Hughes, Uwe Krohn, British Telecom
- Ulrich Reimer, Martin Staudt, Swiss Life
- Robert Engels, CognIT
- Bernt A. Bremdal and Fredrik Ygge, EnerSearch

Questions

34

- What's the big deal over the semantic web?
- Describe 5 areas of research in which progress needs to be made to realize the semantic web.
- How long will it take to have most of the functionality of the semantic web?
- Define: RFD, XML, OIL, DAML, ontology