

## CS520 Web Programming

Introduction to the Semantic Web

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## Tim Berners-Lee

- ◆ Inventor of the WWW
- ◆ Wrote the first web client (browser-editor) and server in 1990
- ◆ Chair of MIT CSAIL and director of World Wide Web Consortium (W3C)

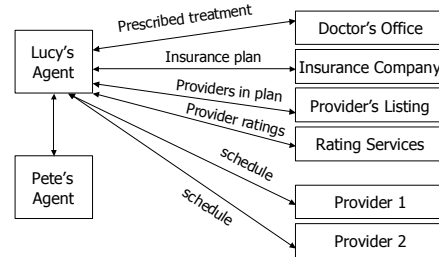
## The Vision

In the first part, the Web becomes a much more powerful means for collaboration between people. [...]

In the second part of the dream, collaborations extend to computers. Machines become capable of analyzing all the data on the Web - the content, links, and transactions between people and computers. A "Semantic Web," which should make this possible, has yet to emerge, but when it does, the day-to-day mechanisms of trade, bureaucracy, and our daily lives will be handled by machines talking to machines, leaving humans to provide the inspiration and intuition. The intelligent "agents" people have touted for ages will finally materialize. This machine-understandable Web will come about through the implementation of a series of technical advancements and social agreements that are now beginning (and which I describe in the next chapter).

*Weaving the Web*, Tim Berners-Less, 2000

## The Example

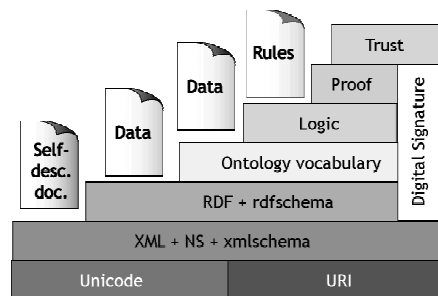


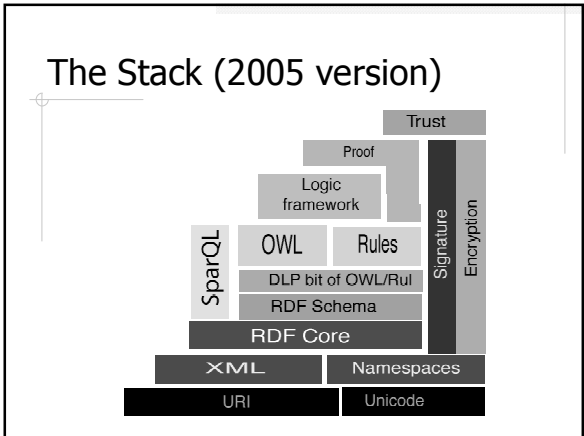
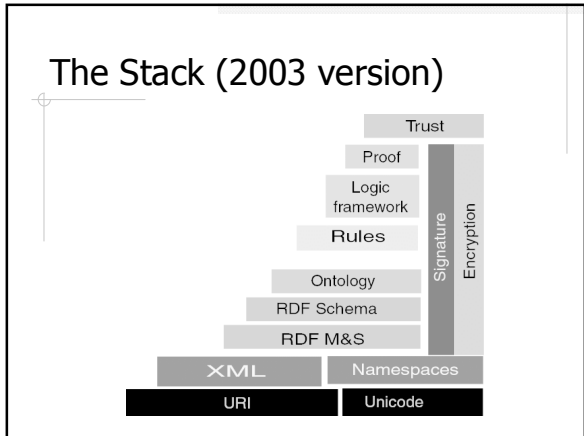
*The Semantic Web*, Berners-Lee et. al, 2001

## The Issues

- ◆ Knowledge representation
- ◆ Intelligent agent

## The Stack (2000 version)





### Resource Description Framework (RDF)

- ◆ A language that describes *resources*, which essentially can be anything
- ◆ RDF triple: *<subject, predicate, object>*

### RDF Example 1

Kobe Bryant plays for the Lakers. The official web site of the Lakers is <http://www.nba.com/lakers>.

↓

```

@prefix nba: <http://www.nba.com/ontology>
<nba:Bryant> <nba:play-for> <nba:lakers>
<nba:lakers> <nba:webaddr> "http://www.nba.com/laker"
  
```

↑ subject      ↑ predicate      ↑ literal      → object

### RDF Example 2

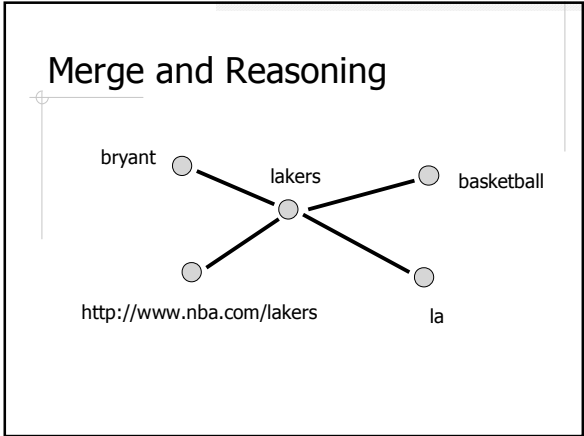
Name	Sport	Location
Lakers	Basketball	Los Angeles
Yankees	Baseball	New York

↓

```

@prefix nba: <http://www.nba.com/ontology>
@prefix mlb: <http://www.mlb.com/ontology>
@prefix general: <http://www.w3c.org/ontology>

<nba:lakers> <general:sport> <general:basketball>
<nba:lakers> <general:location> <general:la>
<mlb:yankees> <general:sport> <general:baseball>
<mlb:yankees> <general:location> <general:ny>
  
```



## Other Features

### ◆ Containers

- Bag, sequence, alternate
- Statements can be made about either a collection or an individual element of the collection

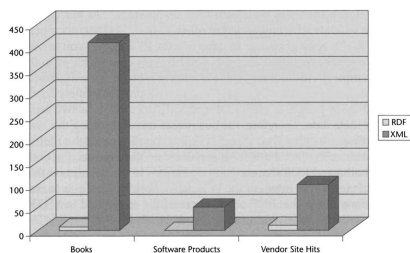
### ◆ Reification – making statements about statements

- Statement as subject

## RDF/XML Serialization

```
<rdf:RDF xmlns:nba="http://www.nba.com/ontology#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
  <rdf:Description rdf:about="http://www.nba.com/ontology#Bryant">
    <nba:plays-for>
      <rdf:Description rdf:about="http://www.nba.com/ontology#Lakers">
        <nba:webaddr rdf:resource="http://www.nba.com/lakers"/>
      </rdf:Description>
    </nba:plays-for>
  </rdf:Description>
</rdf:RDF>
```

## RDF Adoption



*The Semantic Web*, Daconta et. al, 2003

## Ontology

- ◆ Description, representation, and classification concepts and their relationships
- ◆ Vocabulary, taxonomy, thesaurus, database schema, UML diagram, logic
- ...

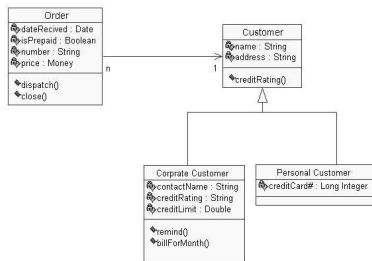
## Dublin Core Metadata Initiative

- ◆ <http://dublincore.org/>

## Open Directory Project

- ◆ <http://dmoz.org/>

## UML Diagram



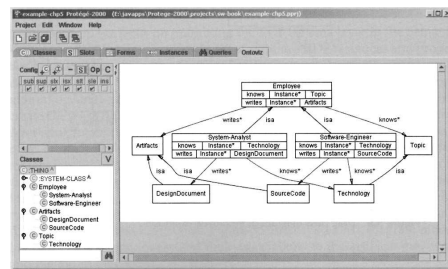
## So How to We Define an Ontology?

- ◆ RDF Schema
- ◆ OWL

## RDF Schema

- ◆ rdfs:Class
- ◆ rdfs:label
- ◆ rdfs:subClassOf
- ◆ rdfs:Property
- ◆ Rdfs:subPropertyof
- ◆ rdfs:domain
- ◆ rdfs:range
- ◆ rdfs:type
- ◆ rdfs:seeAlso
- ◆ rdfs:isDefinedBy
- ◆ rdfs:comment
- ◆ rdfs:Literal
- ◆ rdfs:XMLLiteral

## RDF Schema Example



*The Semantic Web, Daconta et. al, 2003*

## OWL

- ◆ Web Ontology Language (OWL)
  - OWL Full
  - OWL DL
  - OWL Lite

## Some OWL Elements

- ◆ owl:AllDifferent
- ◆ owl:Class
- ◆ owl:DatatypeProperty
- ◆ owl:DeprecatedClass
- ◆ owl:DeprecatedProperty
- ◆ owl:FunctionalProperty
- ◆ owl:InverseFunctionalProperty
- ◆ owl:Nothing
- ◆ owl:ObjectProperty
- ◆ owl:Ontology
- ◆ owl:Restriction
- ◆ owl:SymmetricProperty
- ◆ owl:maxCardinality
- ◆ owl:minCardinality
- ◆ owl:oneOf
- ◆ owl:onProperty
- ◆ owl:priorVersion
- ◆ owl:sameAs
- ◆ owl:sameIndividualAs
- ◆ owl:someValuesFrom
- ◆ owl:subClassOf
- ◆ owl:TransitiveProperty
- ◆ owl:unionOf
- ◆ owl:versionInfo
- ◆ ...

## References

- ◆ *The Semantic Web* by Daconta, Obrst, and Smith, 2003.
- ◆ Various presentations by Tim Berners-Lee - <http://www.w3.org/People/Berners-Lee/>

## The Other Side of the Story

I'd rather make progress by having computers understand what humans write, than by forcing humans to write in ways that computers can understand.

Sergey Brin at *InfoWorld 2002 CTO Forum*