Knowledge Representation for the Semantic Web

Winter Quarter 2010

Slides 4 – 01/21/2010

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Slides are based on

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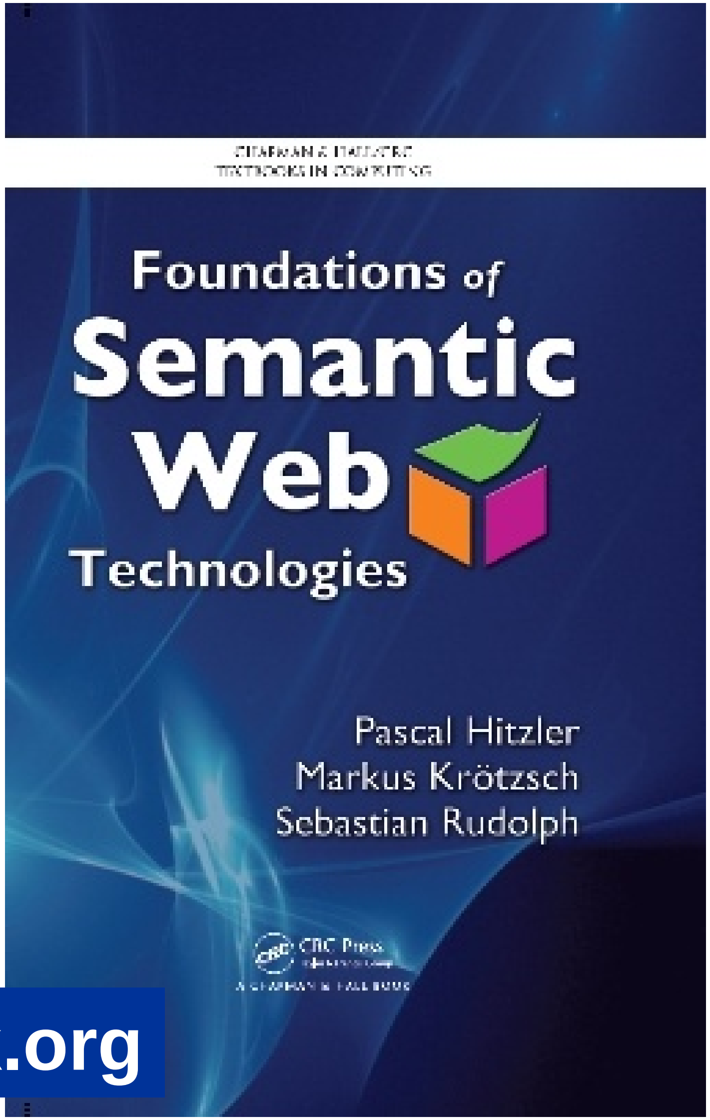
Foundations of Semantic Web Technologies

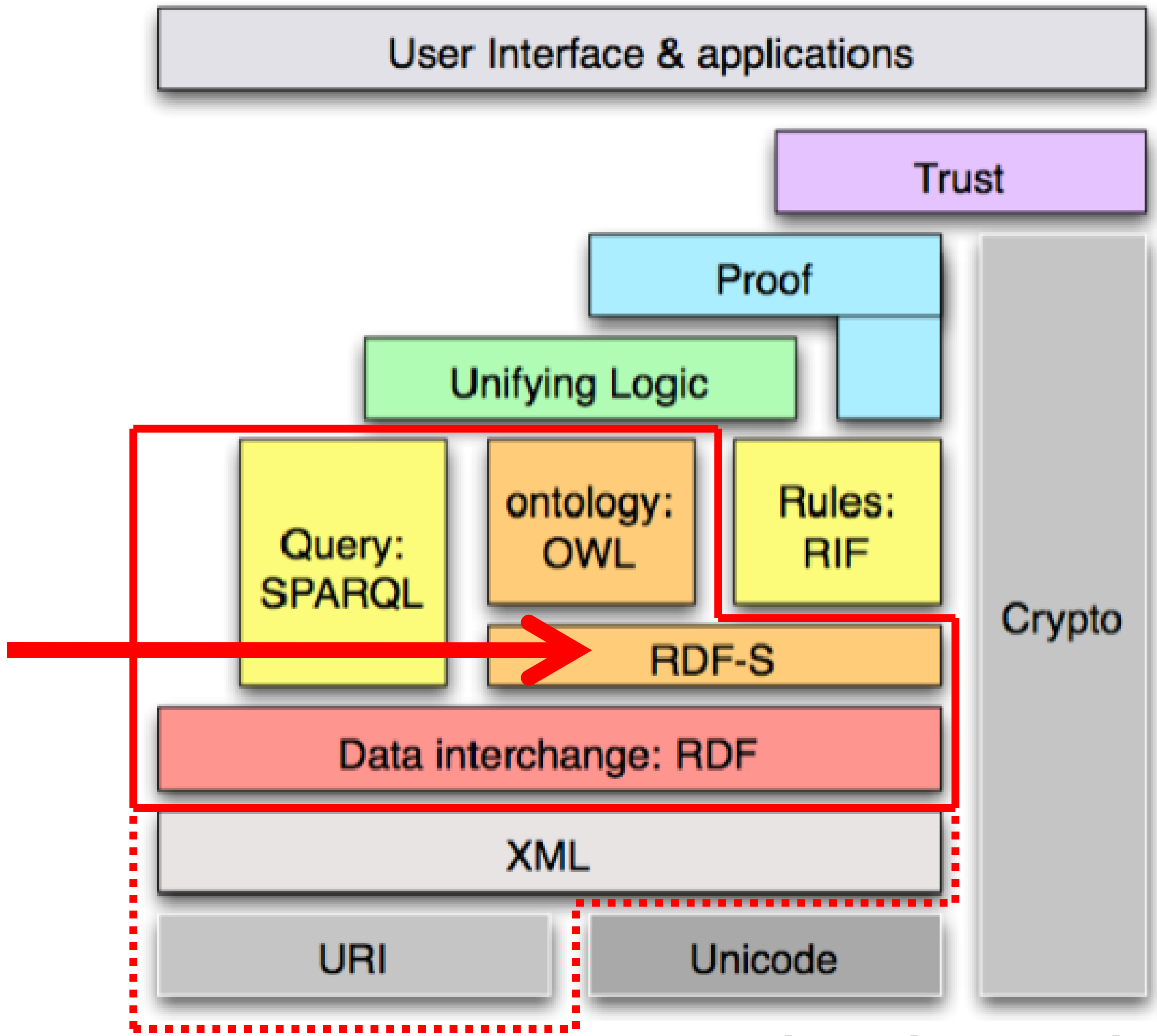
Chapman & Hall/CRC, 2010

Flyer with special offer is available.



http://www.semantic-web-book.org

Today: RDF syntax



+ conjunctive queries for OWL

Today's Session: RDF Schema

1. Motivation
2. Classes and Class Hierarchies
3. Properties and Property Hierarchies
4. Property Restrictions
5. Open Lists Revisited
6. Reification
7. Supplementary Information in RDFS
8. Simple Ontologies in RDFS
9. Class project
10. Class presentations

Motivation

- RDF allows to express facts
  - Anne is the mother of Merula
- But we'd like to be able to express more generic knowledge
  - Mothers are female
  - If somebody has a daughter then that person is a parent
- This kind of knowledge is often called *schema* knowledge or *terminological* knowledge.

RDF Schema (RDFS)

- part of the W3C Recommendation RDF
- for schema/terminological knowledge
- uses RDF vocabulary with pre-defined semantics
- every RDFS document is an RDF document
- Namespace: http://www.w3.org/2000/01/rdf-schema# - usually abbreviated by rdfs:

- vocabulary is generic, not bound to a specific application area
  - allows to (partially) specify the semantics of other/user-defined vocabularies (it‘s a kind of meta vocabulary)
  - hence, RDF software correctly interprets each vocabulary defined using RDF Schema

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Classes and Instances

- **Classes stand for sets of things.**
  In RDF: Sets of URIs.

- **book:uri is a member of the class ex:Textbook**

```
book:uri    rdf:type    ex:Textbook .
```

- **a URI can belong to several classes**

```
book:uri    rdf:type    ex:Textbook .
book:uri    rdf:type    ex:WorthReading .
```

- **classes can be arranged in hierarchies:**
  each textbook is a book

```
ex:Textbook    rdfs:subClassOf    ex:Book .
```

Pre-defined classes

- every URI denoting a class is a member of rdfs:Class

```
ex:Textbook   rdf:type   rdfs:Class .
```

- this also makes rdfs:Class a member of rdfs:Class (!)

```
rdfs:Class   rdf:type   rdfs:Class .
```

- rdfs:Resource (class of all URIs)
- rdf:Property (class of all properties)
- rdf:XMLLiteral
- rdfs:Literal (each datatype is a subclass)
- rdf:Bag, rdf:Alt, rdf:Seq, rdfs:Container , rdf:List, rdf:nil, rdfs:ContainerMembershipProperty (see later)
- rdfs:Datatype (contains all datatypes – a class of classes)
- rdf:Statement (see later)

Implicit knowledge

- **if an RDFS document contains**

```
u    rdf:type    ex:Textbook .
```

and

```
ex:Textbook    rdfs:subClassOf    ex:Book .
```

then

```
u    rdf:type    ex:Book .
```

is *implicitly* also the case: it's a *logical consequence*. (We can also say it is *deduced* (deduction) or *inferred* (inference).
We do not have to state this explicitly.
Which statements are logical consequences is governed by the formal semantics (covered in the next session).

Implicit knowledge – another example

- **From**

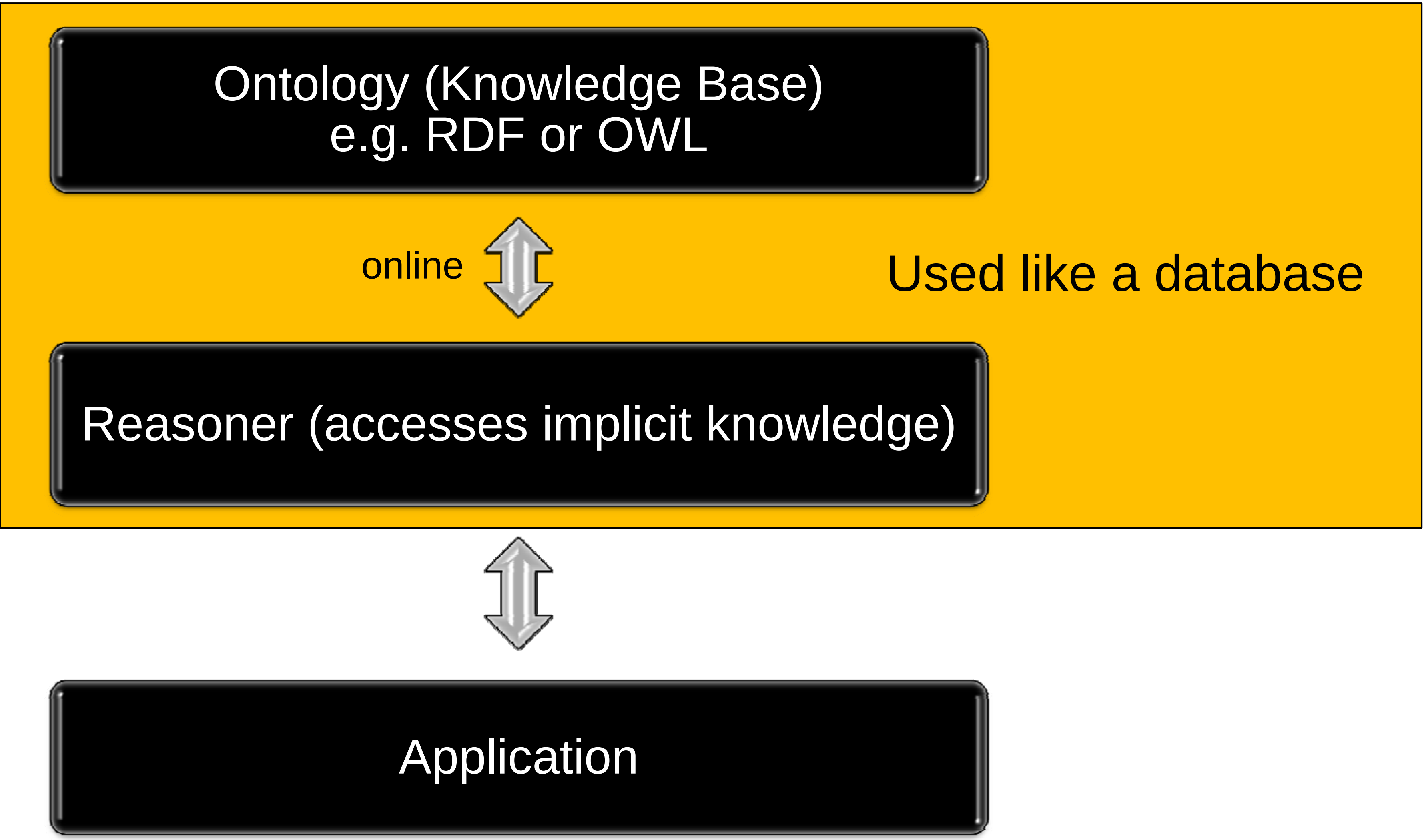
```
ex:Textbook   rdfs:subClassOf   ex:Book .
ex:Book       rdfs:subClassOf   ex:PrintMedia .
```

the following is a logical consequence:

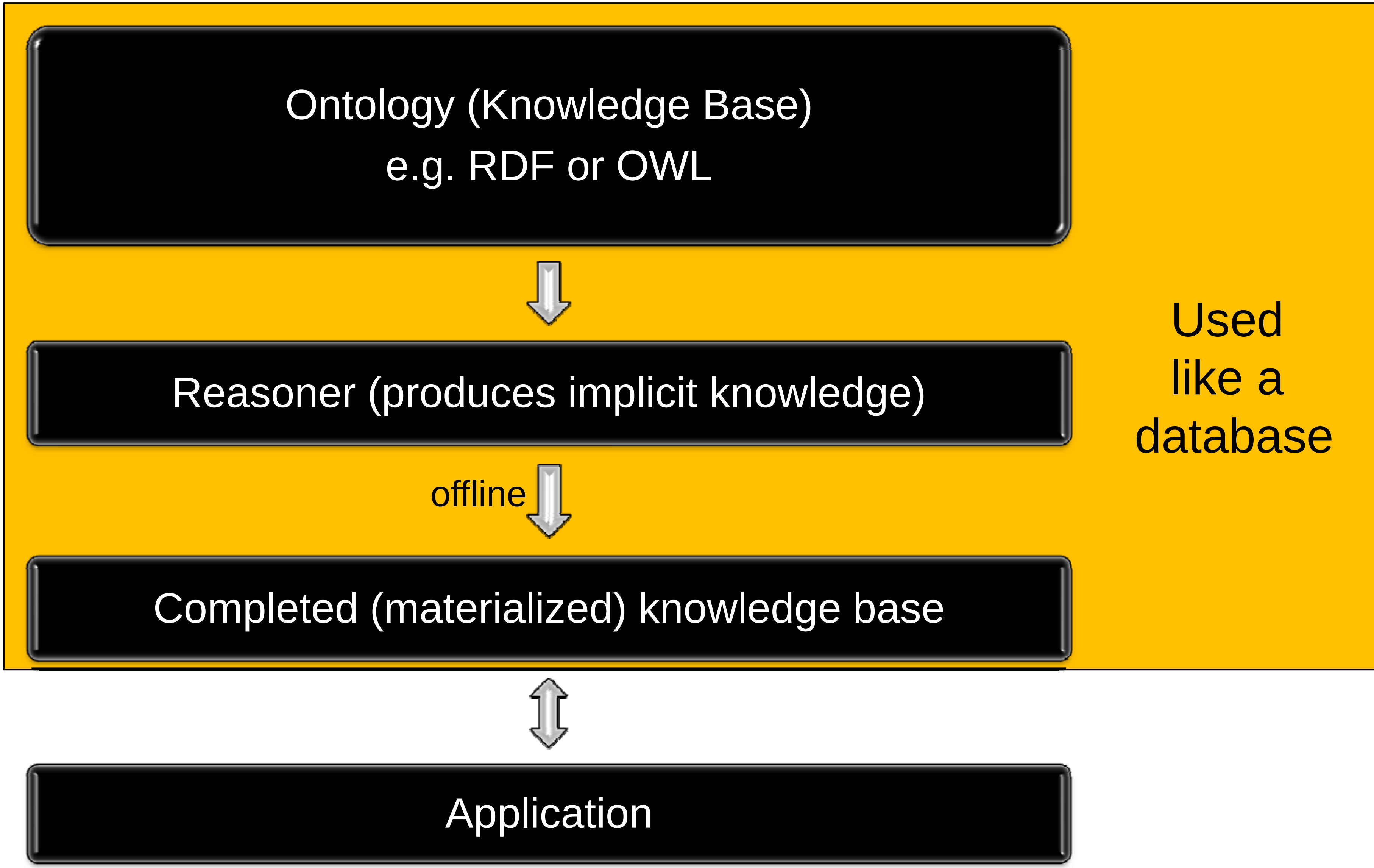
```
ex:Textbook   rdfs:subClassOf   ex:PrintMedia .
```

I.e. rdfs:subClassOf is *transitive*.

Using implicit knowledge



Using implicit knowledge



Class equivalence

```
ex:MorningStar   rdfs:subClassOf   ex:EveningStar .
ex:EveningStar   rdfs:subClassOf   ex:MorningStar .
```

```
ex:Book   rdfs:subClassOf   ex:Book .
```

I.e. rdfs:subClassOf is *reflexive*.

Classes and RDF/XML syntax

```
<ex:HomoSapiens rdf:about="&ex;SebastianRudolph"/>
```

is short for

```
<rdf:Description rdf:about= "&ex;SebastianRudolph">
<rdf:type rdf:resource= "&ex;HomoSapiens">
</rdf:Description>
```

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Property Hierarchies

From

```
ex:isHappilyMarriedTo  rdf:subPropertyOf ex:isMarriedTo.
```

and

```
ex:markus   ex:isHappilyMarriedTo   ex:anja .
```

we can infer that

```
ex:markus   ex:isMarriedTo   ex:anja .
```

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Property Restrictions

- **Allow to state that a certain property can only be between things of a certain rdf:type.**
- **E.g. when a is married to b, then both a and b are Persons.**
- **Expressed by rdfs:domain and rdfs:range:**

```
ex:isMarriedTo   rdfs:domain   ex:Person .
ex:isMarriedTo   rdfs:range    ex:Person .
```

- **And similarly for datatypes:**

```
ex:hasAge   rdfs:range   xsd:nonNegativeInteger .
```

Pitfalls 1

```
ex:authorOf   rdfs:range   ex:Textbook .
ex:authorOf   rdfs:range   ex:Storybook .
```

states that everything in the rdfs:range of ex:authorOf is both a ex:Textbook and a ex:Storybook!

Pitfalls 2

```
ex:isMarriedTo      rdfs:domain     ex:Person .
ex:isMarriedTo      rdfs:range      ex:Person .
ex:instituteAIFB    rdf:type        ex:Institution .
```

```
ex:pascal           ex:isMarriedTo  ex:instituteAIFB .
```

A logical consequence of this is

```
ex:instituteAIFB    rdf:type        ex:Person .
```

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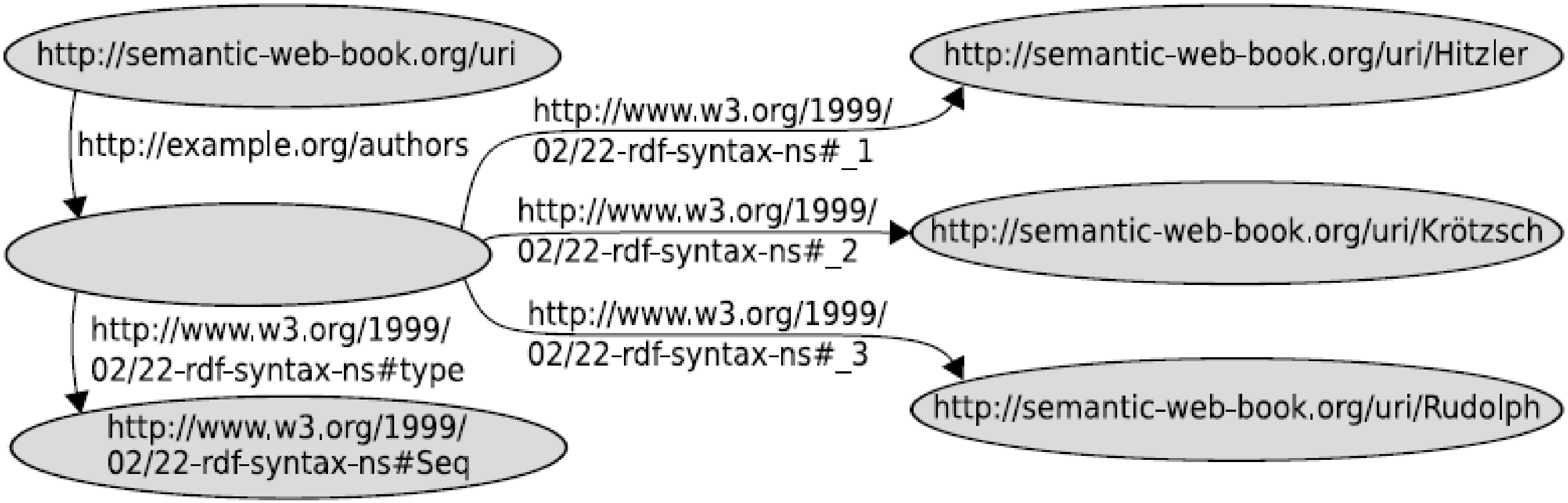
Open Lists revisited



- **New class: rdfs:Container as superclass of rdf:Seq, rdf:Bag, rdf:Alt.**
- **New class: rdfs:ContainerMembershipProperty containing the properties used with containers, e.g.**

```
rdf:_1  rdf:type  rdfs:ContainerMembershipProperty .
rdf:_2  rdf:type  rdfs:ContainerMembershipProperty .
```

Open Lists revisited

- **New property rdfs:member**
  Is superproperty of all properties contained in rdfs:ContainerMembershipProperty.

- **The RDFS semantics specifies:**

  From

  p rdf:type rdfs:ContainerMembershipProperty .

  and

  a p b .

  the following is inferred:

  a rdfs:member b .

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Talking about triples

- **How do you state in RDF:**
  "The detective supposes that the butler killed the gardener."

- **unsatisfactory:**

```
ex:detective   ex:supposes   "The butler killed the gardener." .
```

```
ex:detective   ex:supposes   ex:theButlerKilledTheGardener .
```

- **We would really like to talk about the triple**

```
ex:butler   ex:killed   ex:gardener   .
```

Talking about triples

- **How to do it properly in RDFS:**

```
ex:detective  ex:supposes     ex:theory .
ex:theory     rdf:subject     ex:butler .
ex:theory     rdf:predicate   ex:hasKilled .
ex:theory     rdf:object      ex:gardener .
```

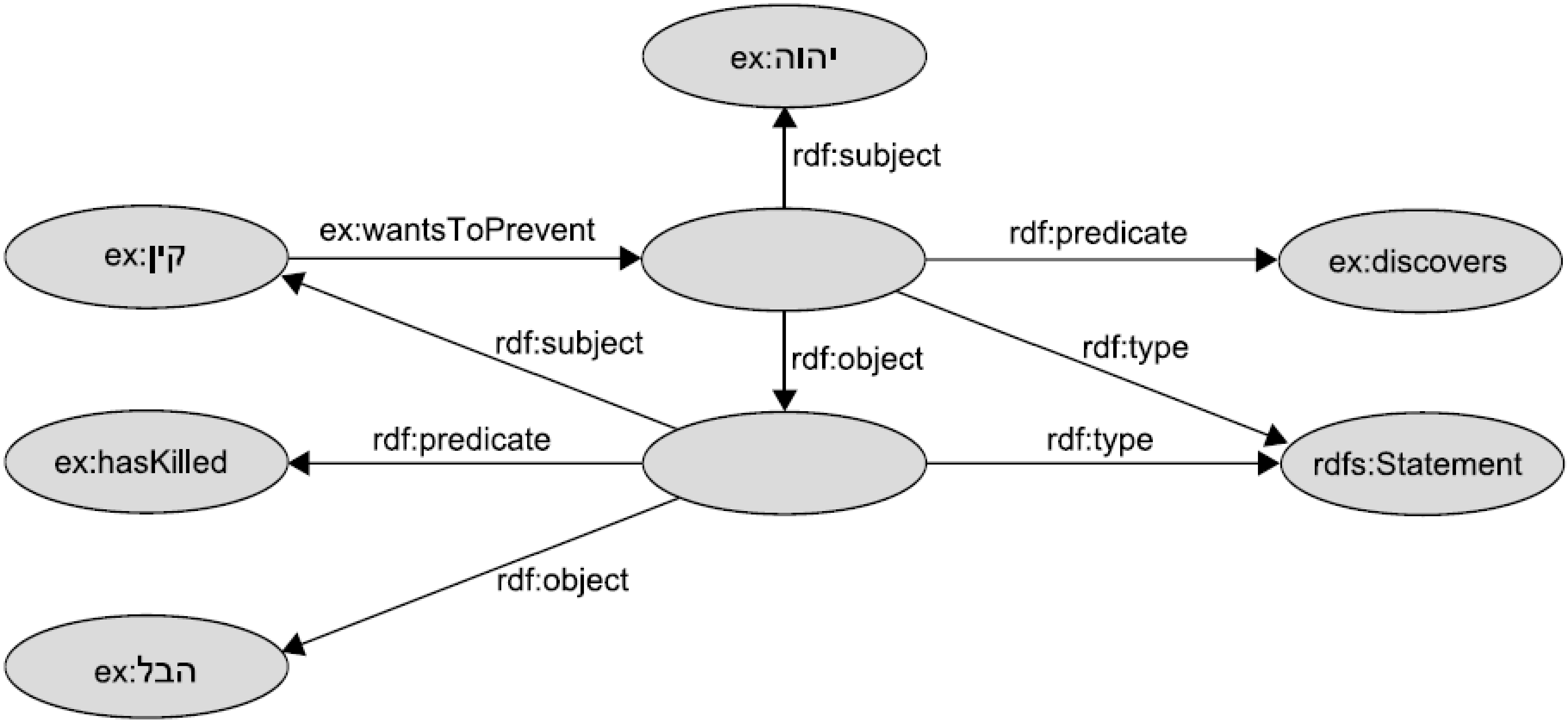
```
ex:theory     rdf:type        rdf:Statement .
```

- **Note however, that the following is not a logical consequence of this:**

```
ex:butler   ex:hasKilled   ex:gardener   .
```

- **One would usually use a blank node instead of ex:theory.**

A reification puzzle



You know that story? It's in the old testament :)

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Supplementary information

- comments etc. which are not part of the actual ontology, but are for the human reader/user/developer
- in RDF, we also use triples to encode these
- i.e. we have a set of pre-defined properties which do this job
- rdfs:label: e.g. to give a human-readable name for a URI
- rdfs:comment: used for lengthy commentary/explanatory text
- rdfs:seeAlso, rdfs:definedBy: properties pointing to URIs where further information or definitions can be found

Supplementary Information example

```
  :
  xmlns:wikipedia="http://en.wikipedia.org/wiki/"
  :
<rdfs:Class rdf:about="&ex;Primates">
  <rdfs:label xml:lang="en">primates</rdfs:label>
  <rdfs:comment>
    Order of mammals. Primates are characterized by an
    advanced brain. They mostly populate the tropical
    earth regions. The term 'Primates' was coined by
    Carl von Linné.
  </rdfs:comment>
  <rdfs:seeAlso rdf:resource="&wikipedia;Primates" />
  <rdfs:subClassOf rdfs:resource="&ex;Mammalia" />
</rdfs:Class>
```

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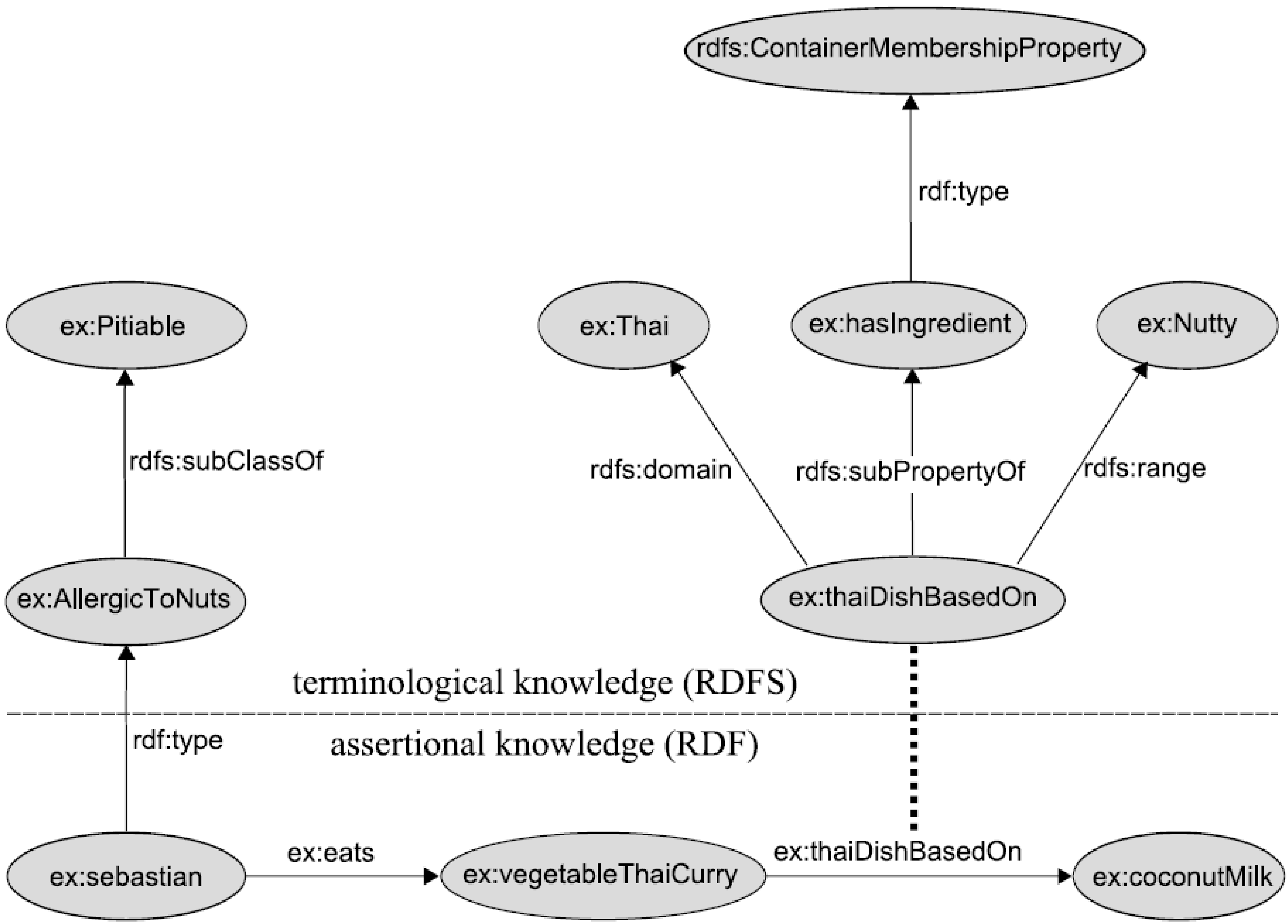
An example ontology

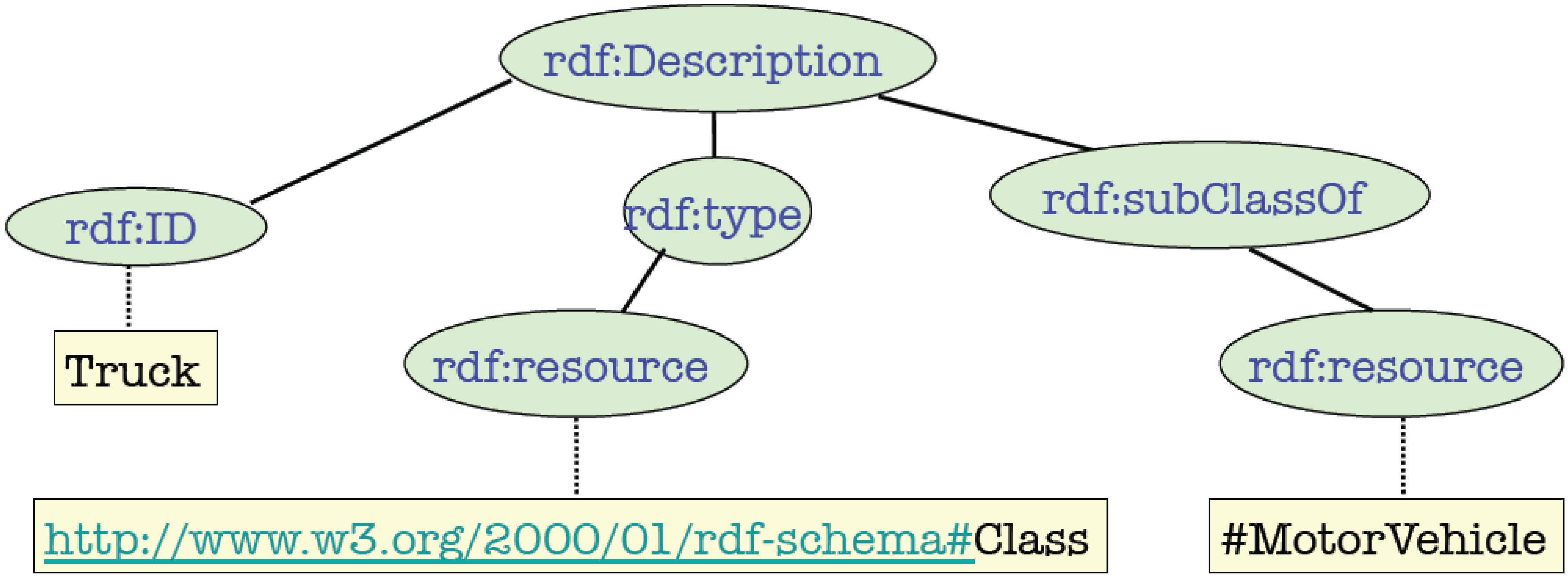
```
ex:vegetableThaiCurry  ex:thaiDishBasedOn     ex:coconutMilk .
ex:sebastian           rdf:type               ex:AllergicToNuts .
ex:sebastian           ex:eats                ex:vegetableThaiCurry .

ex:AllergicToNuts      rdfs:subClassOf        ex:Pitiable .
ex:thaiDishBasedOn     rdfs:domain            ex:Thai .
ex:thaiDishBasedOn     rdfs:range             ex:Nutty .
ex:thaiDishBasedOn     rdfs:subPropertyOf     ex:hasIngredient .
ex:hasIngredient       rdf:type    rdfs:ContainerMembershipProperty.
```

The same as graph



Note the multiple views: XML

```
<rdf:Description rdf:ID="Truck">
  <rdf:type rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
  <rdfs:subClassOf rdf:resource="#MotorVehicle"/>
</rdf:Description>
```



Note the multiple views: RDF

```
<rdf:Description rdf:ID="Truck">
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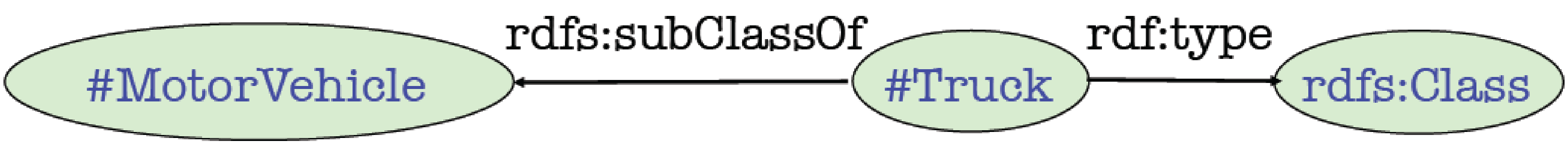

Note the multiple views: RDF Schema

```
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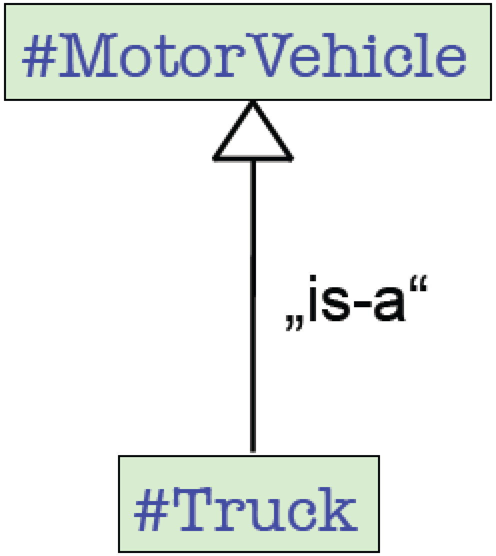

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Type separation

- When is something an instance? When is something a class?

Father	rdf:type	SocialRole .
Pascal	rdf:type	Father .

- What about triples like the following?

Parasite	hasHostOrganism	LivingThing .
LeapYear	isFollowedby	NonLeapYear .

- These all are valid RDF triples, and it's also valid RDFS.
- But what does it mean?

Type separation

- It’s usually good to clearly separate types (as long as it’s feasible) and only break this if really needed.
  Types: instances, properties, classes
- Reason: The semantics is clearer.

- <instance> rdf:type <class>
- <instance> someProperty <instance>
- <class> rdfs:subClassOf <class>
- <property> rdfs:subPropertyOf <property>

- In OWL 1 DL, type separation was strictly enforced.
- In OWL 2 DL, it’s more relaxed, but the semantics is different.

- We’ll talk more about this in the OWL sessions.

Class project: next step

- keep bugfixing
- extend, where necessary, your ontology so that it makes a correct use of each of the following (each at least once):
  - rdf:datatype
  - rdfs:subPropertyOf
- for each property in your ontology, add triples which give their rdfs:domain and rdfs:range.
- write up your ontology in RDF Turtle syntax and group axioms in such a way that it's easy to keep an overview of the contents.

- send to me by next Wednesday
  - the Turtle file as .txt file (validator: http://www.rdfabout.com/demo/validator/)
  - brief notes with lessons learned from this round of modeling (including the bugfixing)

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Class presentations – scheduled

- **RDFa – embedding RDF in HTML (W3C standard)**
  Pavan, Thursday 28th of January

- **Scalable Distributed Reasoning using MapReduce (Urbani, Kotoulas, Oren, van Harmelen, ISWC2009)**
  Wenbo, Thursday 28th of January

- **Semantic MediaWiki, Vinh, to be scheduled**
- **Linked Open Data, Ashutosh, to be scheduled**
- **FOAF, Hemant, to be scheduled**

Class presentations – open topics

Applications:

- **The SNOMED ontology (major biomedical ontology)**
- **Yahoo! Search Monkey (enhancing web search)**

Standards:

- **SKOS – data model for sharing and linking knowledge organization systems via the Web (W3C standard)**

Research papers:

- **Parallel Materialization of the Finite RDFS Closure for Hundreds of Millions of Triples (Weaver, Hendler, ISWC2009)**

Class presentations – open topics

Tools:

- **Protege – Ontology editing tool**
- **Jena – Java framework for Semantic Web by HP**
- **RDF triple stores (Virtuoso, Redland, Sesame, AllegroGraph)**

Class Planning

Tuesday 26th of January: RDF and RDFS Semantics

+ you get an exercise sheet

Thursday 28st of January: 2 class presentations

Tuesday 2nd of February: Exercise session

Estimated breakdown of sessions:

Intro + XML: 2

RDF: 3

OWL and Logic: 5

SPARQL and Querying: 2

Class Presentations: 3

Exercise sessions: 3