Knowledge Representation for the Semantic Web

Winter Quarter 2011

Slides 4 – 01/13/2010

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Textbook (required)

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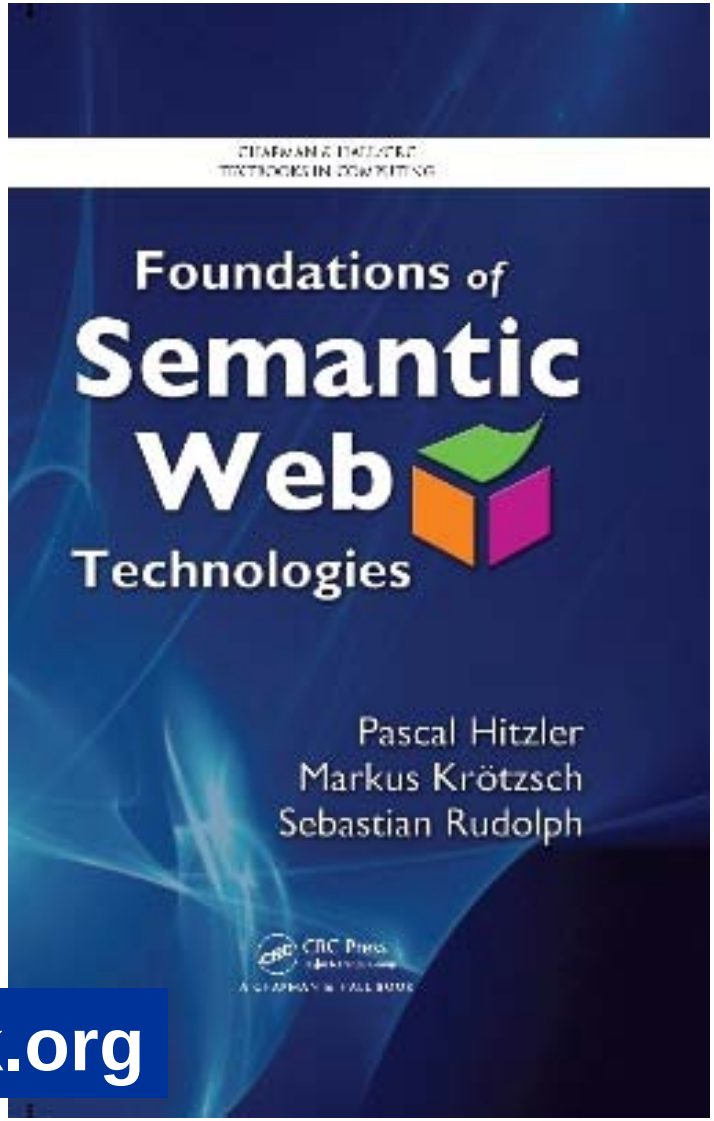
Foundations of Semantic Web Technologies

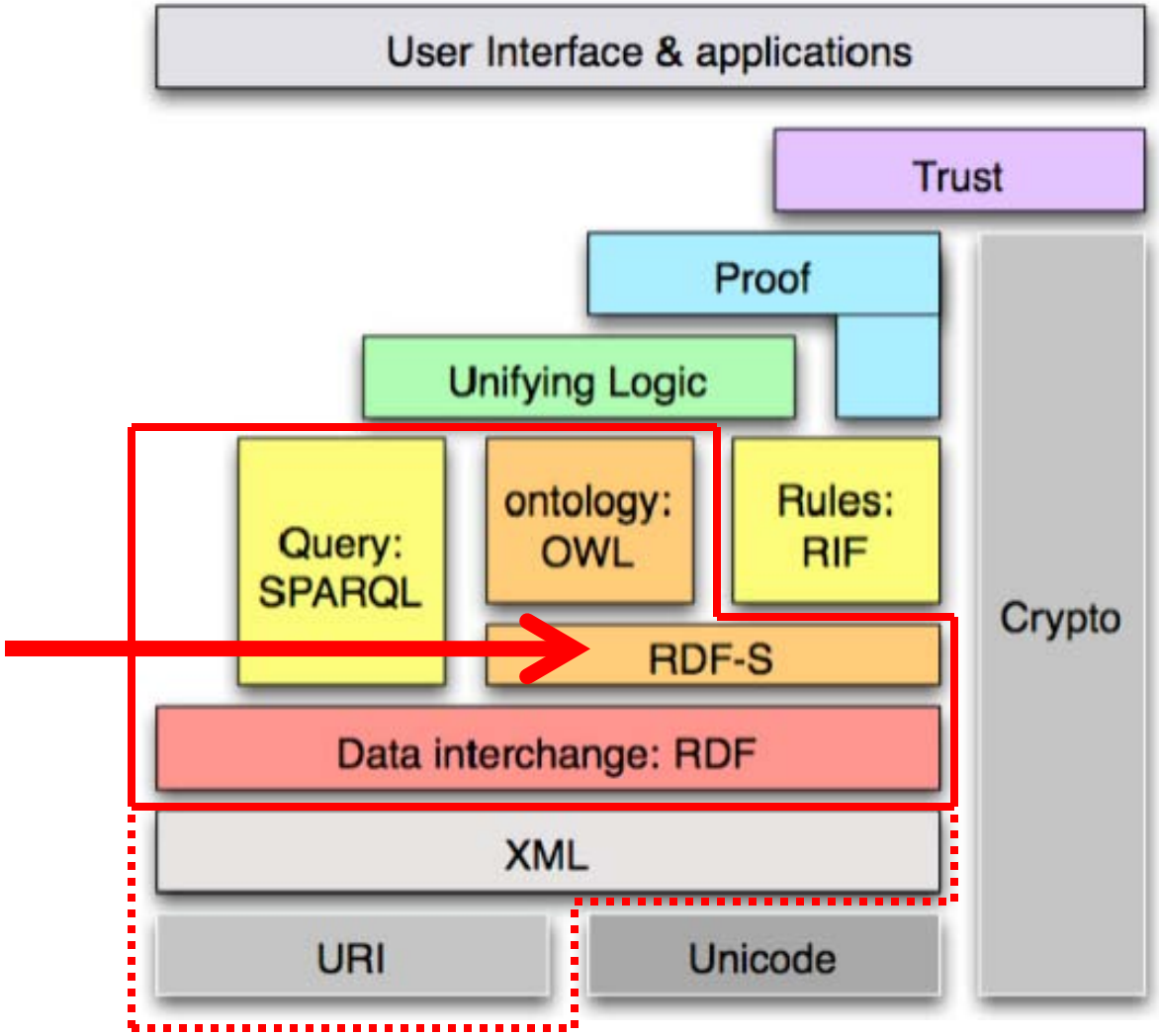
Chapman & Hall/CRC, 2010

Choice Magazine Outstanding Academic Title 2010 (one out of seven in Information & Computer Science)



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

Today: RDF syntax – RDF Schema



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 allows us to do some schema knowledge modeling. OWL (discussed later) gives even more expressivity.**

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**

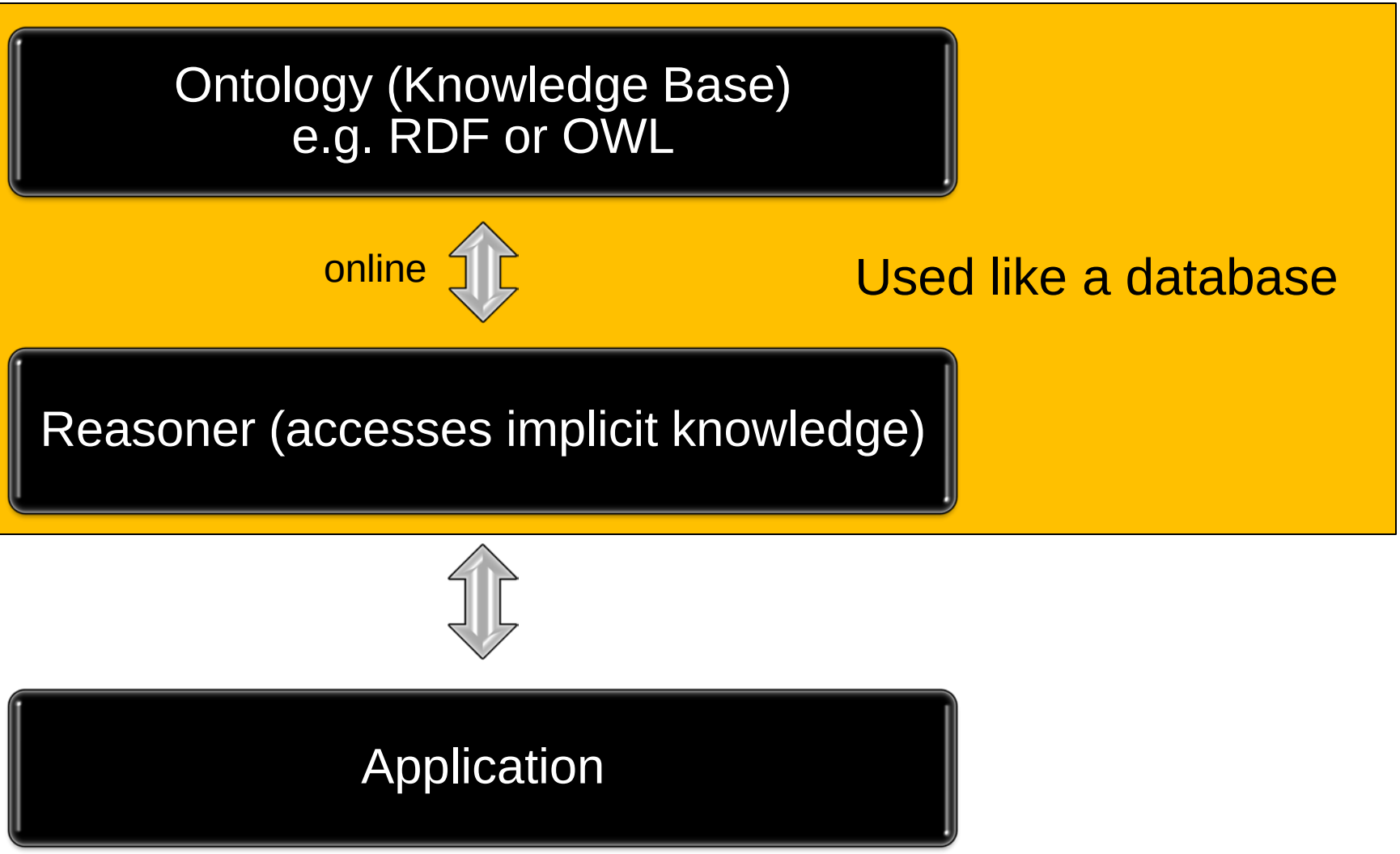
```
ex:Textbook    rdfs:subClassOf    ex:Book .
ex:Book        rdfs:subClassOf    ex:PrintMedia .
```

the following is a logical consequence:

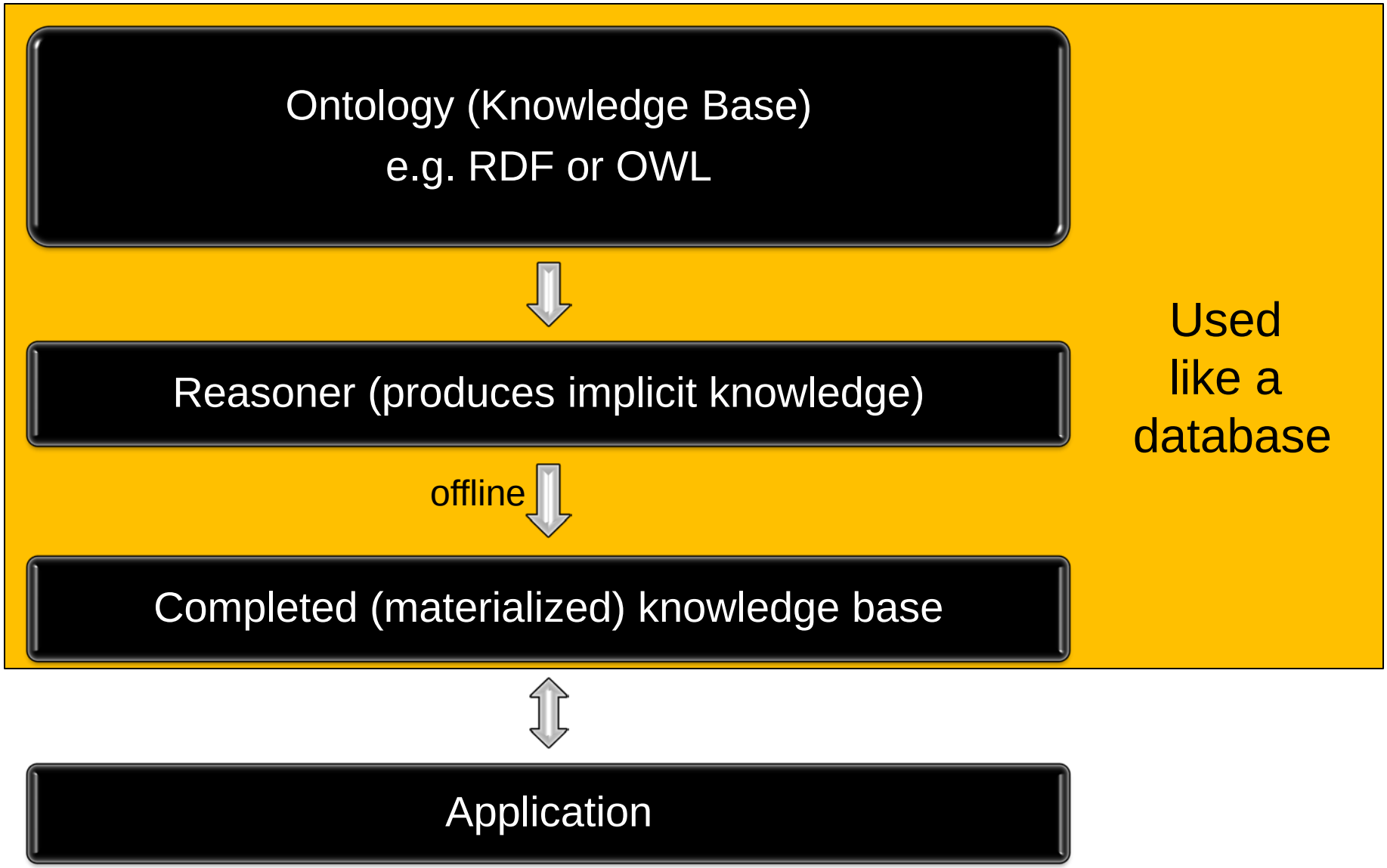
```
ex:Textbook    rdfs:subClassOf    ex:PrintMedia .
```

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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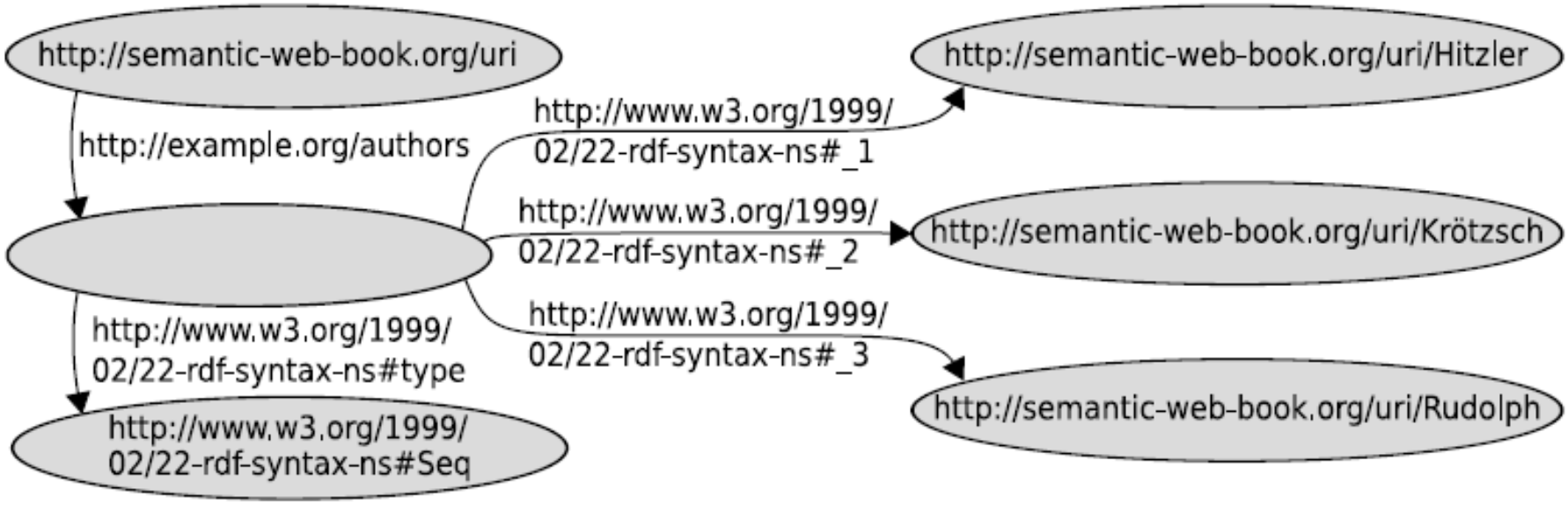
Open Lists revisited



- **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 .
```

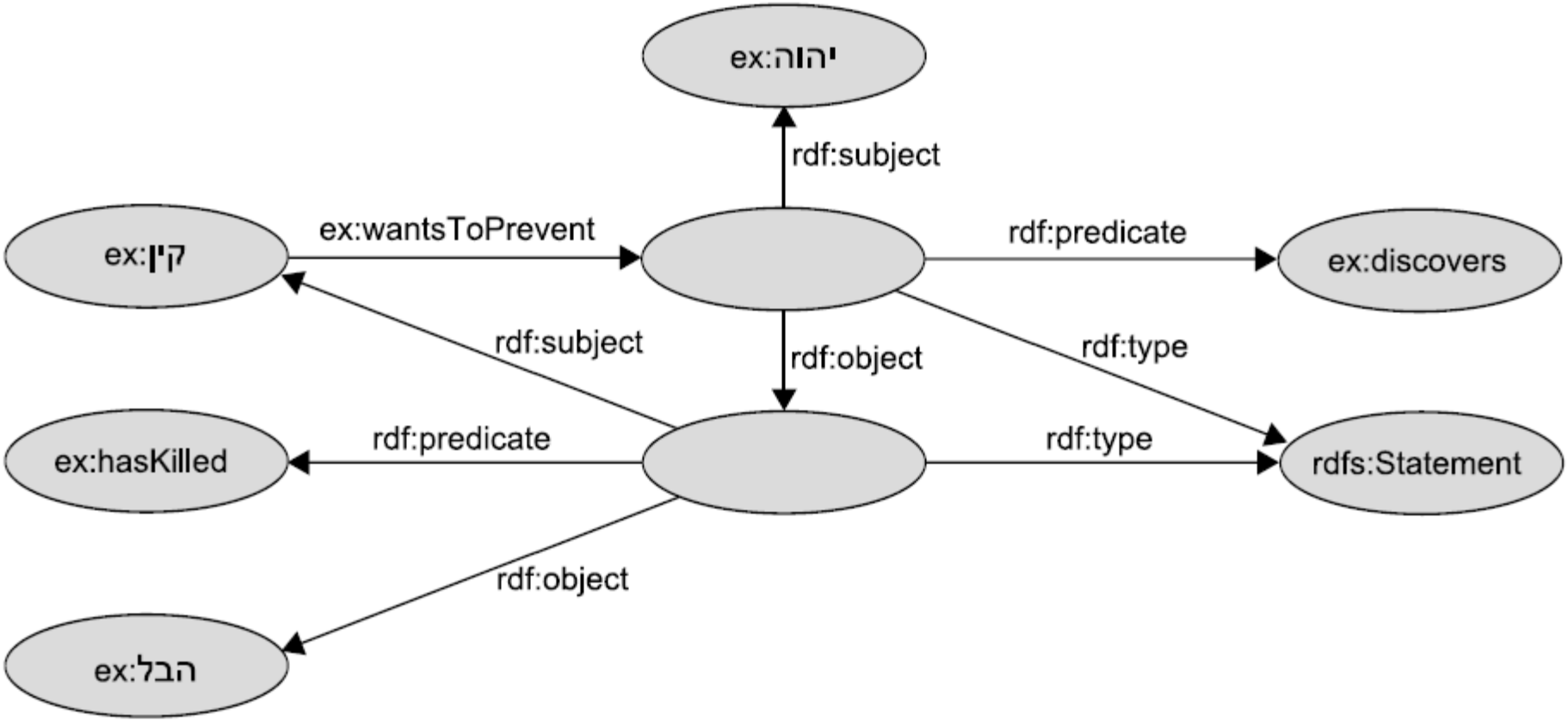
```
ex:theory   rdf:type   rdf:Statement .
```

- **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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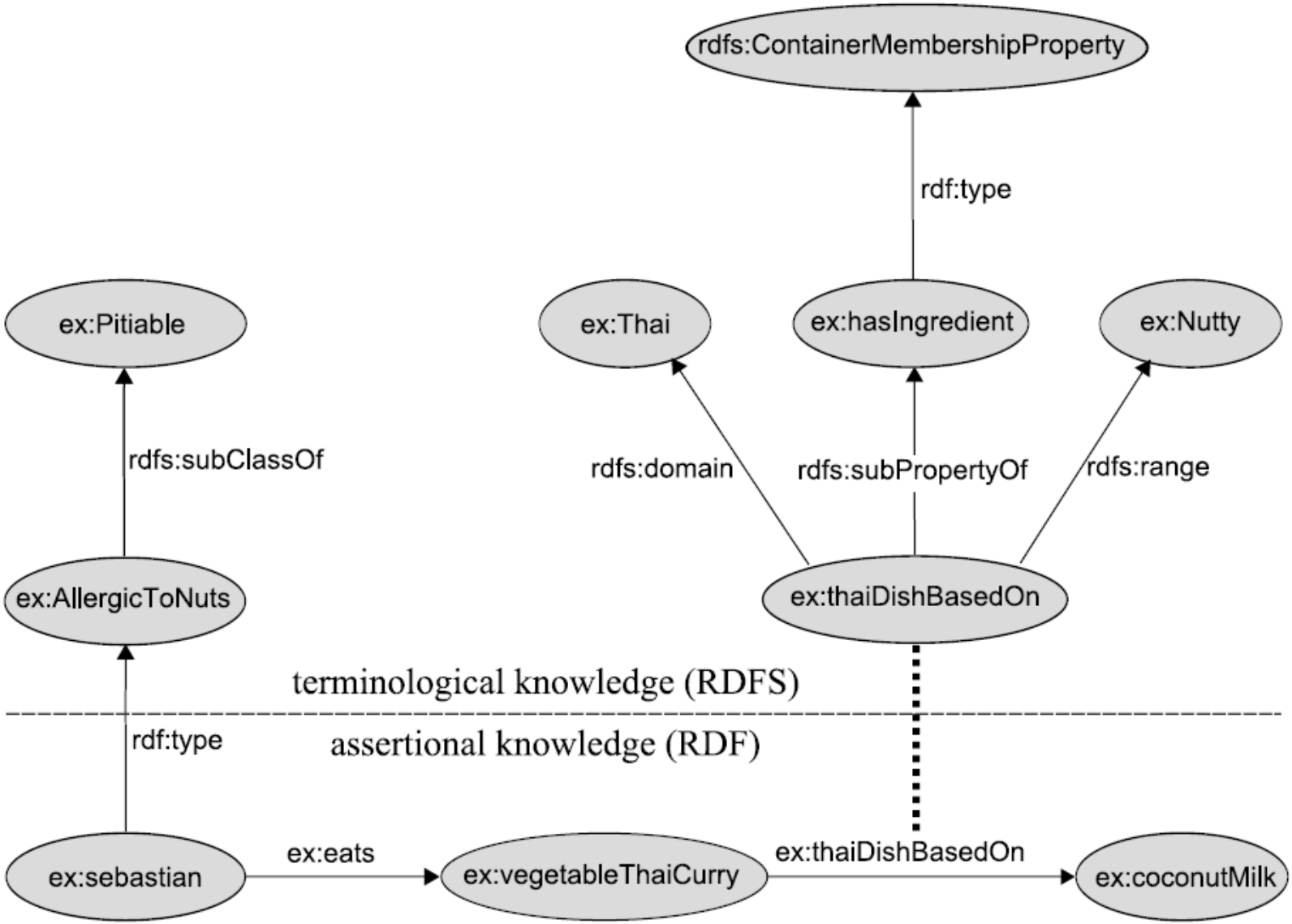
An example ontology

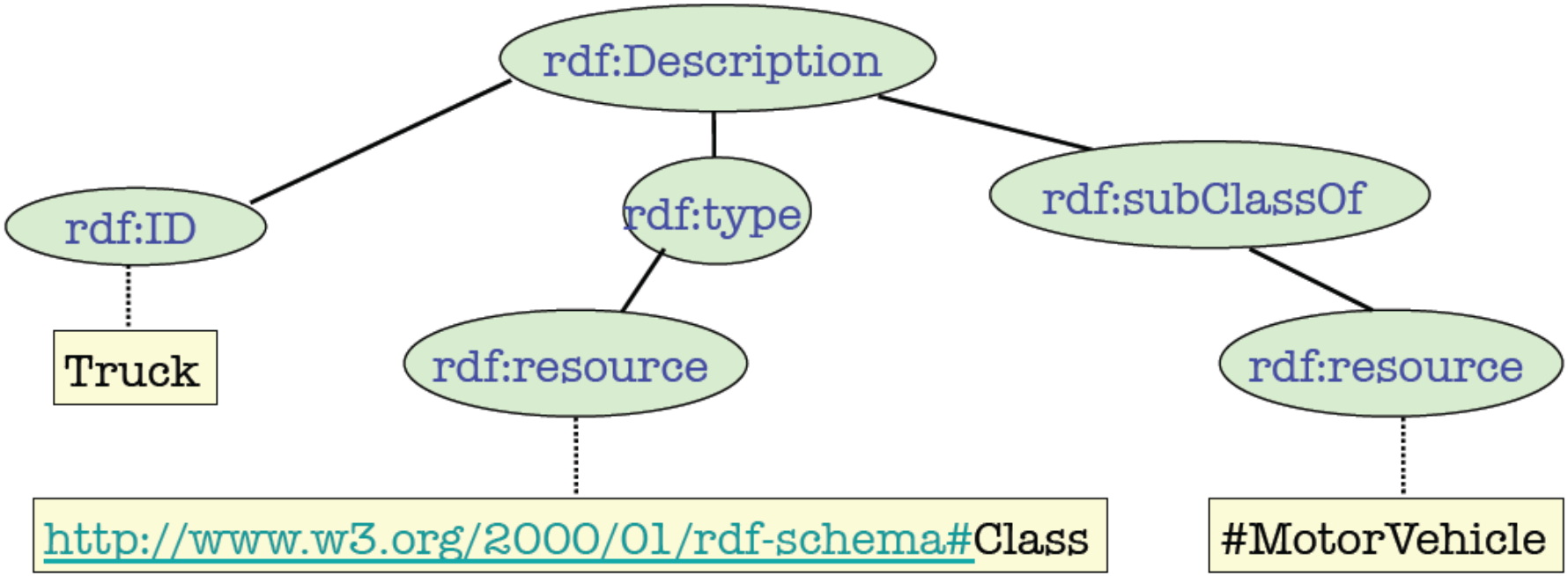
```
ex:vegetableThaiCurry   ex:thaiDishBasedOn    ex:coconutMilk .
ex:sebastian            rdf:type              ex:AllergicToNuts .
ex:sebastian            ex:eats               ex:vegetableThaiCurry .

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

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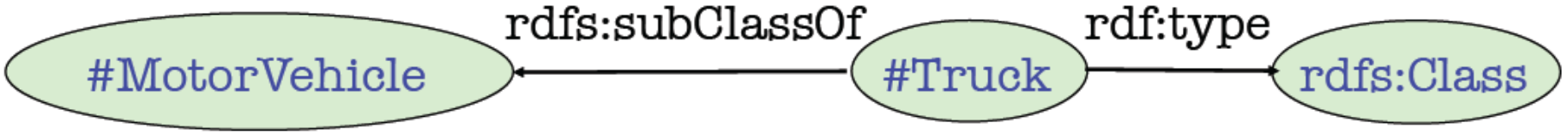

Note the multiple views: RDF Schema

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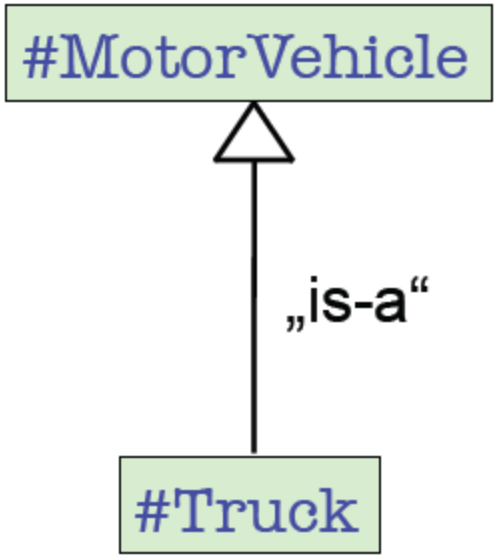

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Type separation

- 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 Tuesday
  - 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 – first topics

- **SPARQL 1.1 entailment regimes: http://www.w3.org/TR/2010/WD-sparql11-entailment-20100126/ http://www.w3.org/2009/sparql/docs/entailment/xmlspec.xml**
- **Aidan Hogan, Andreas Harth, Axel Polleres: SAOR: Authoritative Reasoning for the Web. ASWC 2008: 76-90**
- **Jacopo Urbani, Spyros Kotoulas, Jason Maassen, Frank van Harmelen, Henri E. Bal: OWL Reasoning with WebPIE: Calculating the Closure of 100 Billion Triples. ESWC (1) 2010: 213-227**
- **Yuan Ren, Jeff Z. Pan, Yuting Zhao: Soundness Preserving Approximation for TBox Reasoning. AAAI 2010**
- **Franz Baader, Sebastian Brandt, Carsten Lutz: Pushing the EL Envelope. IJCAI 2005: 364-369**

Class Planning

Thursday 13th of January: RDFS Part I
Tuesday 18th of January: Exercise Session
Thursday 20th of January: RDF and RDFS Semantics

Estimated breakdown of sessions:

Intro + XML: 2

RDF: 3

OWL and Logic: 6

SPARQL and Querying: 2

Class Presentations: 3

Exercise sessions: 3