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Intelligent Systems on the World Wide Web

OIL

Lecture Slides
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(acknowledgements to Jeen Broekstra)

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Context

On-To-Knowledge

IST project about content-driven knowledge management through evolving ontologies

http://www.ontoknowledge.org/

OIL = Ontology Inference Layer

http://www.ontoknowledge.org/oil

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Is XML sufficient for semantic annotation?

- XML: user definable and domain specific markup
- XML document is a labeled tree
- constraints on structure via DTD or XML Schema

```
<animal>
       <name>Tux</name>
       <species>penguin</species>
       <eats>fish</eats>
       ...
</animal>
```


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Shortcomings of XML
(for our purposes)

XML makes no commitment on:

❶ Domain specific ontological vocabulary

❷ Ontological modeling primitives

⇨ requires pre-arranged agreement on ❶ & ❷

Only feasible for closed collaboration

- agents in a small & stable community
- pages on a small & stable intranet

not for sharable Web-resources

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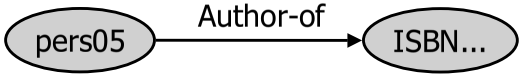
Is RDF(S) sufficient for semantic annotation?

- RDF provides metadata about Web resources
- Object -> Attribute-> Value triples



- RDF Schema
  - Defines vocabulary for RDF
  - Organizes this vocabulary in a typed hierarchy
    - `Class, subClassOf, type`
    - `Property, subPropertyOf`
    - `domain, range`

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Conclusions about RDF(S)

- Next step up from plain XML:
  - (small) ontological commitment to modeling primitives
  - possible to define vocabulary
- However:
  - no precisely described meaning
  - no inference model

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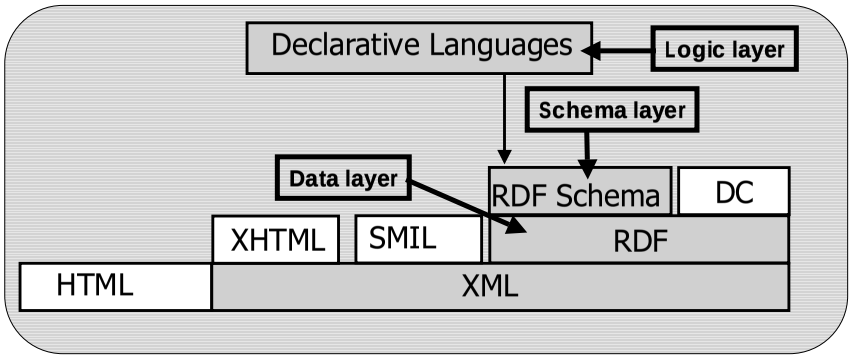
Semantic annotation: how

W3C's vision: The Semantic Web



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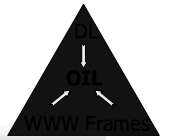
OIL

- Based on standard frame languages (OKBC)
  - restricts & extends
- formalized by DL style logical constructs
- Still has frame "look and feel"
- Can still function as a basic frame language
- OIL language restricted:
  - to allow for reasoning support



OIL (explained by example)

```
class-def animal                          % animals are a class
class-def plant                           % plants are a class
   subclass-of not animal                 % that is disjoint from animals
class-def tree
   subclass-of plant                      % trees are a type of plants
class-def branch
   slot-constraint is-part-of             % branches are parts of some tree
        has-value tree
        max-cardinality 1
class-def defined carnivore               % carnivores are animals
   subclass-of animal
   slot-constraint eats                   % that eat any other animals
        value-type animal
class-def defined herbivore               % herbivores are animals
   subclass-of animal, not carnivore      % that are not carnivores, and
   slot-constraint eats                   % they eat plants or parts of plants
        value-type plant or (slot-constraint is-part-of has-value plant)
```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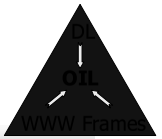
OIL has a formal semantics

- Defined by mapping to expressive DL
  - slot-constraint eats has-value meat, fish
    =
    $\exists$ eats:meat $\cap$ $\exists$ eats:fish
- Mapping is used to provide reasoning support from a DL system (e.g., FaCT)



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Extending RDF Schema

Goal

- make RDFS useable as ontology language
  - give RDF(S) precise semantics
  - extend RDF(S) with additional modeling primitives
- to facilitate semantically grounded metadata

Procedure

- formulate ontology language as RDF Schema document
  - using existing primitives as much as possible
  - placing additional primitives in the hierarchy of RDFS primitives

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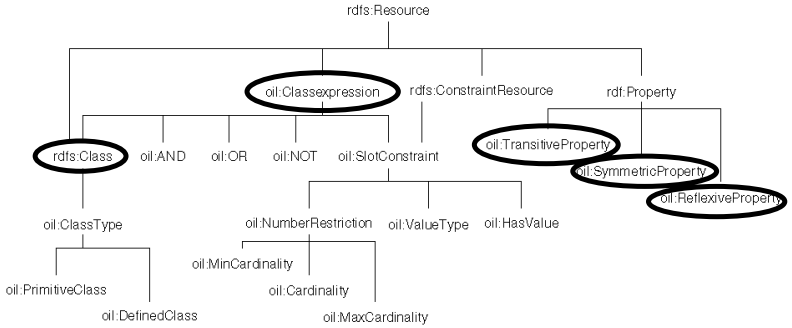
OIL as extension to RDFS (1)

- part of the is-a hierarchy of RDFS extension
- ontology language is defined in RDFS



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OIL as extension to RDFS (3)

```
<rdfs:Class rdf:ID="herbivore">
  <rdf:type
      rdf:resource="http://www.ontoknowledge.org/#DefinedClass"/>
  <rdfs:subClassOf rdf:resource="#animal"/>
  <rdfs:subClassOf>



  </rdfs:subClassOf>
</rdfs:Class>
```


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Using the extension: three levels

❶ OIL modeling primitives
slot-constraint, subclass-of, value-type,...
– RDF-S document which extends RDF-S

❷ a specific OIL ontology
animal, plant, herbivore, leaf
– RDF-S document (using ❶)

❸ instances of this ontology
"Mel the giraffe", "Tux the penguin"
– RDF expressions (uses ❶&❷)
– explicit metadata

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What did we gain?

- Any RDF agent can
  process OIL instances
- Any RDF-S agent can
  process OIL ontologies
- Any OIL-aware agent can
  exploit semantics & reasoning
  (and materialize the OIL derivations
  for use by OIL-ignorant RDF agents)

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Some more examples...

OIL: Erweitert Frame-Sprachen

- Klassen können primitiv sein (notwendige Bedingungen)
  - elephant ⟹ animal that has-colour grey
- oder definiert (notwendige und hinreichende Bedingungen)
  - vegetarian ⟺ person who eats meat nor fish
- Klassen sind als Slot-Constraints zugelassen
  - slot-constraint eats has-value meat (eats some meat)
  - slot-constraint eats value-type meat (eats only meat)

OIL: Erweitert Frame-Sprachen

- Verwendung arbiträrer Klassennamen
  - slot-constraint eats value-type NOT (OR meat fish)
- Kardinalitätsrestriktion kann Klassennamen enthalten
  - slot-constraint eats max-cardinality 1 plant
- Die sub-slot-Relation wird unterstützt
  - daughter-of sub-slot of child-of
- Slot-Eigenschaften können spezifiziert werden
  - transitive (e.g., part-of)
  - symmetrical (e.g., connected-to)

OIL: Einfaches Beispiel

```
class-def animal                    % animals are a class
class-def plant                     % plants are a class
   subclass-of NOT animal           % that is disjoint from animals
class-def tree
   subclass-of plant                % trees are a type of plants
class-def branch
   slot-constraint is-part-of       % branches are parts of some tree
      has-value tree
      max-cardinality 1
class-def defined carnivore         % carnivores are animals
   subclass-of animal
   slot-constraint eats             % that eat any other animals
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   subclass-of animal, NOT carnivore % that are not carnivores, and
   slot-constraint eats             % they eat plants or parts of plants
      value-type plant OR (slot-constraint is-part-of has-value plant)
```


OIL als RDFS-Erweiterung

```
<rdfs:Class rdf:ID="herbivore">
  <rdf:type
      rdf:resource="http://www.ontoknowledge.org/#DefinedClass"/>
  <rdfs:subClassOf rdf:resource="#animal"/>
  <rdfs:subClassOf>
     <oil:NOT>
        <oil:hasOperand rdf:resource="#carnivore"/>
     </oil:NOT>
  </rdfs:subClassOf>
</rdfs:Class>
```

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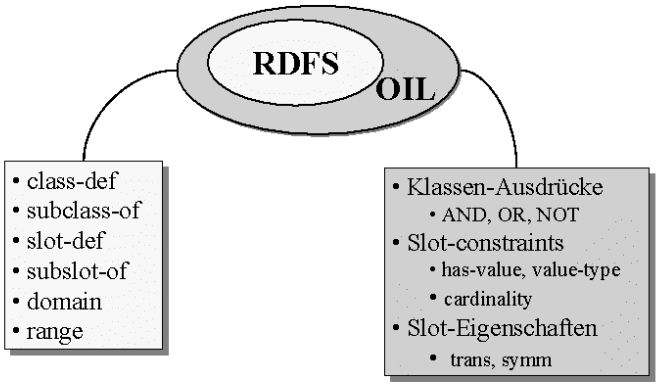
OIL als RDFS-Erweiterung



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OIL in XML:

Für OIL gibt es ein DTD, ein XML-Schema und eine Abbildung auf RDFS.

```
<slot-def>
  <slot-name = "has-component"/>
  <inverse> <slot-name = "is-component-of"/> </inverse>
  <properties> <transitive/> </properties>
</slot-def>
<class-def> <class-name= "nucleic-acid"/> </class-def>
<class-def>
  <class-name= "rna"/>
  <subclass-of> <class name = "nucleic-acid"/> </subclass-of>
  <slot-constraint>
    <slot-name = "has-backbone"/>
    <value-type> <class name= "ribophosphate" </value-type>
  </slot-constraint>
</class-def>
```


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OIL: Ontologie-Metadaten (gemäß Dublin Core)

Ontology-container
title "macromolecule fragment"
creator "robert stevens"
subject "macromolecule generic ontology"
description "example for a tutorial"
description.release "1.0"
publisher "R Stevens"
type "ontology"
formal "pseudo-xml"
identifier "http://www.ontoknowledge.org/oil/oil.pdf"
source "http://img.cs.man.ac.uk/ismb00/mmexample.pdf"
language "OIL"
language "en-uk"
relation.haspart "http://www.ontoRus.com/bio/mmole.onto"

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OIL: Primitive Bio-Ontologie-Definition

slot-def has-backbone
  inverse is-backbone-of
slot-def part-of
  inverse is -part-of
  properties transitive

class-def rna
  subclass-of nucleic-acid
  slot-constraint has-backbone
    value-type ribophosphate

class-def ribophosphate
class-def deoxyribophosphate
  subclass-of NOT ribophosphate

OIL: Definierte Klassen der Bio-Ontologie

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class-def defined dna
  subclass-of nucleic-acid
  slot-constraint has-backbone
    value-type deoxyribophosphate
class-def dna
  subclass-of NOT rna

class-def defined catalyst
  subclass-of macromolecule
  slot-constraint promotes
    has-value reaction

class-def defined enzyme
  subclass-of protein, catalyst

OIL: Definierte Klassen der Bio-Ontologie

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class-def defined mitochondrial
  subclass of location
  slot-constraint cellularlocation
    cardinality 1 **((has-value** mitochondrion**)** OR
    (slot-constraint part-of **has-value** mitochondrion**))**

class-def defined succinate-dehydrogenase
  subclass of enzyme
  slot-constraint promotes
    value-type oxidation
  slot-constraint cellularlocation
    cardinality 1 **(has-value (slot-constraint** part-of **has-value**
      mitochondrion**)**

OIL: Beispiel einer Ontologie für Drucker (Teil 1)

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class-def Product
slot-def Price
  domain Product
slot-def ManufacturedBy
  domain Product
class-def PrintingAndDigitalImagingProduct
  subclass-of Product
class-def HPProduct
  subclass-of Product
  slot-constraint ManufacturedBy
    has-value "Hewlett Packard"
class-def Printer
  subclass-of PrintingAndDigitalImagingProduct
slot-def PrinterTechnology
  domain Printer
slot-def Printing Speed
  domain Printer
slot-def PrintingResolution
  domain Printer
class-def PrinterForPersonalUse
  subclass-of Printer
class-def HPPrinter
  subclass-of HPProduct and Printer

OIL: Beispiel einer Ontologie für Drucker (Teil 2)

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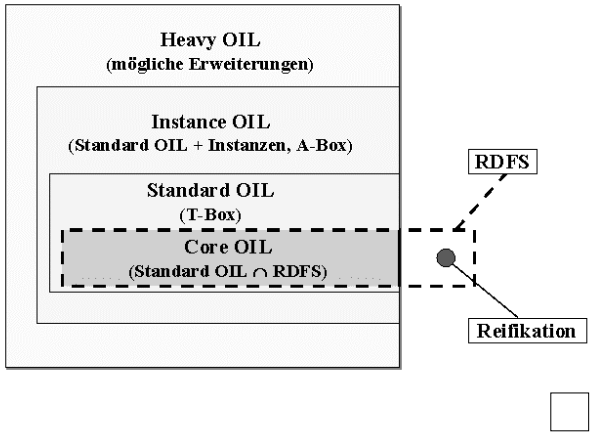
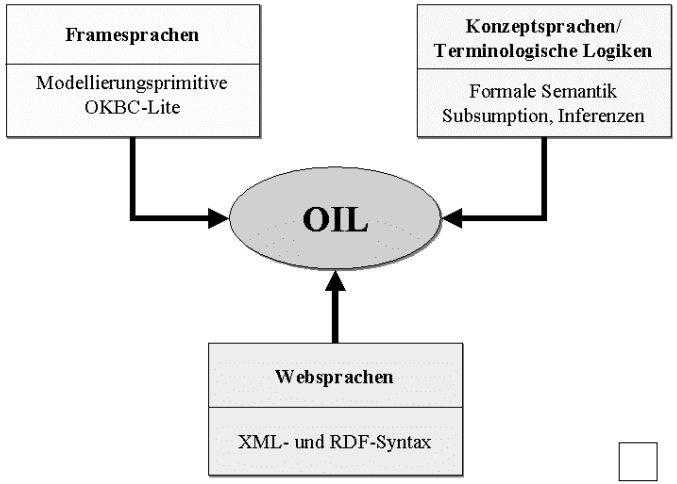
class-def LaserJetPrinter
  subclass-of Printer
  slot-constraint PrintingTechnology
    has-value "Laser Jet"
class-def HPLaserJetPrinter
  subclass-of LaserJetPrinter and HPProduct
class-def HPLaserJet1100Series
  subclass-of HPLaserJetPrinter and PrinterForPersonalUse
  slot-constraint PrintingSpeed
    has-value "8 ppm"
  slot-constraint PrintingResolution
    has-value "600 dpi"
class-def HPLaserJet1100se
  subclass-of HPLaserJet1100Series
  slot-constraint Price
    has-value "$479"
class-def HPLaserJet1100xi
  subclass-of HPLaserJet1100Series
  slot-constraint Price
    has-value "$399"

OIL: Ontology Inference Layer / Ontology Interchange Language



OIL führt drei Sprachfamilien zusammen



Future

- FOWL
- DAML-L(ogic)
  - Including Rules
- DAML-S(ervice)
  - Primitives for intelligent services

    ⇒ **http://www.aifb.uni-karlsruhe.de/Lehrangebot/Winter2002-03/ebiz+iw/**

Summary

- to enable intelligent information handling, machine-understandable semantics are needed
- advantages of our approach
  - reuse of modeling primitives
  - conform W3C view of the world
  - added benefits (from OIL):
    - **reasoning support**
    - **formal semantics**
- Full schema available
  - http://www.ontoknowledge.org/oil/rdf-schema