INF3580 – Semantic Technologies – Spring 2010

Lecture 8: OWL, the Web Ontology Language

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Today's Plan

1. Reminder: RDFS
2. Description Logics
3. Introduction to OWL

Outline

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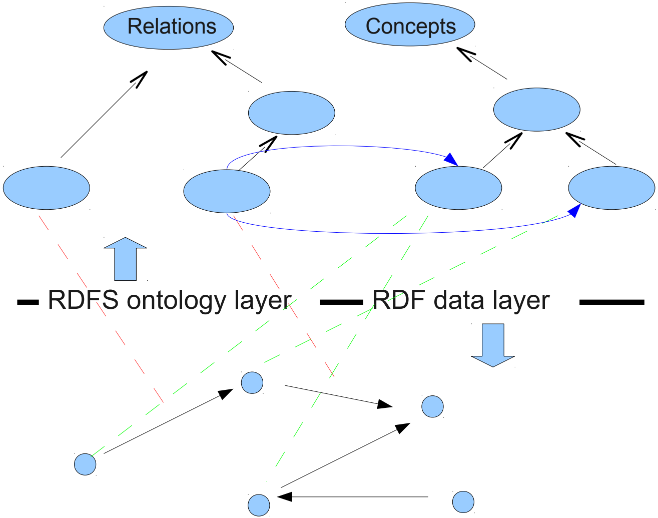
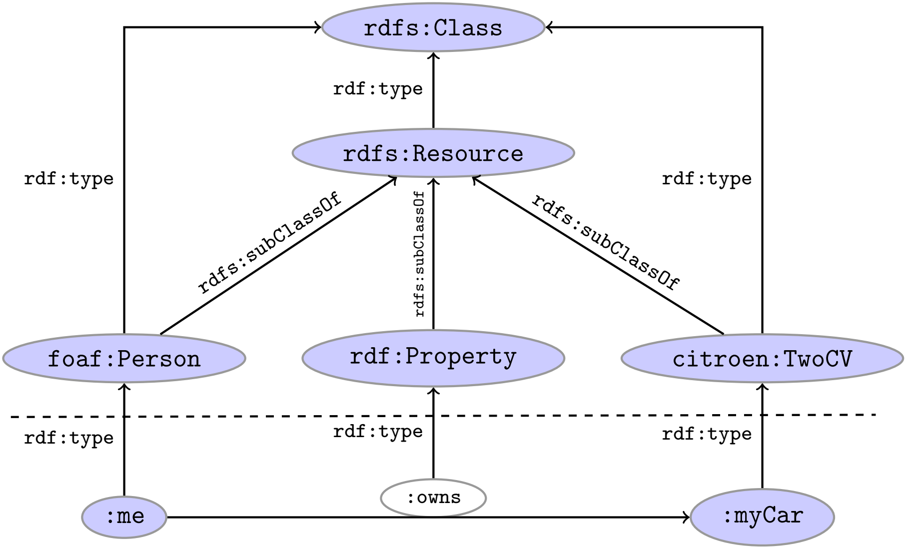
- There are rules to reason about classes

An RDFS knowledge base



Example


rdfs:Class
rdf:type
rdfs:Resource
rdf:type
rdf:type
rdfs:subClassOf
rdfs:subClassOf
rdfs:subClassOf
foaf:Person
rdf:Property
citroen:TwoCV
rdf:type
rdf:type
rdf:type
:owns
:me
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  - rdfs:Class not quite the same as a set

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- A setting well-studied as *Description Logics*

Example: The $\mathcal{ALC}$ Description Logic

Vocabulary

Fix a set of *atomic concepts* A and of *roles* R

$\mathcal{ALC}$ concept descriptions

$$
\begin{array}{rlcl}
C, D \rightarrow & A & | & \text{(atomic concept)} \\
 & \top & | & \text{(universal concept)} \\
 & \bot & | & \text{(bottom concept)} \\
 & \neg C & | & \text{(atomic negation)} \\
 & C \sqcap D & | & \text{(intersection)} \\
 & C \sqcup D & | & \text{(union)} \\
 & \forall R.C & | & \text{(value restriction)} \\
 & \exists R.C & | & \text{(existential restriction)}
\end{array}
$$

Axioms

$C \sqsubseteq D$ and $C \equiv D$ for concept descriptions D and C.

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  - A 4WD has at least one front drive axle and one rear drive axle

$\mathcal{ALC}$ Semantics

Interpretation

An interpretation $\mathcal{I}$ fixes a set $\Delta^{\mathcal{I}}$, the *domain*, $A^{\mathcal{I}} \subseteq \Delta$ for each atomic concept A, and $R^{\mathcal{I}} \subseteq \Delta \times \Delta$ for each role R

Interpretation of concept descriptions

$$
\begin{array}{rcl}
\top^{\mathcal{I}} & = & \Delta^{\mathcal{I}} \\
\bot^{\mathcal{I}} & = & \emptyset \\
(\neg C)^{\mathcal{I}} & = & \Delta^{\mathcal{I}} \setminus C^{\mathcal{I}} \\
(C \sqcap D)^{\mathcal{I}} & = & C^{\mathcal{I}} \cap D^{\mathcal{I}} \\
(C \sqcup D)^{\mathcal{I}} & = & C^{\mathcal{I}} \cup D^{\mathcal{I}} \\
(\forall R.C)^{\mathcal{I}} & = & \{a \in \Delta^{\mathcal{I}} \mid \forall b.(a, b) \in R^{\mathcal{I}} \rightarrow b \in C^{\mathcal{I}}\} \\
(\exists R.C)^{\mathcal{I}} & = & \{a \in \Delta^{\mathcal{I}} \mid \exists b.(a, b) \in R^{\mathcal{I}} \wedge b \in C^{\mathcal{I}}\}
\end{array}
$$

Interpretation of Axioms

$C \sqsubseteq D$ holds in $\mathcal{I}$ ($\mathcal{I} \models C \sqsubseteq D$) if $C^{\mathcal{I}} \subseteq D^{\mathcal{I}}$. $\mathcal{I} \models C \equiv D$ if $C^{\mathcal{I}} = D^{\mathcal{I}}$

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- Since all 2CV are cars, $TwoCV^{\mathcal{I}} \subseteq Car^{\mathcal{I}}$

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- Since potatoes are not fruit, $TwoCV^{\mathcal{J}} \not\subseteq Car^{\mathcal{J}}$

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is

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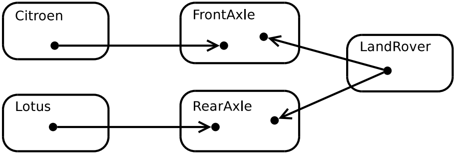
Universal and Existential Restrictions cont.

- Assume:
  - All *Citroen* cars have one drive axle and that is the front axle
  - All *Lotus* cars have one drive axle and that is the rear axle
  - All *LandRover* cars have two drive axles, one front and one back



- In such a model:
  - $Citroen \sqsubseteq \forall driveAxle.FrontAxle$
  - $LandRover \sqsubseteq \exists driveAxle.FrontAxle \sqcap \exists driveAxle.RearAxle$
  - $Lotus \sqsubseteq \forall driveAxle.RearAxle$

Universal Restrictions and `rdfs:range`

- If the *range* of a role R is C...

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  - and role assertions $R(b, c)$

Example TBox and ABox

TBox

$TwoCV \sqsubseteq Car$

$Car \sqsubseteq \exists driveAxle.\top$

$TwoCV \sqsubseteq \forall driveAxle.FrontAxle$

$FrontDrivenCar \equiv Car \sqcap \forall driveAxle.FrontAxle$

$FrontAxle \sqcap RearAxle \sqsubseteq \bot$

$FourWheelDrive \equiv \exists driveAxle.FrontAxle \sqcap \exists driveAxle.RearAxle$

ABox

$TwoCV(myCar)$

$owns(me, myCar)$

$driveAxle(myCar, ax)$

$(FrontAxle \sqcup RearAxle)(ax)$

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Outline

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2 Description Logics

3 Introduction to OWL

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OWL Syntaxes

- Reminder: RDF is an abstract construction, several concrete syntaxes: RDF/XML, Turtle,. . .
- Same for OWL:
- Defined as set of things that can be said about classes, properties, instances
- DL symbols ($\sqcap, \sqcup, \exists, \forall$) hard to find on keyboard
- OWL/RDF: Uses RDF to express OWL ontologies
  - Then use any of the RDF serializations
- OWL/XML: a non-RDF XML format
- Functional OWL syntax: simple, used in definition
- Manchester OWL syntax: close to DL, but text, used in some tools

Example: Universal Restrictions in OWL/RDF

- $TwoCV \sqsubseteq \forall driveAxle.FrontAxle$

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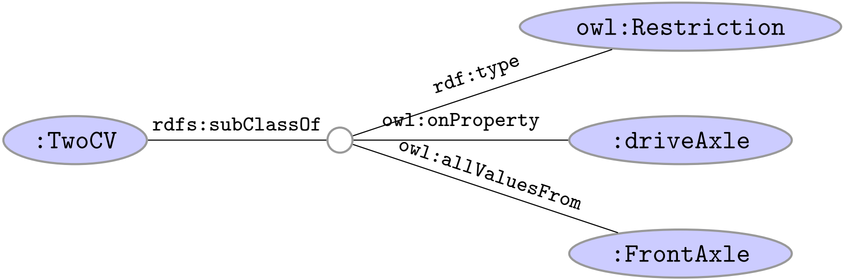

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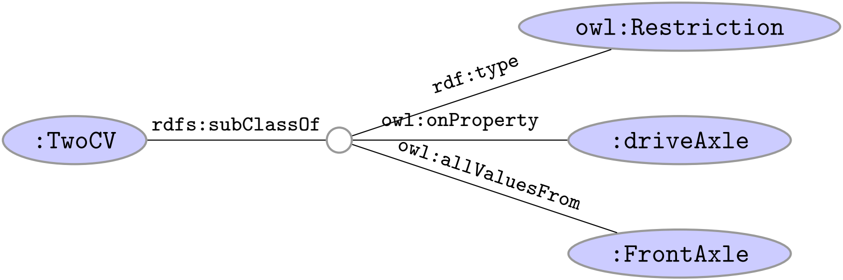

- In Turtle syntax:

```
:TwoCV rdfs:subClassOf [ rdf:type owl:Restriction ;
                         owl:onProperty :driveAxle ;
                         owl:allValuesFrom :FrontAxle
                       ] .
```

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- In OWL Functional syntax:

```
SubClassOf(CV ObjectAllValuesFrom(driveAxle FrontAxle))
```

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- Examples:

DL	Manchester
$FrontAxle \sqcup RearAxle$	FrontAxle or RearAxle
$\forall driveAxle.FrontAxle$	driveAxle only FrontAxle
$\exists driveAxle.RearAxle$	driveAxle some RearAxle

Demo: Using Protégé

- Create a Car class
- Create an Axle class
- Create FrontAxle and RearAxle as subclasses
- Make the axle classes disjoint
- Add a driveAxle object property
- Add domain Car and range Axle
- Add 2CV, subclass of Car
- Add superclass driveAxle only FrontAxle
- Add Lotus, subclass of Car
- Add superclass driveAxle only RearAxle
- Add LandRover, subclass of Car
- Add superclass driveAxle some FrontAxle
- Add superclass driveAxle some RearAxle
- Add 4WD as subclass of Thing
- Make equivalent to driveAxle some RearAxle and driveAxle some FrontAxle
- Classify.
- Show inferred class hierarchy: Car $\sqsupseteq$ 4WD $\sqsupseteq$ LandRover
- Tell story of 2CV Sahara, which is a 2CV with two motors, one front, one back
- Add Sahara as subclass of 2CV
- Add 4WD as superclass of 2CV
- Classify.
- Show that Sahara is equivalent to bottom.
- Explain why. In particular, disjointness of front and rear axles

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- Reasoning (e.g. Classification) maps everything to DL first

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  - See class OntModelSpec

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- Works on the level of concept descriptions and axioms
- Can parse and write all mentioned OWL formats, and then some

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