INF3580/4580 – Semantic Technologies – Spring 2018

Lecture 10: OWL, the Web Ontology Language

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Reminders

- Oblig. 5:
  First deadline tomorrow (21.03).

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- Oblig. 6: Will be published 03.04.

Today's Plan

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

Outline

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    - property inheritance, and
    - domain and range reasoning.

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- Hence, because of OWA, all RDFS graphs are satisfiable.

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- ✗ If Homer is a parent of Bart, then Bart is a child of Homer.

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- The RDFS entailment rules are incomplete.
  - Can't derive all statements that are semantically valid.

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- A setting well-studied as *Description Logics*.

The $\mathcal{ALC}$ Description Logic

Vocabulary

Fix a set of *atomic concepts* $\{A_1, A_2, \ldots\}$, *roles* $\{R_1, R_2, \ldots\}$ and individuals $\{a_1, a_2, \ldots\}$.

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Axioms

- $C \sqsubseteq D$ and $C \equiv D$ for concept descriptions D and C.
- $C(a)$ and $R(a, b)$ for concept description C, atomic role R and individuals a, b.

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- $FourWheelDrive \equiv \exists driveAxle.FrontAxle \sqcap \exists driveAxle.RearAxle$
  - A 4WD has at least one front drive axle and one rear drive axle.

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Interpretation of Axioms

- $\mathcal{I} \models C \sqsubseteq D$ if $C^\mathcal{I} \subseteq D^\mathcal{I}$ and $\mathcal{I} \models C \equiv D$ if $C^\mathcal{I} = D^\mathcal{I}$
- $\mathcal{I} \models C(a)$ if $a^\mathcal{I} \in C^\mathcal{I}$ and $\mathcal{I} \models R(a, b)$ if $\langle a^\mathcal{I}, b^\mathcal{I}\rangle \in R^\mathcal{I}$.

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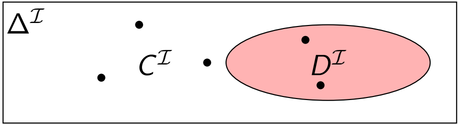

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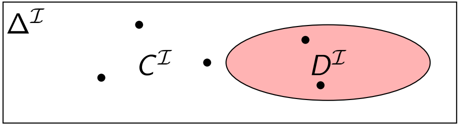

- Example: $EvenNo \equiv \neg OddNo$, assuming the domain is $\mathbf{N}$.
  "An even number is not an odd number."

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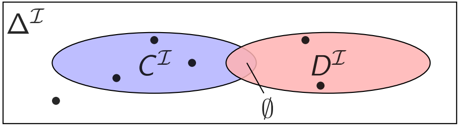

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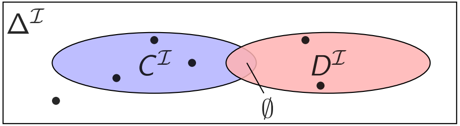

- Example: $\mathit{FrontAxle} \sqcap \mathit{RearAxle} \sqsubseteq \bot$.
  "A FrontAxle is not a RearAxle, and vice versa."

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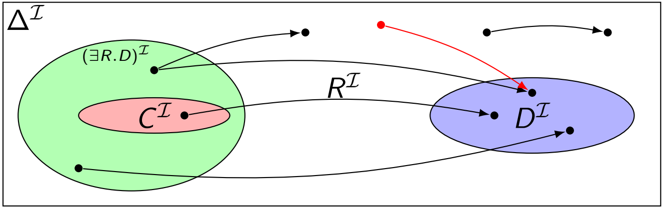

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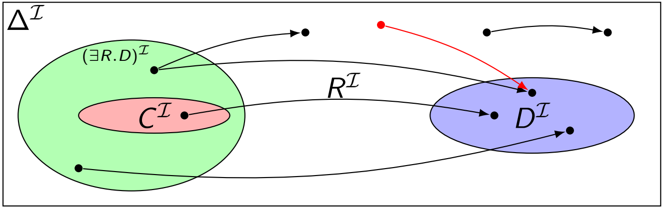

- Example: $Toyota \sqsubseteq \exists driveAxle.FrontAxle$.
  "A Toyota has a front axle as drive axle."

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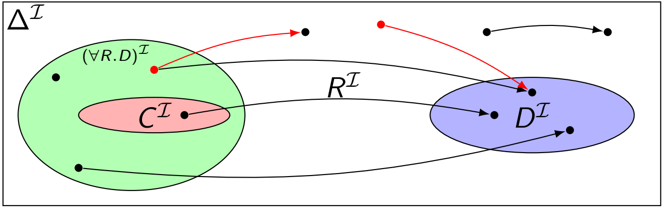

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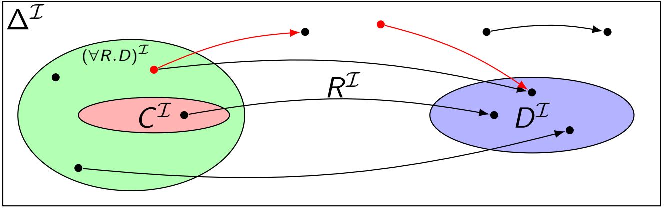

- Example: $Lotus \sqsubseteq \forall driveAxle.RearAxle$.
  "A Lotus has only rear axles as drive axles."

Example interpretation

Assume $\mathcal{K}$ is the knowledge base with the axioms:

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\begin{aligned}
\mathit{Donkey} &\sqsubseteq \mathit{Animal} \sqcap \mathit{Stubborn} \\
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- Much research on how expressivity affects complexity/decidability.

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- Combines DL expressiveness with RDF technology (e.g., URIs, namespaces).

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- Acronym for *The Web Ontology Language*.
- Became a W3C recommendation in 2004.
- The undisputed standard ontology language.
- Superseded by OWL 2;
  - a backwards compatible extension that adds new capabilities.
- Built on Description Logics.
- Combines DL expressiveness with RDF technology (e.g., URIs, namespaces).
- Extends RDFS with boolean operations, universal/existential restrictions and more.

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- Manchester OWL syntax: close to DL, but text, used in some tools.

OWL vocabulary in OWL/RDF

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- (XSD datatypes: `xsd:string`, ...)

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   - Examples: `rdfs:label`, `dc:creator`.

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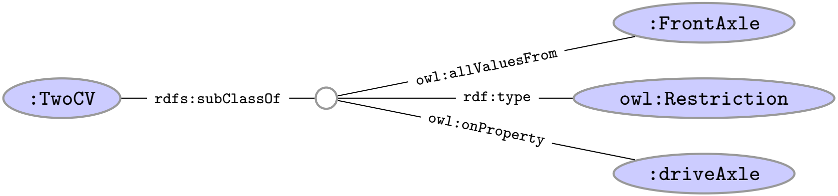

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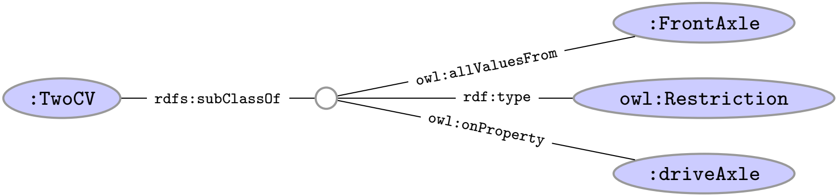

- In Turtle syntax:

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

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- In OWL Functional syntax:

```
SubClassOf(TwoCV 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 Sahara.
- Classify.
- Show that Sahara is equivalent to bottom.
- Explain why. In particular, disjointness of front and rear axles.

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- Many ways of saying the same thing in OWL, more in Protégé.
- Reasoning (e.g., Classification) maps everything to DL first.

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Property driveAxle = model.createProperty(CARS+"driveAxle");
OntClass car = model.createClass(CARS+"Car");
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Resource r = model.createAllValuesFromRestriction(
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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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- Datatypes.
- Work through some modelling problems.