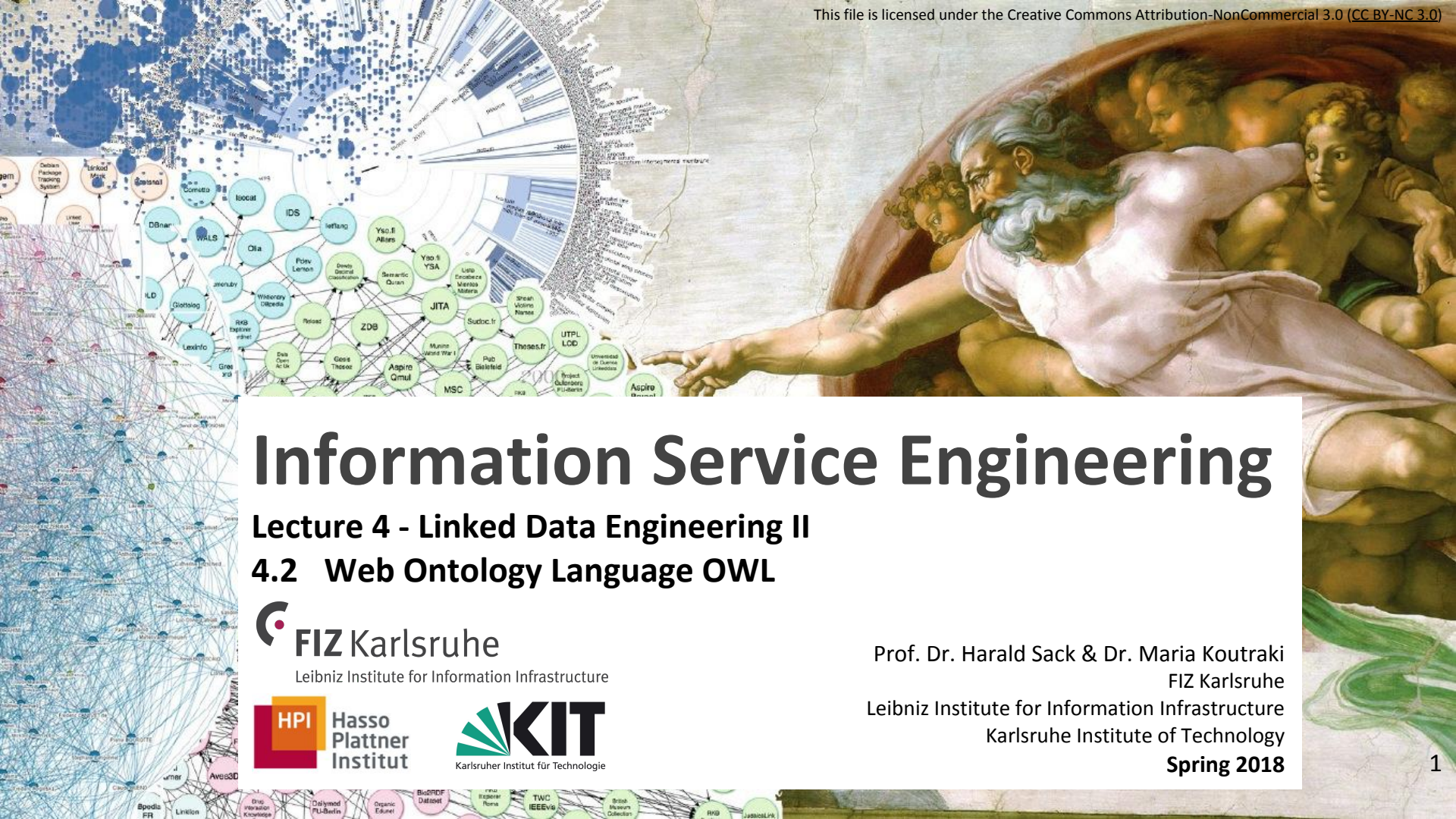




Information Service Engineering

Lecture 4 - Linked Data Engineering II

4.2 Web Ontology Language OWL

 **FIZ Karlsruhe**

Leibniz Institute for Information Infrastructure

 **Hasso Plattner Institut**

 **KIT**
Karlsruher Institut für Technologie

Prof. Dr. Harald Sack & Dr. Maria Koutraki
FIZ Karlsruhe

Leibniz Institute for Information Infrastructure
Karlsruhe Institute of Technology
Spring 2018

Information Service Engineering

Lecture 4: Linked Data Engineering II

4.1 Linked Data Principles

4.2 Web Ontology Language OWL

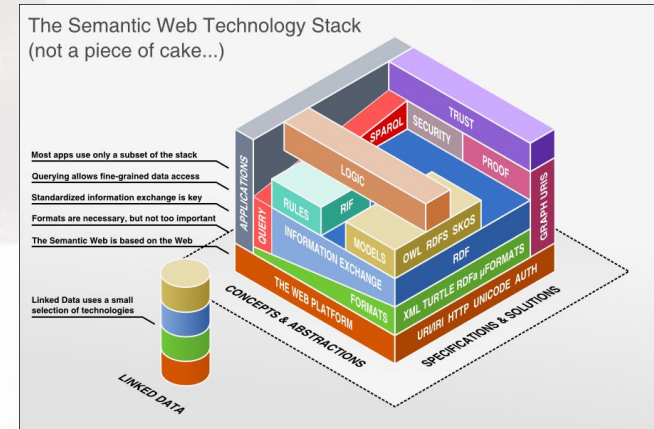
4.3 Web Ontology Language OWL II

4.4 How to Query RDF with SPARQL

4.5 Complex Queries with SPARQL

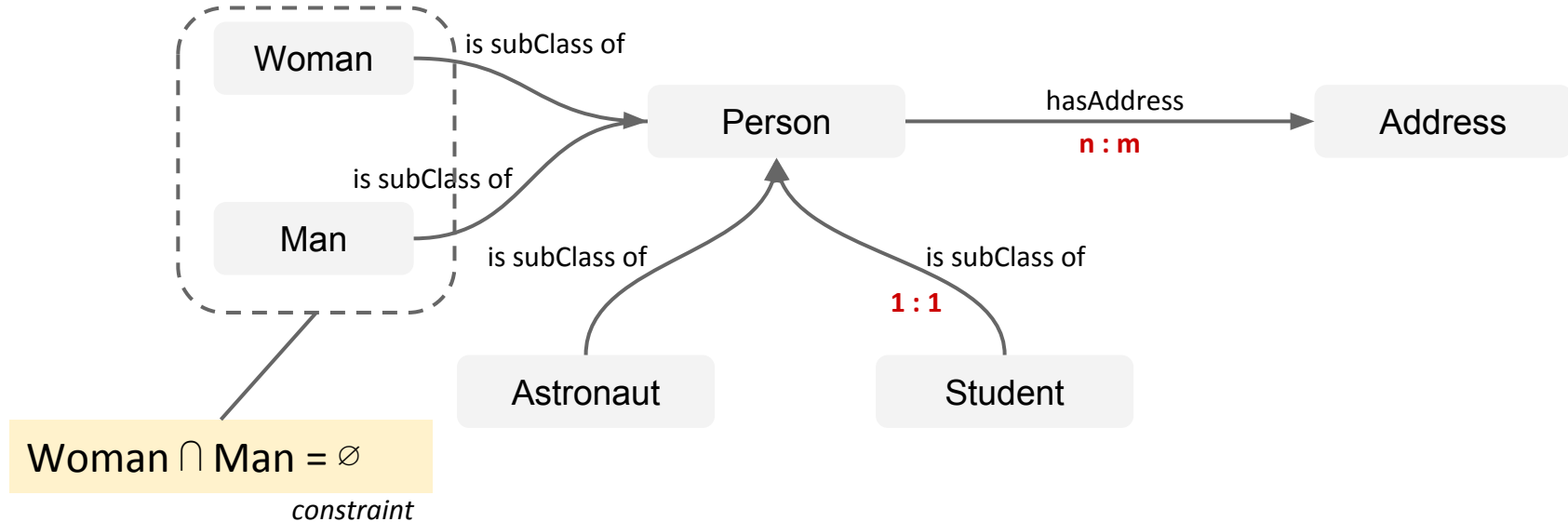
4.6 More Complex SPARQL Queries

4.7 Linked Data Knowledge Graphs



Remember Ontologies

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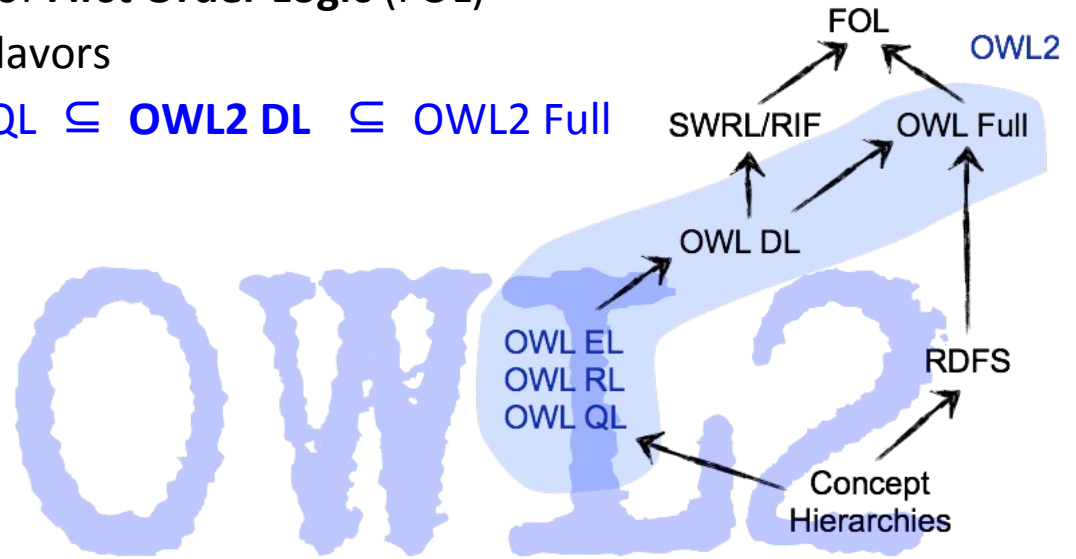


- RDF(S) lacks semantic expressivity to represent fully fledged ontologies

Web Ontology Language OWL - OWL FLavours

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- OWL is a semantic fragment of **First Order Logic** (FOL)
- OWL also exists in different flavors
 - $\text{OWL EL, OWL RL, OWL QL} \subseteq \text{OWL2 DL} \subseteq \text{OWL2 Full}$



OWL is based on the Description Logics $\mathcal{SROIQ}(\mathcal{D})$

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Class Expressions

- Class names A, B
- Conjunction $C \sqcap D$
- Disjunction $C \sqcup D$
- Negation $\neg C$
- Exist. property restriction $\exists R.C$
- Univ. property restriction $\forall R.C$
- Self $\exists S.\text{Self}$
- Greater-than $\geq n \ S.C$
- Less-than $\leq n \ S.C$
- Enumerated classes $\{a\}$

Properties

- Property names R, S, T
- Simple properties S, T
- Inverse properties R^{-}
- Universal property U

Tbox (Class axioms)

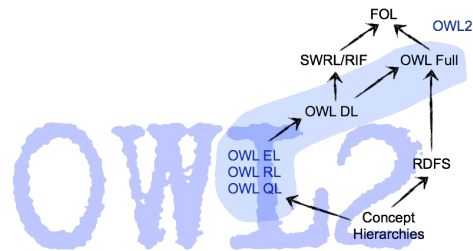
- Inclusion $C \sqsubseteq D$
- Equivalence $C \equiv D$

Rbox (Property Axioms)

- Inclusion $R_1 \sqsubseteq R_2$
- General Inclusion $R^{(-)}_1 \circ R^{(-)}_2 \circ \dots \circ R^{(-)}_n \sqsubseteq R$
- Transitivity
- Symmetry
- Reflexivity
- Irreflexivity
- Disjointness

Abox (Facts)

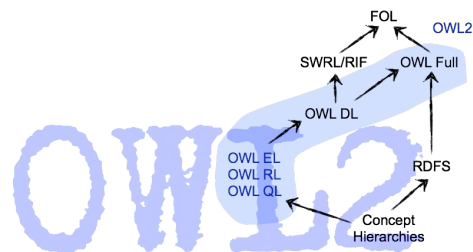
- Class membership $C(a)$
- Property relation $R(a, b)$
- Negated property relation $\neg S(a, b)$
- Equality $a=b$
- Inequality $a \neq b$



OWL Basic Building Blocks

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- **OWL namespace:**
`@prefix owl: <http://www.w3.org/2002/07/owl#>`
- There is a **Turtle Syntax** for OWL
- OWL axioms consist of the following three **building blocks**:
 - **Classes**
 - comparable with classes in RDFS
 - **Individuals**
 - comparable with class instances in RDFS
 - **Properties**
 - comparable with properties in RDFS



OWL Classes

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- there exist two **predefined classes**

`owl:Thing` (class that contains all individuals)

`owl:Nothing` (empty class)

- Definition of a class**

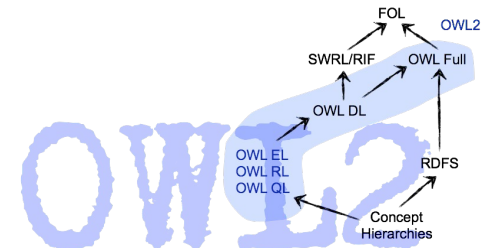
`:Book a owl:Class .`

This is OWL in RDF/Turtle serialization

equivalent expression in
description logics

$$\top \equiv C \sqcup \neg C$$

$$\perp \equiv C \sqcap \neg C$$



OWL Individuals

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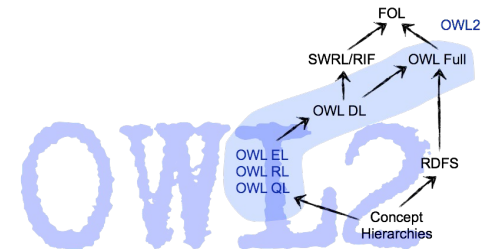
- **Definition of individuals** via class membership

`:NineteenEightyfour a :Book .`

`Book(NineteenEightyfour)`

- Individuals can also be defined **without class membership**
as **named individuals**

`:HaraldSack a owl:NamedIndividual .`



OWL Object Properties

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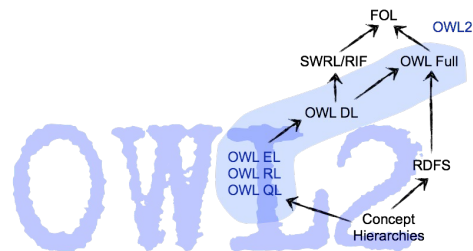
- there exist two **property variants**:
 - object properties
 - datatype properties
- **Object properties** have classes as range
:author a owl:ObjectProperty .
- **Domain and Range** of object properties
:author a owl:ObjectProperty ;
rdfs:domain :Book ;
rdfs:range :Writer .



OWL Datatype Properties

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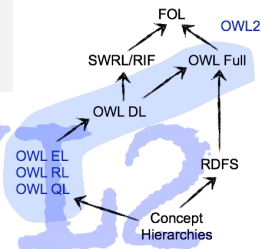
- **Datatype properties** have datatypes as range
:publicationYear a owl:DatatypeProperty .
- **Domain and Range** of datatype properties
:publicationYear a owl:DatatypeProperty ;
rdfs:domain :Book ; $\exists \text{publicationYear}.\top \sqsubseteq \text{Book}$
rdfs:range xsd:integer . $\top \sqsubseteq \forall \text{publicationYear}.\text{Integer}$



OWL Properties and Individuals - Example

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```
:Book a owl:Class .  
:Writer a owl:Class .  
  
:author a owl:ObjectProperty ;  
    rdfs:domain :Book ;  
    rdfs:range :Writer .  
  
:publicationYear a owl:DatatypeProperty ;  
    rdfs:domain :Book ;  
    rdfs:range xsd:integer .  
  
:GeorgeOrwell a Writer .  
:NineteenEightyFour a :Book ;  
    :author :GeorgeOrwell ;  
    :publicationYear 1948 .
```



OWL2

OWL Class Hierarchies

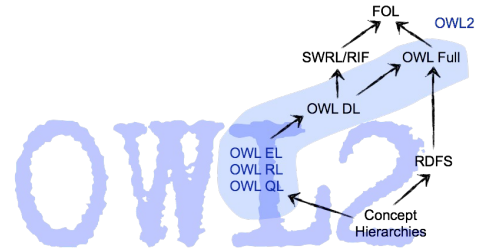
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```
:Novel a owl:Class ;  
      rdfs:subClassOf :Book .  
:Book a owl:Class ;  
      rdfs:subClassOf :Work .  
:Work a owl:Class .
```

we don't need to define a new
subClassOf property for owl, we
simply reuse rdfs:subClassOf

Novel $\sqsubseteq$ Book
Book $\sqsubseteq$ Work

- via **inference** it can be entailed that :Novel is also a subclass of :Work



OWL Disjunct Classes

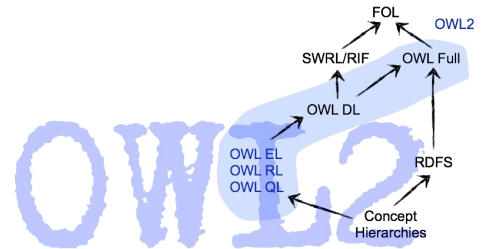
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```
:Book a owl:Class .
:Writer a owl:Class .
:Novel a owl:Class ;
    rdfs:subClassOf :Book .
:Poet a owl:Class ;
    rdfs:subClassOf :Writer .
:Book owl:disjointWith :Writer .
```

In OWL everything might be potentially identical if we don't explicitly state the difference

Novel $\sqsubseteq$ Book
Poet $\sqsubseteq$ Writer
Book $\sqcap$ Writer $\sqsubseteq \perp$

- via **inference** it can be entailed that :Novel and :Poet are also disjoint classes



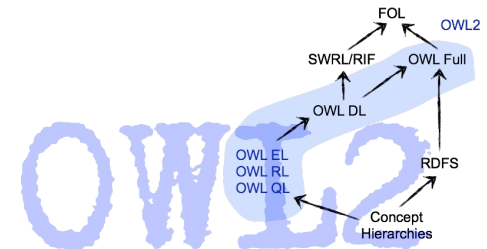
OWL Class Equivalence

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```
:Writer a owl:Class .  
:Author a owl:Class .  
:Poet a owl:Class ;  
      rdfs:subClassOf :Writer .  
  
:Writer owl:equivalentClass :Author .
```

Poet $\sqsubseteq$ Writer
Writer $\equiv$ Author

- via **inference** it can be entailed that :Poet is also an :Author



OWL Individuals - Disjunctness and Equivalence

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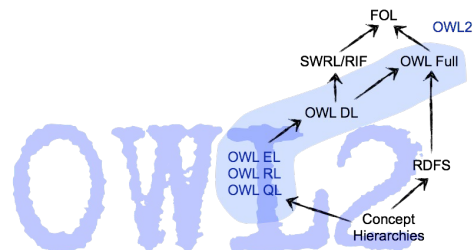
```
:NineteenEightyfour a :Novel ;  
    :author :GeorgeOrwell ;  
    :publicationYear 1948 ;  
    owl:sameAs :ARX012345 .  
  
:Novel a owl:Class ;  
    rdfs:subClassOf :Book .  
  
:Book a owl:Class.
```

For identical individuals: owl:sameAs

For identical classes: owl:equivalentClass

- via **inference** it can be entailed that :ARX012345 is a :Book
- **difference of Individuals** via owl:differentFrom

```
:ARX012345 a :Novel ;  
    owl:differentFrom :ARX012346 .
```



OWL2

OWL Individuals - Disjunctness and Equivalence

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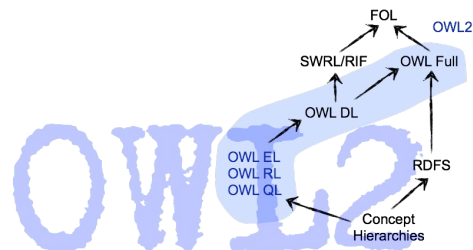
```
:NineteenEightyfour a :Novel ;  
    :author :GeorgeOrwell ;  
    :publicationYear 1948 ;  
    owl:sameAs :ARX012345 .  
  
:Novel a owl:Class ;  
    rdfs:subClassOf :Book .  
  
:Book a owl:Class.
```

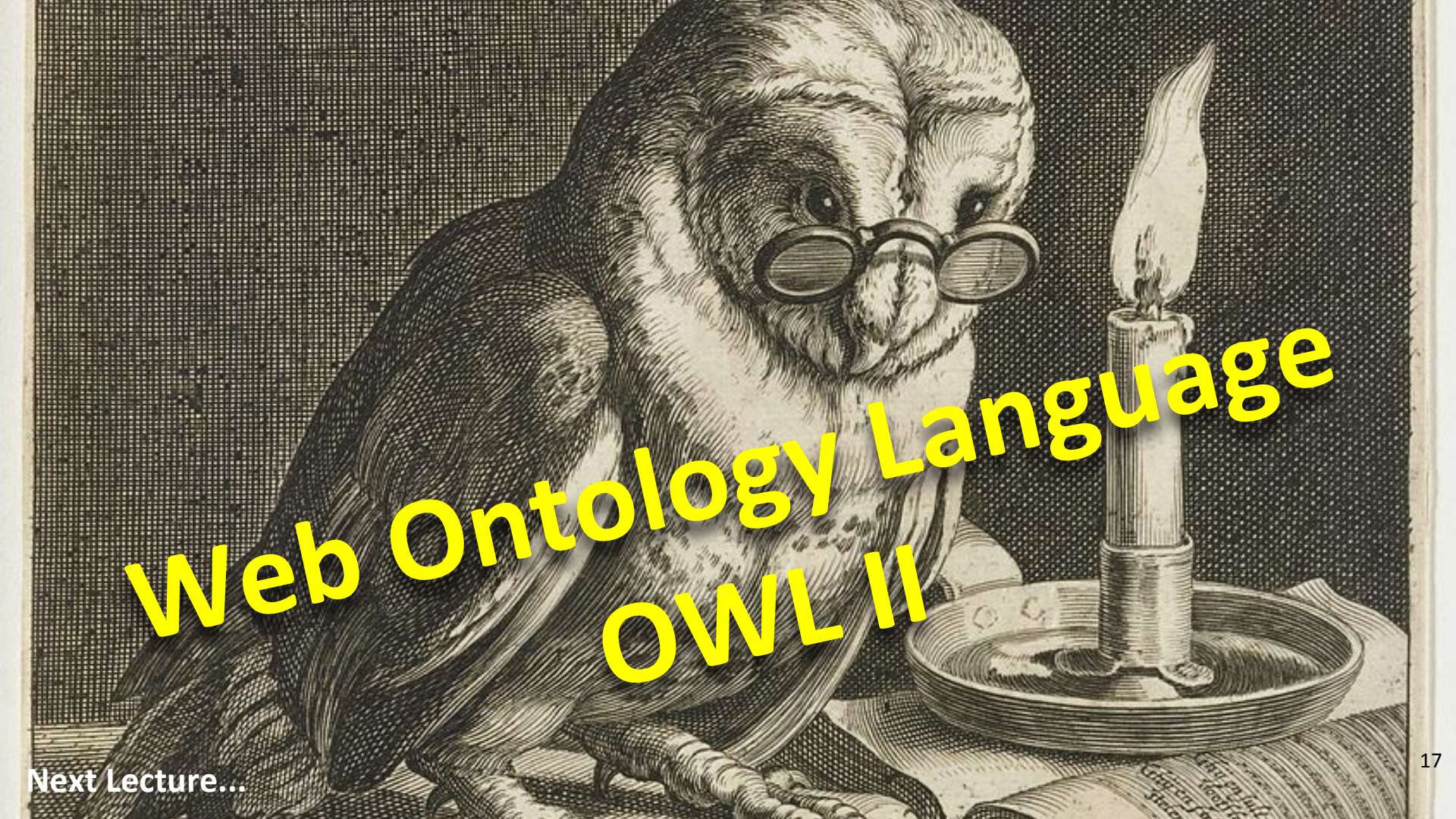
For identical individuals: owl:sameAs

For identical classes: owl:equivalentClass

- via **inference** it can be entailed that :ARX012345 is a :Book
- **difference of Individuals** via owl:differentFrom

```
:ARX012345 a :Novel ;  
    owl:differentFrom :ARX012346 .
```





Web Ontology Language OWL II

Next Lecture...

Picture References:

- P.17: Cornelis Bloemaert, Owl with Glasses and Book, 1625, Rijksmuseum Amsterdam
https://commons.wikimedia.org/wiki/File:Uil_met_bril_en_boeken.jpeg