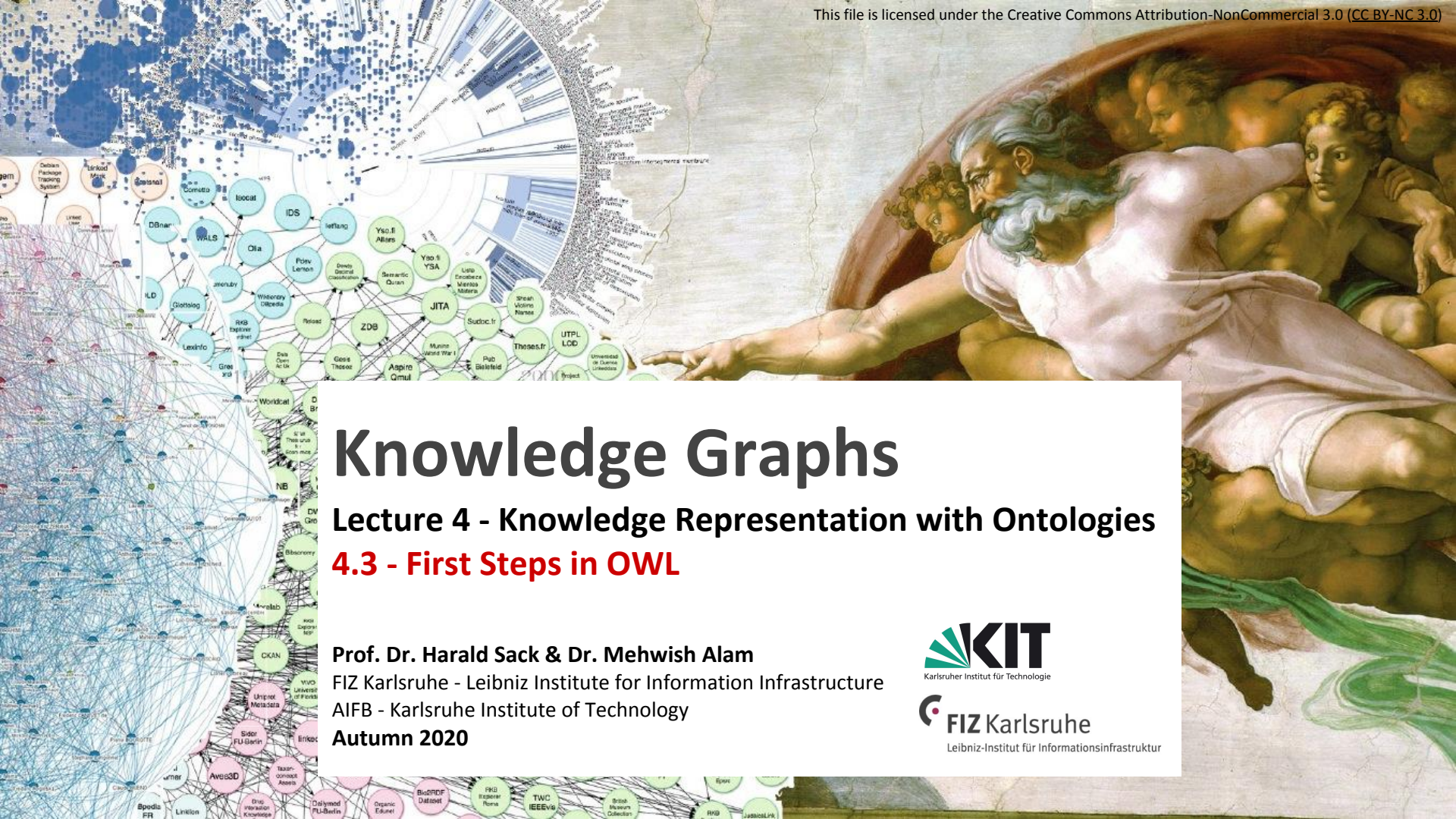

Knowledge Graphs

Lecture 4 - Knowledge Representation with Ontologies

4.3 - First Steps in OWL

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Karlsruher Institut für Technologie

FIZ Karlsruhe
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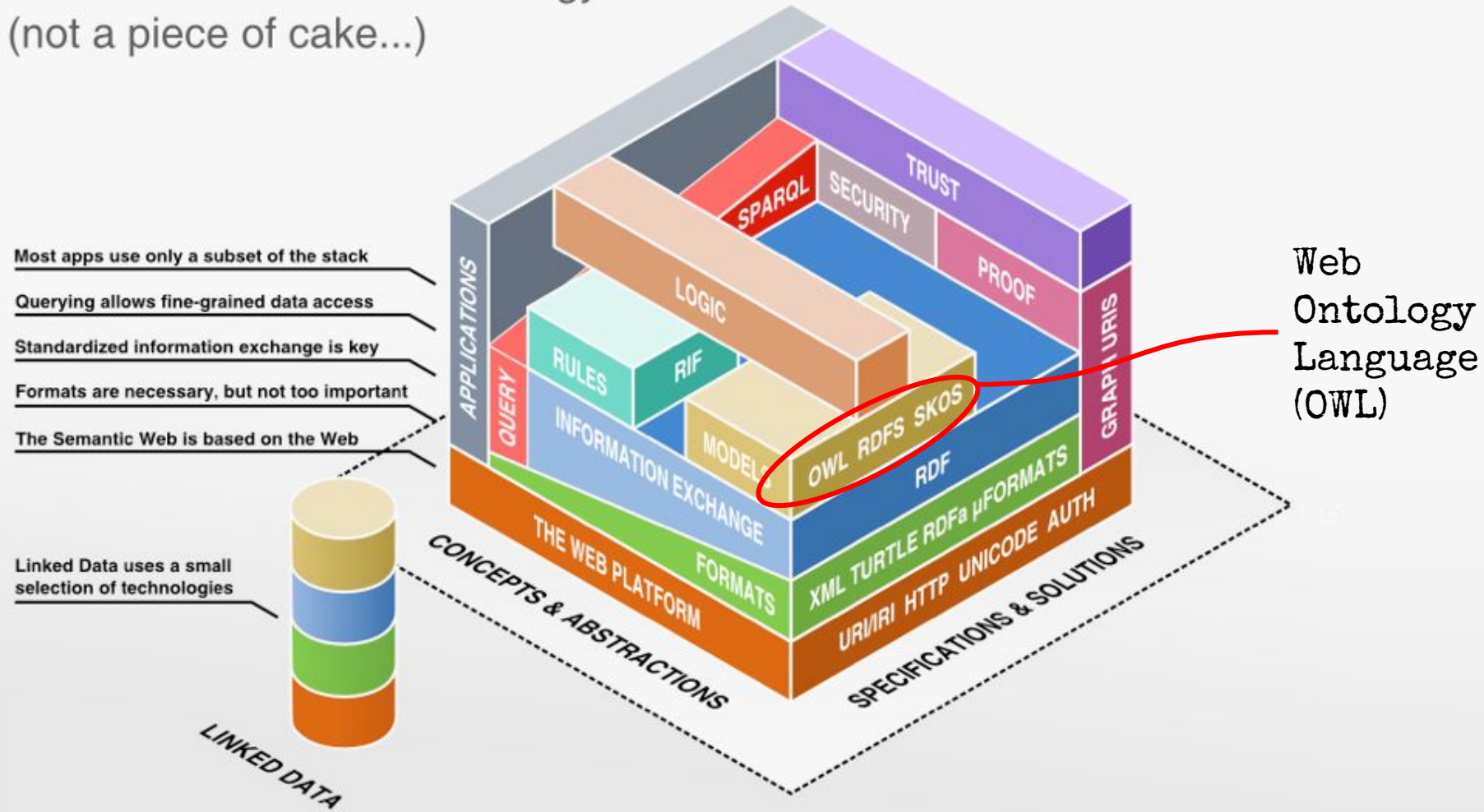
Knowledge Graphs

Lecture 4: Knowledge Representation with Ontologies

The Semantic Web Technology Stack
(not a piece of cake...)

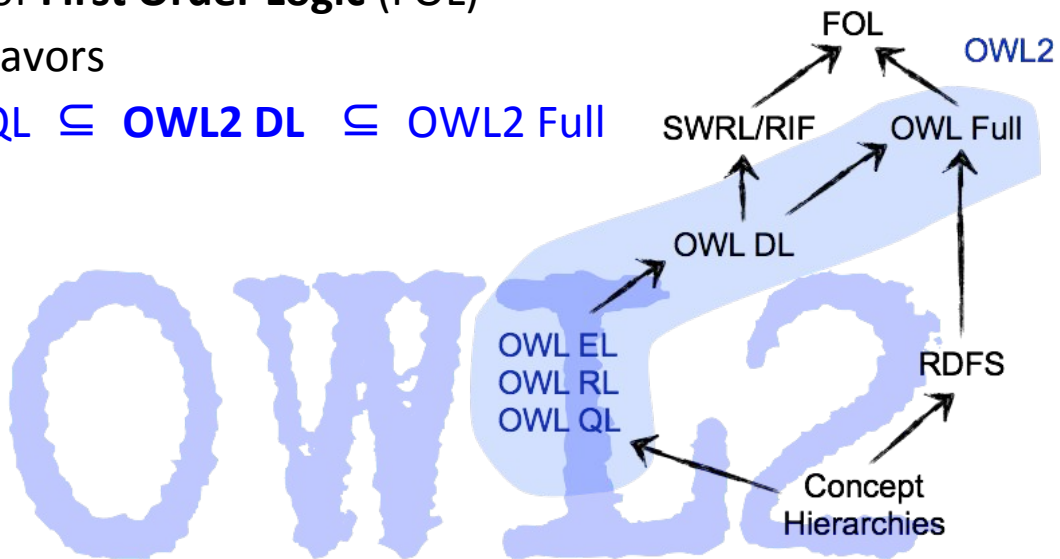


Web Ontology Language (OWL)

[1]

Web Ontology Language OWL - OWL Flavours

- OWL is a semantic fragment of **First Order Logic** (FOL)
- OWL also exists in different flavors
  - OWL EL, OWL RL, OWL QL ⊆ **OWL2 DL** ⊆ OWL2 Full



OWL2 is based on the Description Logic $\mathcal{SROIQ}(\mathcal{D})$

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 $\exists S.Self$
- 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)

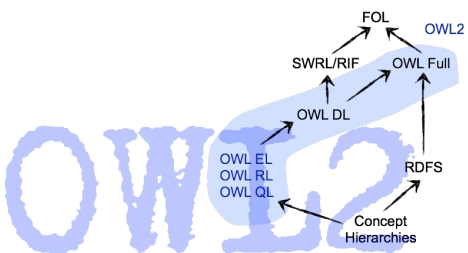
- Inclusion $C \sqsubseteq D$
- Equivalence $C \equiv D$

Rbox (Property Axioms)

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

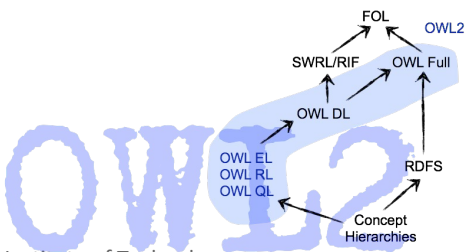
Abox (Facts)

- 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

- 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

- There exist two **predefined classes**
  - `owl:Thing` (class that contains all individuals)
  - `owl:Nothing` (empty class)

equivalent expression in **description logics**

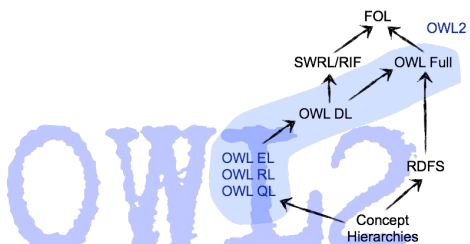
$\top \equiv C \sqcup \neg C$

$\bot \equiv C \sqcap \neg C$

- **Definition of a class**

```
:GreenhouseGas a owl:Class .
```

This is OWL in RDF/Turtle serialization



OWL Individuals

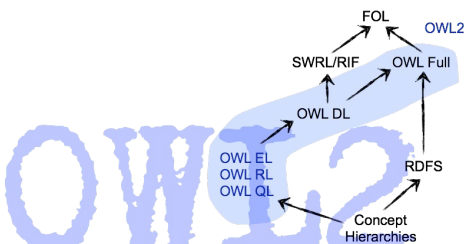
- **Definition of individuals** via class membership

```
:JosephFourier a :Person .
```

```
Person(JosephFourier)
```

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

```
:HaraldSack a owl:NamedIndividual .
```



OWL Object Properties

- There exist two **property variants**:
  - Object properties
  - Datatype properties

- **Object properties** have classes as range

```
:discoverer a owl:ObjectProperty .
```

- **Domain** and **Range** of object properties

```
:discoverer a owl:ObjectProperty ;
            rdfs:domain owl:Thing ;
            rdfs:range  :Person .
```

$\exists \texttt{discoverer}.\top \sqsubseteq \top$

$\top \sqsubseteq \forall \texttt{discoverer}.\texttt{Person}$

OWL Datatype Properties

- **Datatype properties** have datatypes as range

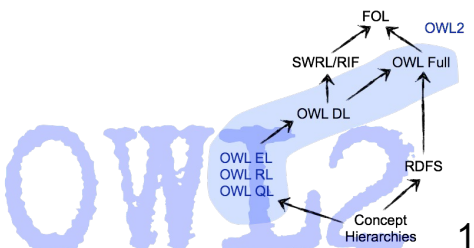
```
:discoveredIn a owl:DatatypeProperty .
```

- **Domain** and **Range** of datatype properties

```
:discoveredIn a owl:DatatypeProperty ;
              rdfs:domain owl:Thing ;
              rdfs:range  xsd:date .
```

$\exists \text{discoveredIn}.\top \sqsubseteq \top$

$\top \sqsubseteq \forall \text{discoveredIn}.\text{Date}$



OWL Properties and Individuals

OWL TBox

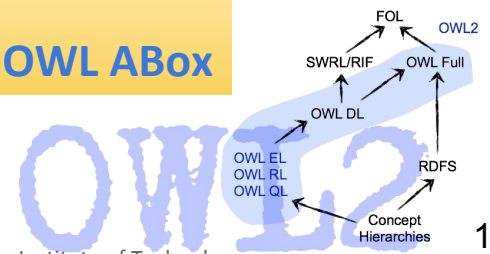
```
:AtmosphericProcess a owl:Class .
:Person a owl:Class .

:discoverer a owl:ObjectProperty ;
            rdfs:domain owl:Thing ;
            rdfs:range  :Person .

:discoveredIn a owl:DatatypeProperty ;
              rdfs:domain owl:Thing ;
              rdfs:range  xsd:date .
```

OWL ABox

```
:JosephFourier a Person .
:GreenhouseEffect a :AtmosphericProcess ;
                  :discoverer :JosephFourier ;
                  :discovered “1824-00-00”^^xsd:date .
```



OWL Class Hierarchies

```
:Physicist a owl:Class ;
       rdfs:subClassOf :Scientist .
:Scientist a owl:Class ;
      rdfs:subClassOf :Person .
:Person a owl:Class .
```

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

$$\text{Physicist} \sqsubseteq \text{Scientist}$$
$$\text{Scientist} \sqsubseteq \text{Person}$$

- via **inference** it can be entailed that `:Physicist` is also a subclass of `:Person`

OWL Class Hierarchies and Disjunctiveness

```
:ChemicalSubstance a owl:Class .
:Person a owl:Class .
:GreenhouseGas a owl:Class ;
       rdfs:subClassOf :ChemicalSubstance .
:Scientist a owl:Class ;
      rdfs:subClassOf :Person .

:ChemicalSubstance owl:disjointWith :Person .
```

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

$$\texttt{GreenhouseGas} \sqsubseteq \texttt{ChemicalSubstance}$$
$$\texttt{Scientist} \sqsubseteq \texttt{Person}$$
$$\texttt{ChemicalSubstance} \sqcap \texttt{Person} \sqsubseteq \bot$$

- via **inference** it can be entailed that `:GreenhouseGas` and `:Scientist` are also disjoint classes

OWL Class Hierarchies and Equivalence

```
:Scientist  a owl:Class .
:Researcher a owl:Class .
:Physicist a owl:Class ;
      rdfs:subClassOf :Scientist .

:Scientist owl:equivalentClass :Researcher .
```

$$\texttt{Physicist} \sqsubseteq \texttt{Scientist}$$
$$\texttt{Scientist} \equiv \texttt{Researcher}$$

- via **inference** it can be entailed that `:Physicist` is also a `:Researcher`

OWL Individuals - Identity and Distinctiveness

```
:CarbonDioxide a :GreenhouseGas ;
    :discoverer :JosephBlack ;
    :discoveredIn "1750-00-00"^^xsd:date ;
    owl:sameAs :ARX012345 .

:GreenhouseGas a owl:Class ;
       rdfs:subClassOf :ChemicalSubstance .

:ChemicalSubstance a owl:Class.
```

For identical individuals: `owl:sameAs`
For identical classes: `owl:equivalentClass`

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

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

Next Lecture...

Karlsruher Institut für Technologie
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Picture References:

- [1] Benjamin Nowack, *The Semantic Web - Not a Piece of cake…*, at bnode.org, 2009-07-08 , [CC BY 3.0]
  http://bnode.org/blog/2009/07/08/the-semantic-web-not-a-piece-of-cake
- [2] Gustave Doré, Two Owls, 19th century [Public Domain]
  https://www.wikiart.org/en/gustave-dore/two-owls