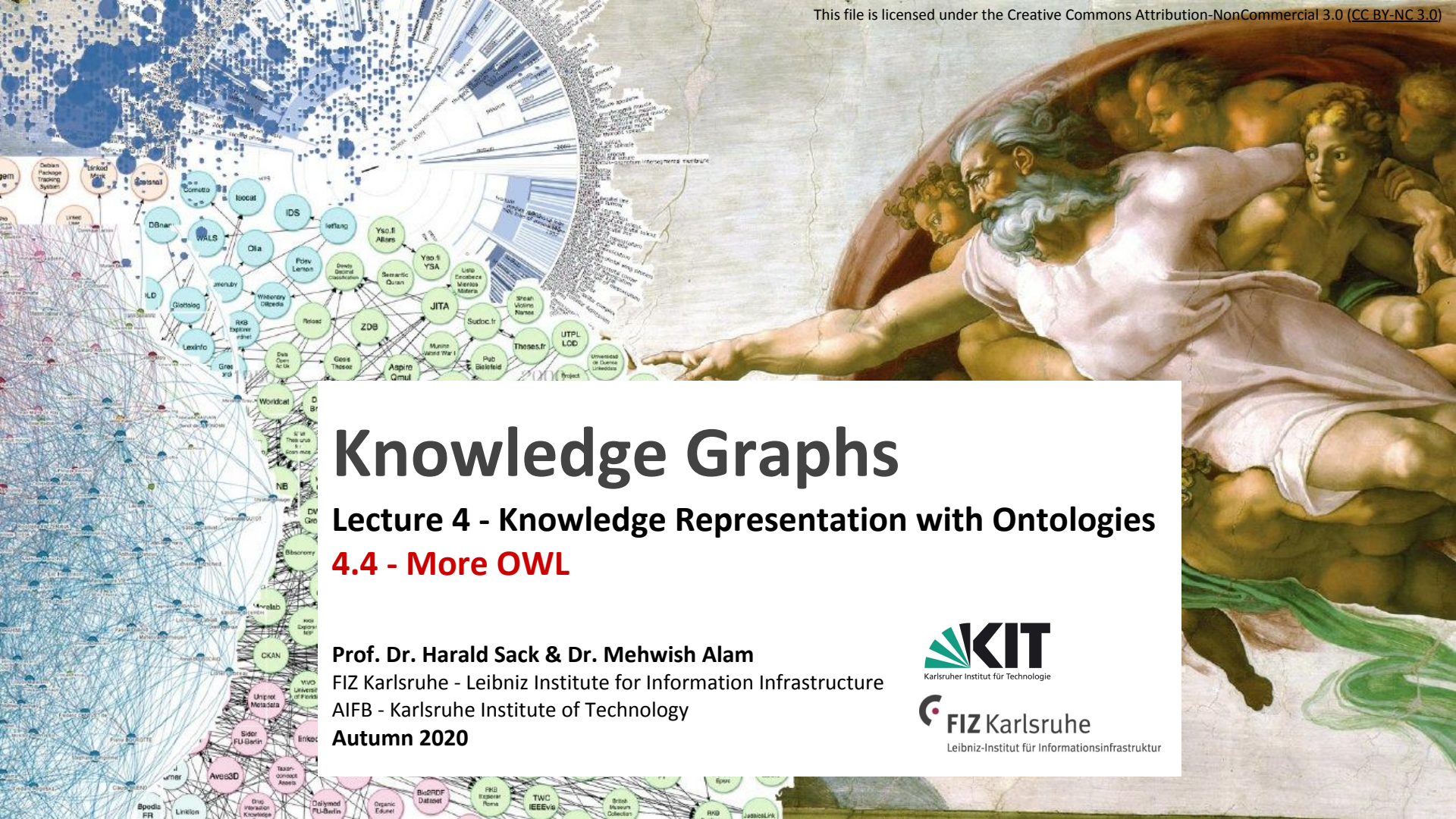


Knowledge Graphs

Lecture 4 - Knowledge Representation with Ontologies

4.4 - More OWL

Prof. Dr. Harald Sack & Dr. Mehwish Alam
FIZ Karlsruhe - Leibniz Institute for Information Infrastructure
AIFB - Karlsruhe Institute of Technology
Autumn 2020

Karlsruher Institut für Technologie

FIZ Karlsruhe
Leibniz-Institut für Informationsinfrastruktur

Knowledge Graphs

Lecture 4: Knowledge Representation with Ontologies

4.1 A Brief History of Ontologies

4.2 Why we do need Logic

Excursion 4: A Brief Recap of Essential Logics

Excursion 5: Description Logics

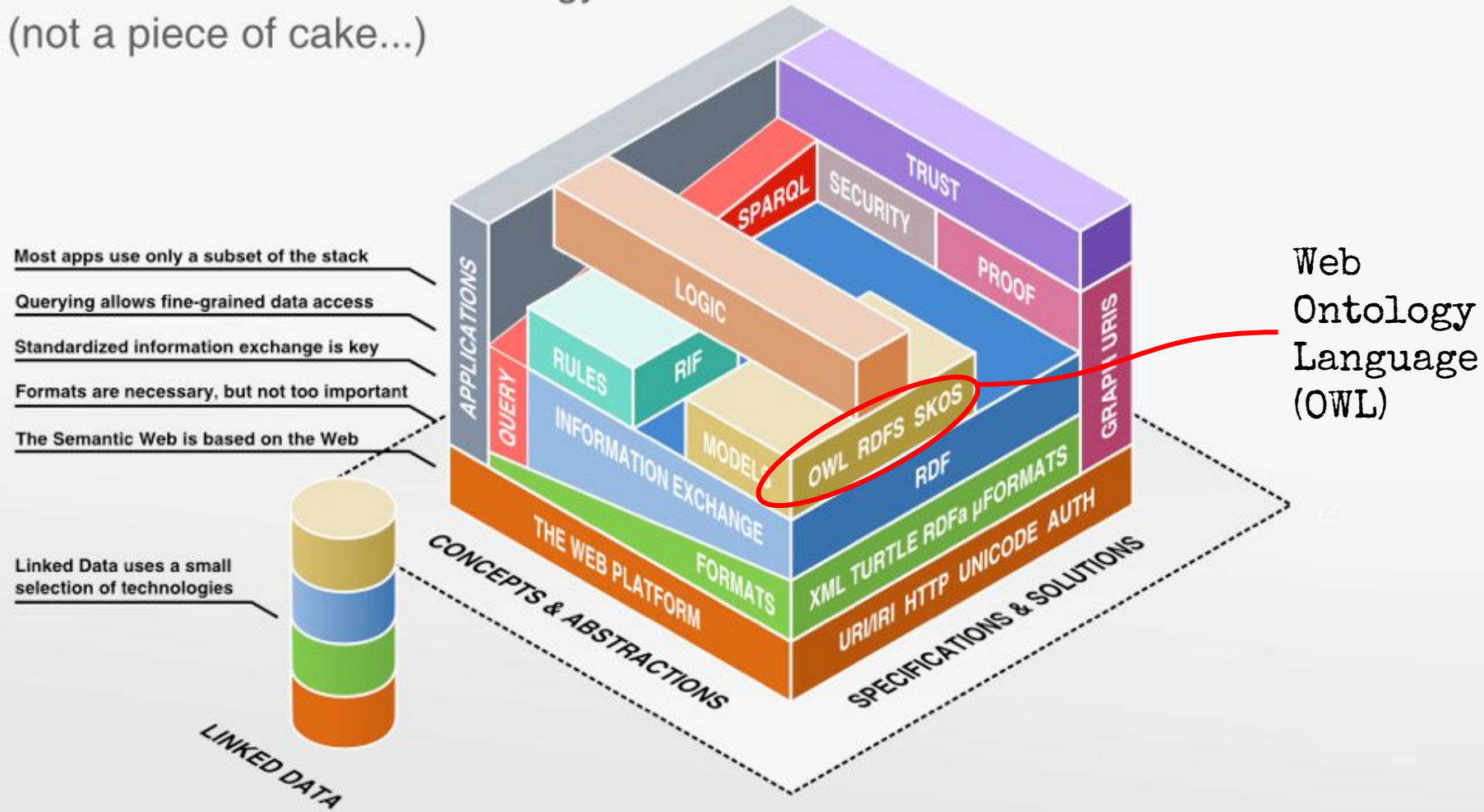
4.3 First Steps in OWL

4.4 More OWL

4.5 OWL and beyond

4.6 How to Design your own Ontology

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



Web Ontology Language (OWL)

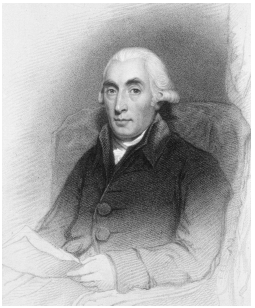
[1]

OWL Complex Classes - Nominals

```
:Chemist   a owl:Class .
:Physicist a owl:Class .
:JosephFourier a :Physicist .
:Jan_Baptist_van_Helmont a :Physicist .
:JosephBlack a Chemist .

:CarbonDioxideClub a owl:Class ;
     owl:oneOf
     ( :JosephFourier
       :Jan_Baptist_van_Helmont
       :JosephBlack ) .
```

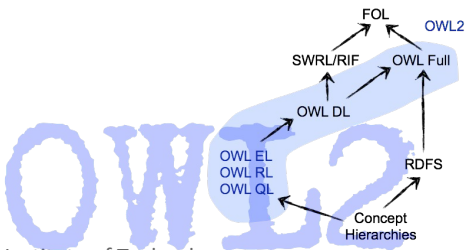




[2,3,4]

$$\text{CarbonDioxideClub} \sqsubseteq \{ \text{JosephFourier}, \text{JanBaptistVanHelmont}, \text{JosepBlack} \}$$

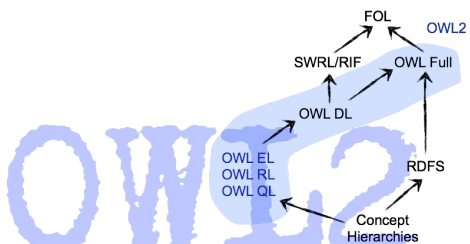
- There are only three scientists in the Carbon Dioxide Club.



OWL Logical Class Constructors

- logical AND (conjunction): `owl:intersectionOf` ⊓
- logical OR (disjunction): `owl:unionOf` ⊔
- logical negation: `owl:complementOf` ¬

Used to create complex classes from atomic classes



OWL Logical Class Constructors - Intersection

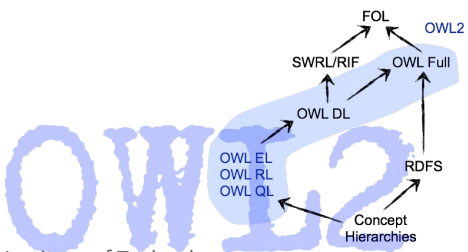
```
:Scientist a owl:Class .

:ClimateActivist a owl:Class .

:Scientists4Future a owl:Class ;
      owl:intersectionOf (:Scientist :ClimateActivist) .
```

$$\texttt{Scientists4Future} \equiv \texttt{Scientist} \sqcap \texttt{ClimateActivist}$$

- The class `:Scientists4Future` results from the intersection of all individuals of the classes `:Scientist` and `:ClimateActivist`

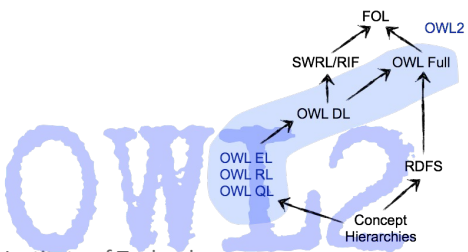


OWL Logical Class Constructors - Union

```
:Environmentalist a owl:Class ;
      owl:equivalentClass [
         owl:unionOf ( :ClimateActivist
                       :AnimalRightsActivist
                       :EnergySaver )
] .
```

$$\texttt{Environmentalist} \equiv \texttt{ClimateActivist} \sqcup \texttt{AnimalRightsActivist} \sqcup \texttt{EnergySaver}$$

- Climate Activists, Animal Rights Activists, and Energy Savers are all Environmentalists



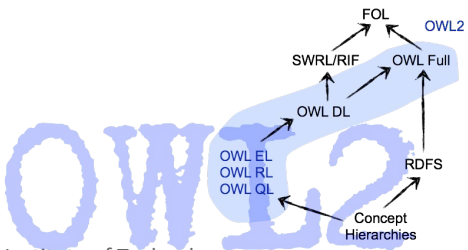
OWL Logical Class Constructors - Negation

```
:Pacifist a owl:Class .

:Warmonger a owl:Class ;
     owl:complementOf (:Pacifist) .
```

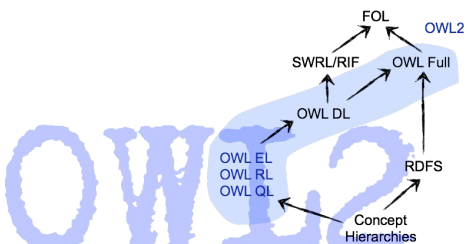
$$\texttt{Warmonger} \equiv \neg \texttt{Pacifist}$$

- The class `:Warmonger` results from the complement of the class `:Pacifist`



OWL Property Restrictions

- **OWL property restrictions** are used to describe **complex classes** via **properties**
- restrictions on values:
  - `owl:hasValue`
  - `owl:allValuesFrom`
  - `owl:someValuesFrom`
- restrictions on cardinality:
  - `owl:cardinality`
  - `owl:minCardinality`
  - `owl:maxCardinality`

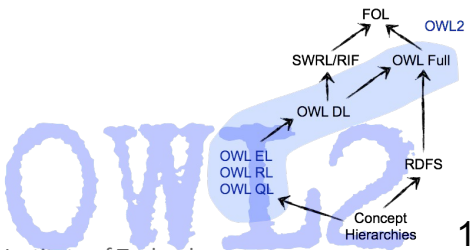


OWL Property Restrictions with Constants

```
:FouriersDiscoveries a owl:Class ;
                rdfs:subClassOf
                  [ a owl:Restriction ;
                    owl:onProperty :discoverer ;
                    owl:hasValue :JosephFourier ] .
```

$$\texttt{FouriersDiscoveries} \sqsubseteq \texttt{discoverer.(JosephFourier)}$$

- The class `:FouriersDiscoveries` is described via fixed value assignment (=constant) of the individual `:JosephFourier` to the property `:discoverer`

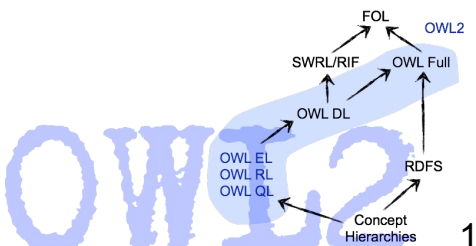


OWL Properties Restriction with Strict Binding

```
:VegetarianDish a owl:Class ;
        rdfs:subClassOf
          [ a owl:Restriction ;
            owl:onProperty :ingredient ;
            owl:allValuesFrom :VegetarianFood ] .
```

$\texttt{VegetarianDish} \sqsubseteq \forall \texttt{ingredient}.\texttt{VegetarianFood}$

- `owl:allValuesFrom`
  fixes all instances of a specific class C
  as allowed range for a property p
  (strict binding) $\forall p.C$



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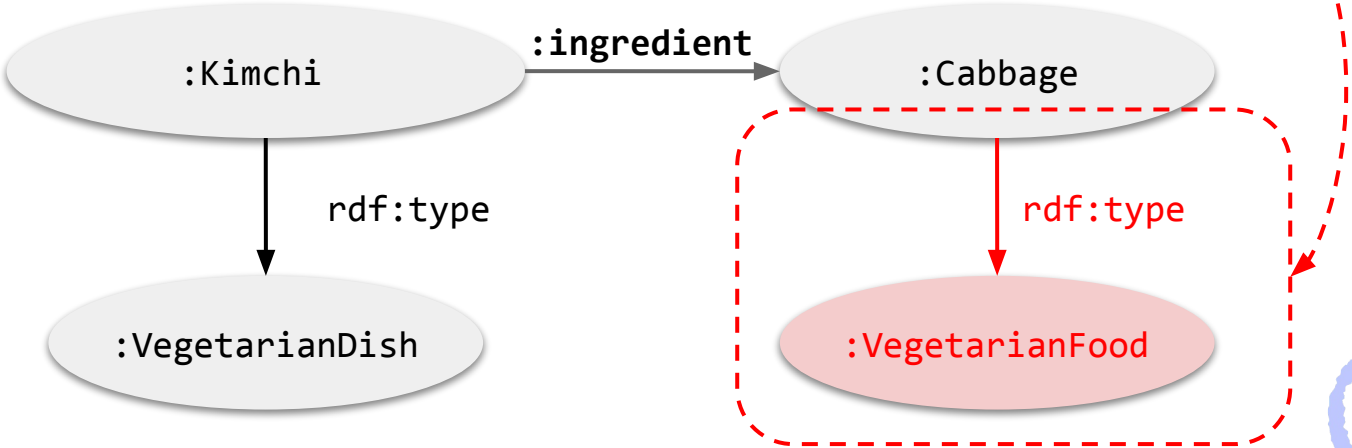
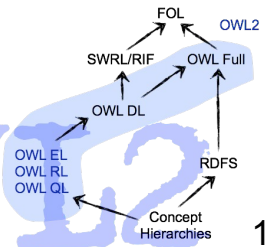


Logical inference

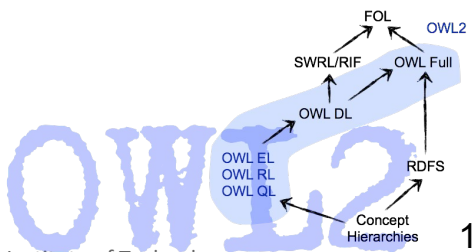


OWL Property Restriction with Loose Binding

```
:Reader a owl:Class ;
        rdfs:subClassOf
          [ a owl:Restriction ;
            owl:onProperty :reads ;
            owl:someValuesFrom :Book ] .
```

$$\texttt{Reader} \sqsubseteq \exists \texttt{reads.Book}$$

- `owl:someValuesFrom`
  describes that there must exist an individual for p and fixes its range to class C (loose binding) $\exists p.C$



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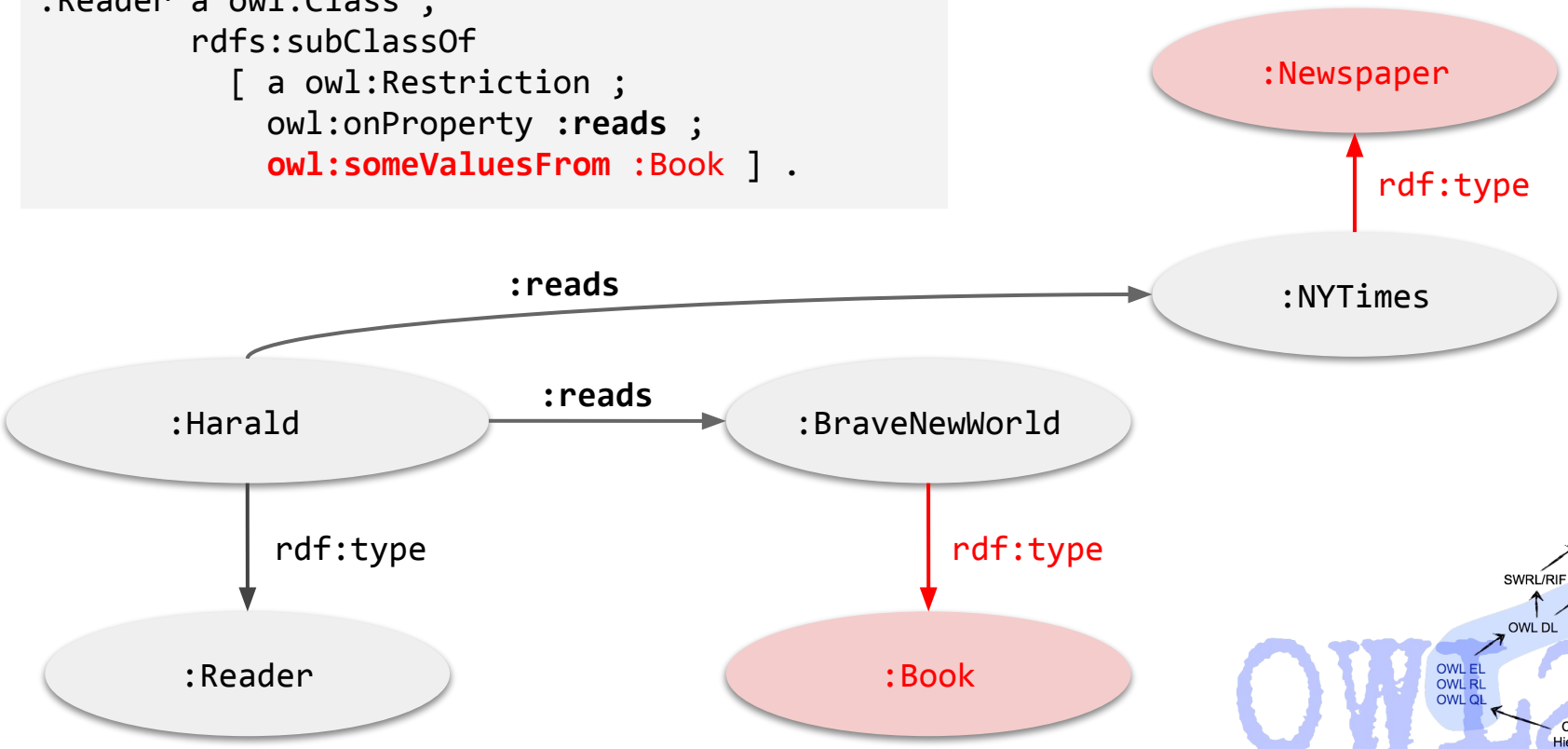

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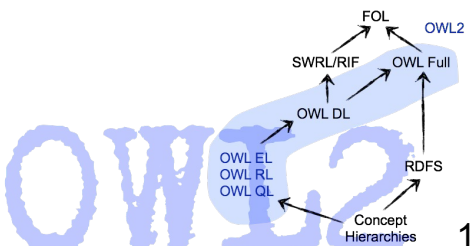
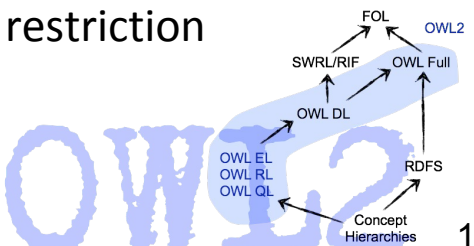


OWL Property Restrictions with Cardinality

```
:StringQuartett a owl:Class ;
     rdfs:subClassOf
        [ a owl:Restriction ;
          owl:onProperty :member ;
          owl:cardinality "4"^^<http://www.w3.org/2001/XMLSchema#int> ] .
```

$\text{StringQuartett} \sqsubseteq =4.\text{member}.\top$

- Class `:StringQuartett` is restricted to exactly `4` members, i.e. any instance of `:StringQuartett` must have exactly 4 values for the property `:member`
- For `owl:maxCardinality` and `owl:minCardinality` the restriction gives upper and lower bounds on property value cardinalities.



Next Lecture...

Karlsruher Institut für Technologie
FIZ Karlsruhe
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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] Louis-Léopold Boilly, Engraved portrait of French mathematician Jean Baptiste Joseph Fourier, early 19th century, [Public Domain]
  https://commons.wikimedia.org/wiki/File:Fourier2.jpg
- [3] Mary Beale, Jan Baptist van Helmont, 1647, [Public Domain]
  https://commons.wikimedia.org/wiki/File:Jan_Baptist_van_Helmont_portrait.jpg
- [4] Joseph Black, Günther Bugge: Das Buch Der Grossen Chemiker, Band 1, Verlag Chemie Weinheim 1929, [Public Domain]
  https://commons.wikimedia.org/wiki/File:Joseph_Black2.JPG
- [5] Museum of Fine Arts of Lyon, Owl standing right, head facing. Reverse of a silver tetradrachm from Athens, ca. 480–420 BC. [CC-BY] https://commons.wikimedia.org/wiki/File:Tetradrachm_Athens_480-420BC_MBA_Lyon.jpg