Ontology Languages: OWL

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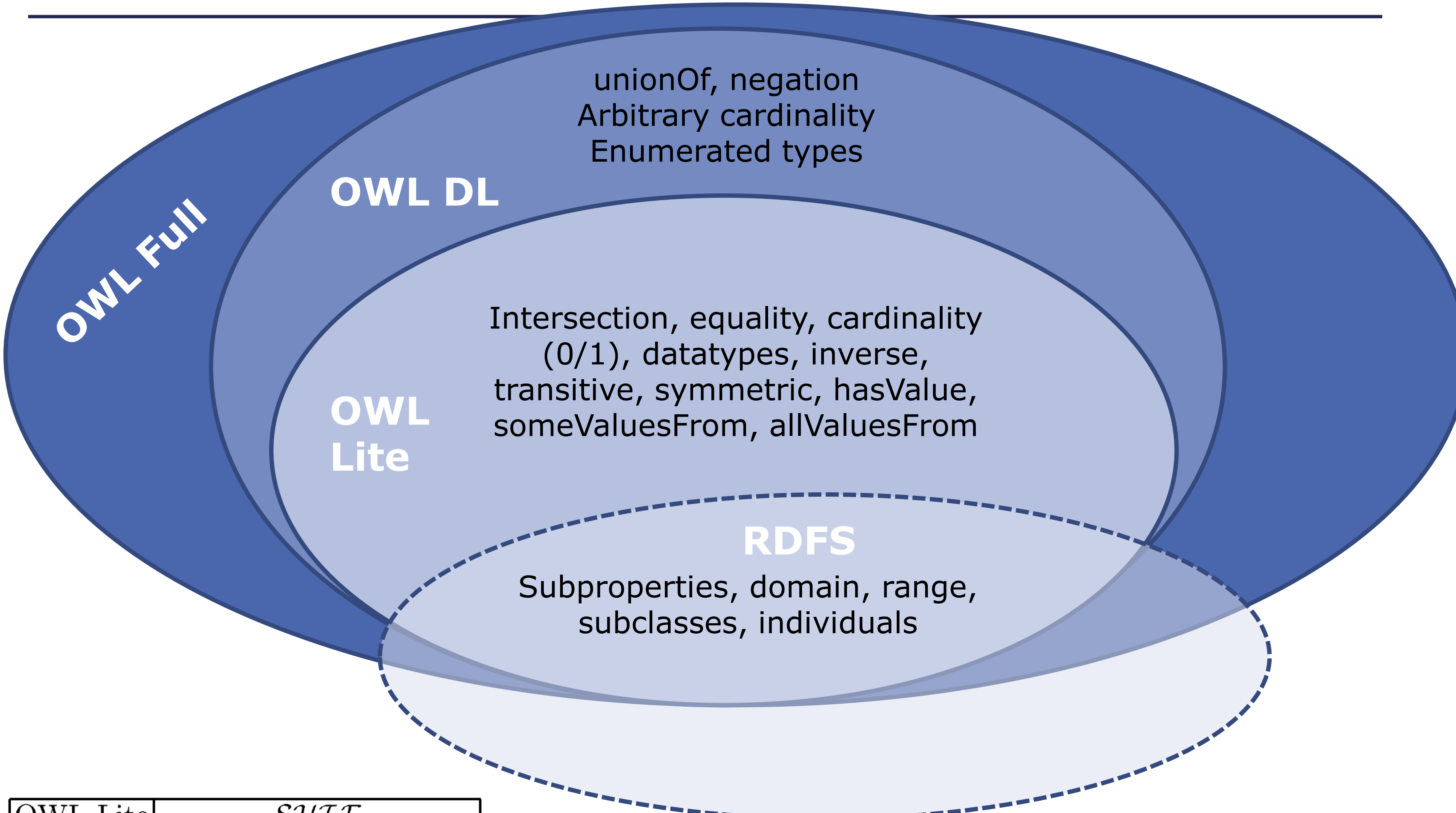
OWL

- W3C recommendation (2003)
- Based on OIL and DAML
- Uses RDF and XML as the underlying representation
- There were three languages in OWL 1.0:
  - Lite
  - DL
  - Full
- OWL 2.0 eliminates OWL Lite and adds three profiles: RL, QL, EL

OWL



OWL-Lite	$\mathcal{SHIF}$
OWL-DL	$\mathcal{SHOIN}$
OWL-Full	Unconstrained $\mathcal{SHOIN}$

Source: Sven Groppe. Data Management and Query Processing in Semantic Web Databases

OWL Versions

- Criticism to OWL 1.0
  - Complex reasoning over the ABOX (i.e., on data complexity)
  - Integrity constraints are not allowed
  - Limited support to data types

- OWL 2.0
  - Syntactic facilities
  - *SROIQ* constructs
    - OWL 1.0 corresponds to *SHOIN*
  - User defined data types
  - Class attributes and primary keys

Syntax Example (Axioms)

OWL axiom	DL syntax	Example
subClassOf	$C_1 \sqsubseteq C_2$	Human $\sqsubseteq$ Animal $\sqcap$ Biped
equivalentClass	$C_1 \equiv C_2$	Man $\equiv$ Human $\sqcap$ Male
disjointWith	$C_1 \sqsubseteq \neg C_2$	Man $\sqsubseteq \neg$Female
sameIndividualAs	$\{a_1\} \equiv \{a_2\}$	{presBush} $\equiv$ {G.W.Bush}
differentFrom	$\{a_1\} \sqsubseteq \neg\{a_2\}$	{john} $\sqsubseteq \neg${peter}
subPropertyOf	$P_1 \sqsubseteq P_2$	hasDaughter $\sqsubseteq$ hasChild
equivalentProperty	$P_1 \equiv P_2$	hasCost $\equiv$ hasPrice
inverseOf	$P_1 \equiv P_2^-$	hasChild $\equiv$ hasParent$^-$
transitiveProperty	$P^+ \sqsubseteq P$	ancestor$^+$ $\sqsubseteq$ ancestor
functionalProperty	$\top \sqsubseteq (\leq 1\, P)$	$\top \sqsubseteq (\leq 1$ hasFather$)$
inverseFunctionalProperty	$\top \sqsubseteq (\leq 1\, P^-)$	$\top \sqsubseteq (\leq 1$ hasSSN$^-)$

Syntax Example (Constructs)

OWL contructor	DL constructor	Example
intersectionOf	$C_1 \sqcap \cdots \sqcap C_n$	Human $\sqcap$ Male
unionOf	$C_1 \sqcup \cdots \sqcup C_n$	Doctor $\sqcup$ Lawyer
complementOf	$\neg C$	$\neg$Male
oneOf	$\{a_1\} \sqcup \cdots \sqcup \{a_n\}$	{john} $\sqcup$ {mary}
allValuesFrom	$\forall P.C$	$\forall$hasChild.Doctor
someValuesFrom	$\exists P.C$	$\exists$hasChild.Lawyer
maxCardinality	$(\leq n\, P)$	$(\leq 1$ hasChild$)$
minCardinality	$(\geq n\, P)$	$(\geq 2$ hasChild$)$

Complex Constraints (Constructs)

- Constructs such as *owl:someValuesFrom,owl:allValuesFrom, owl:minCardinality,owl:maxCardinality* are expressed using blank nodes together with *owl:Restriction* by means of **reification** (i.e., they require a set of triples –not just one- to express sent the construct)
- Example:

_:a	*rdfs:subClassOf*	*owl:Restriction*	*_:a* is a complex constraint
_:a	*owl:onProperty*	*:Leads*	denotes the constrained property
_:a	*owl:allValuesFrom*	*:Professor*	denotes the property constraints / cardinality

The class describing the set of individuals for which all range values of the property *:Leads* come from the class *:Professor*

:Department rdfs:subClassOf _:a would be equivalent to:

$$:Department \sqsubseteq \forall :Leads . :Professor$$

Complex Constraints (II)

- Cardinalities on roles:

```
_:a   rdfs:subClassOf      owl:Restriction
_:a   owl:onProperty       RegisteredTo
_:a   owl:minCardinality   3
_:b   rdfs:subClassOf      owl:Restriction
_:b   owl:onProperty       RegisteredTo
_:b   owl:maxCardinality   6
:Student   rdfs:subClassOf   _:a
:Student   rdfs:subClassOf   _:b
```

- How would you express on OWL the following constraint?

$$C_1 \sqsubseteq \exists P.C$$

Complex Constraints (III)

- Union and Intersection (functional syntax)

```
_:a  rdfs:subClassOf      owl:Restriction
_:a  owl:onProperty       :TeachesTo
_:a  owl:someValuesFrom   :Undergrad
_:b  owl:unionOf          (:Professor,:Lecturer)
_:a  rdfs:subClassOf      _:b
```

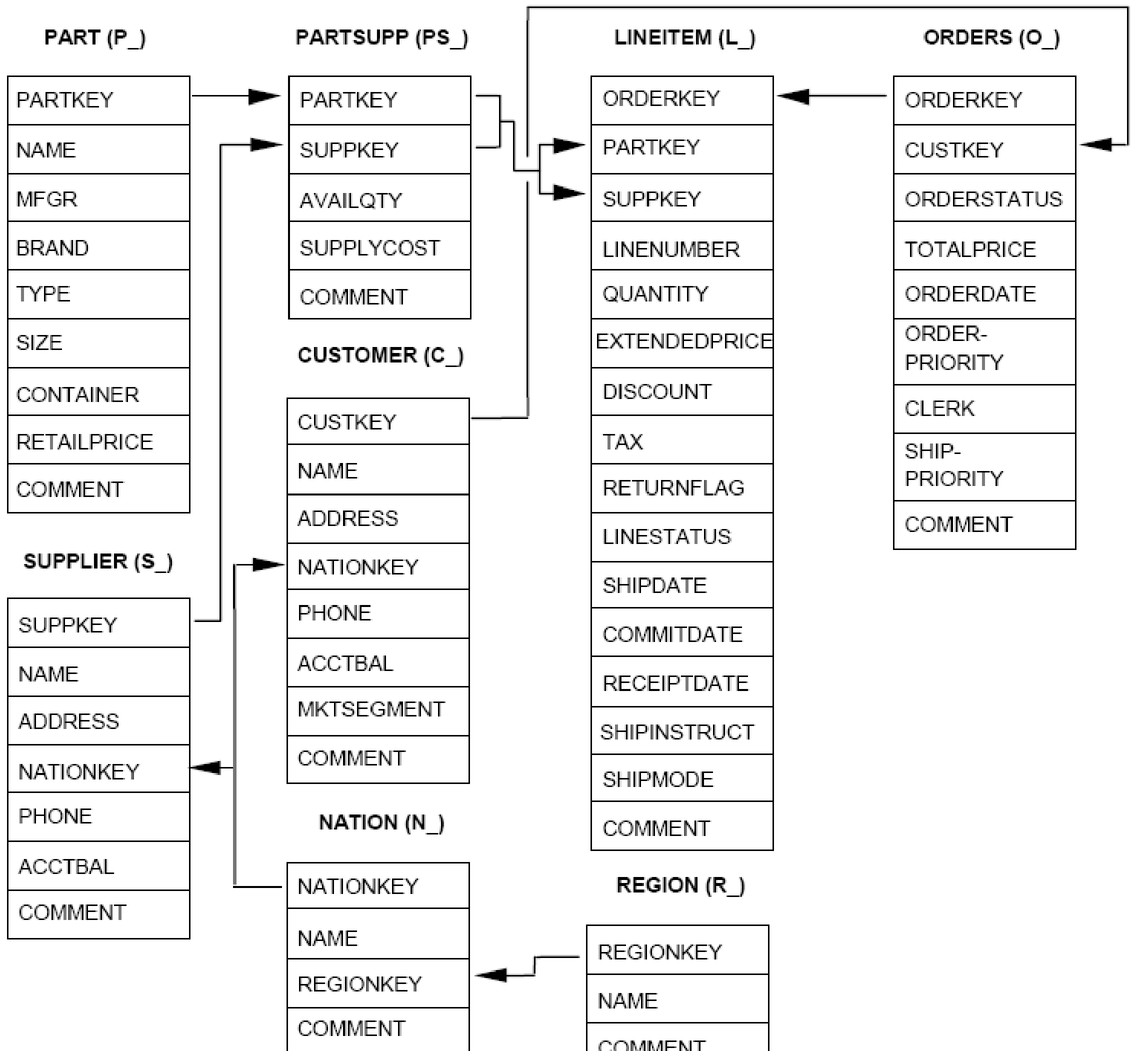
- How do you express this constraint in DL?

OWL Implementation

I. Uses RDF syntax (i.e., URIs and literals that conform valid triples)
II. It reuses some URIs from RDFS (e.g., rdfs:subClassOf). However, be aware that the whole RDFS is NOT a subset of OWL
III. OWL adds new properties and classes based on DL and defined at the OWL namespace: http://www.w3.org/2002/07/owl#

Example of OWL Syntax (I) –RDF/XML

Translation to OWL DL



Legend:

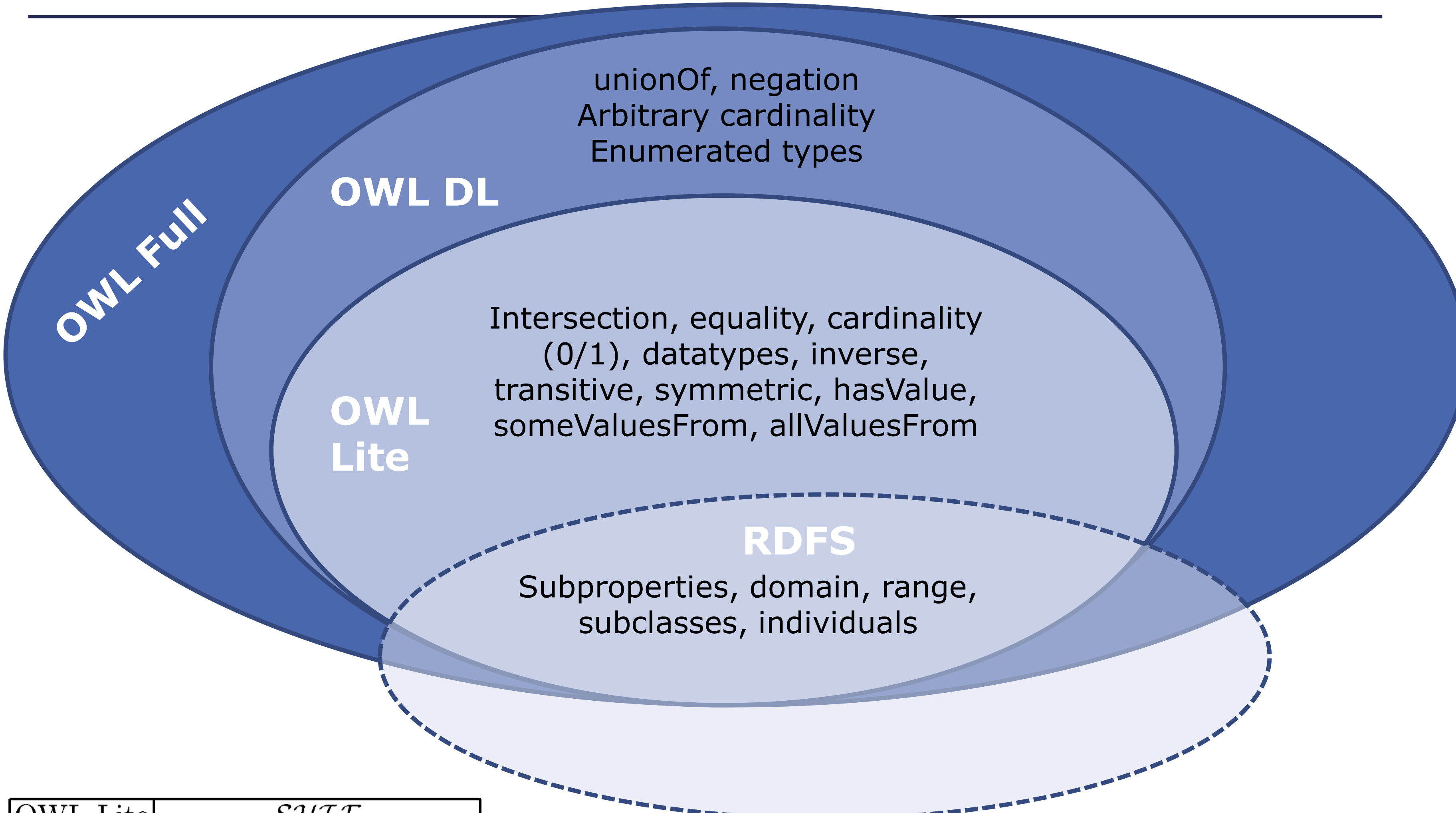
- The arrows point in the direction of the one-to-many relationships between tables;

Example of OWL Syntax (II)

Sample

This example uses a new **functional notation** that avoids the overloading owl:Restriction notation and XML

OWL: Recap



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OWL 2 Profiles

OWL 2 EL:

Based on *EL*++

Large number of properties / classes

Reasoning: Polynomial with regard to the ontology TBOX

OWL 2 QL:

Based on DL-Lite

Captures (most of) ER and UML expressive power

Reasoning: Reducible to LOGSPACE (i.e., DBs)

OWL 2 RL:

Based on Description Logic programs

Scalable reasoning without sacrificing much expressivity

Reasoning: Polynomial with regard to the size of the ontology

The exercise from the previous session to express schema constraints with DL is based on **OWL 2 QL**!

Summary

- Description Logics
  - TBOX
    - Constructs
    - Formal Semantics
  - ABOX
  - Reasoning
- OWL
  - Languages
  - Profiles