

Ontology Languages: OWL



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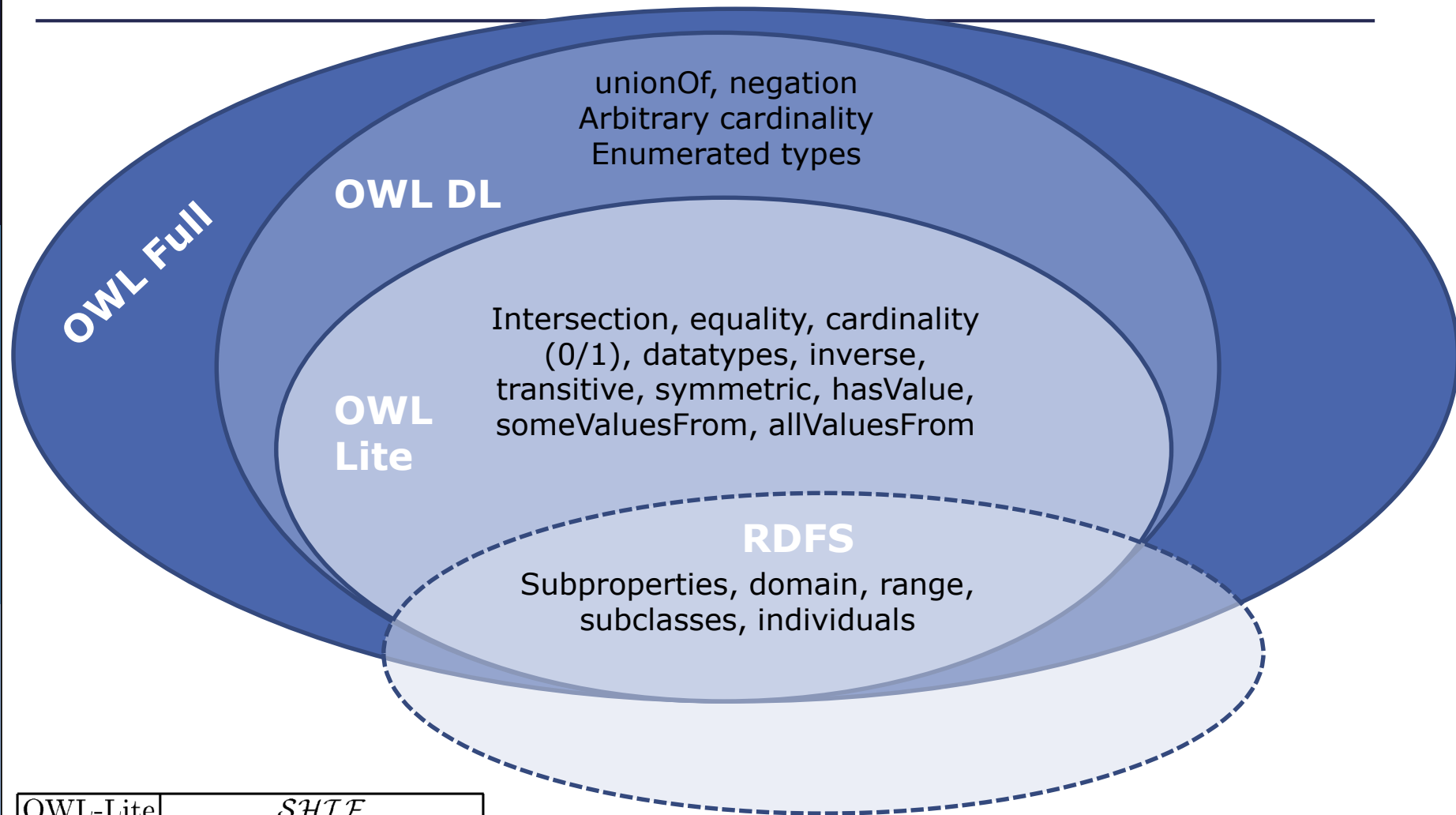
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OWL

- ❑ 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	<i>SHIF</i>
OWL-DL	<i>SHOIN</i>
OWL-Full	Unconstrained <i>SHOIN</i>

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

Syntax Example (Constructs)

OWL constructor	DL constructor	Example
intersectionOf	$C_1 \sqcap \dots \sqcap C_n$	Human \sqcap Male
unionOf	$C_1 \sqcup \dots \sqcup C_n$	Doctor \sqcup Lawyer
complementOf	$\neg C$	\neg Male
oneOf	$\{a_1\} \sqcup \dots \sqcup \{a_n\}$	{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 owl:onProperty :Leads
_:a owl:allValuesFrom :Professor
```

_:a is a complex constraint

denotes the constrained property

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 $\sqsubseteq \forall \text{ :Leads . :Professor}$

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
```

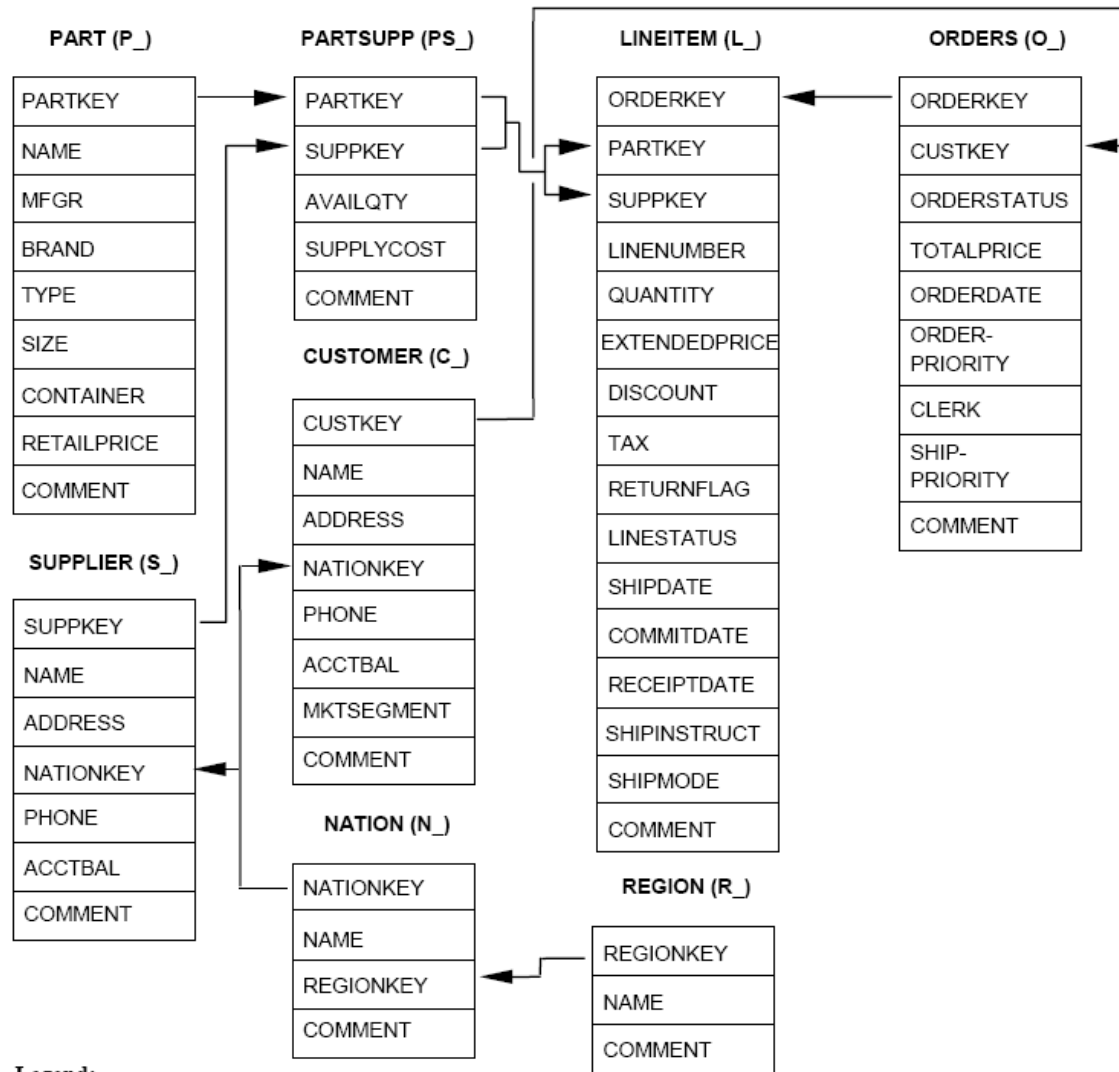
□ How do you express this constraint in DL?

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



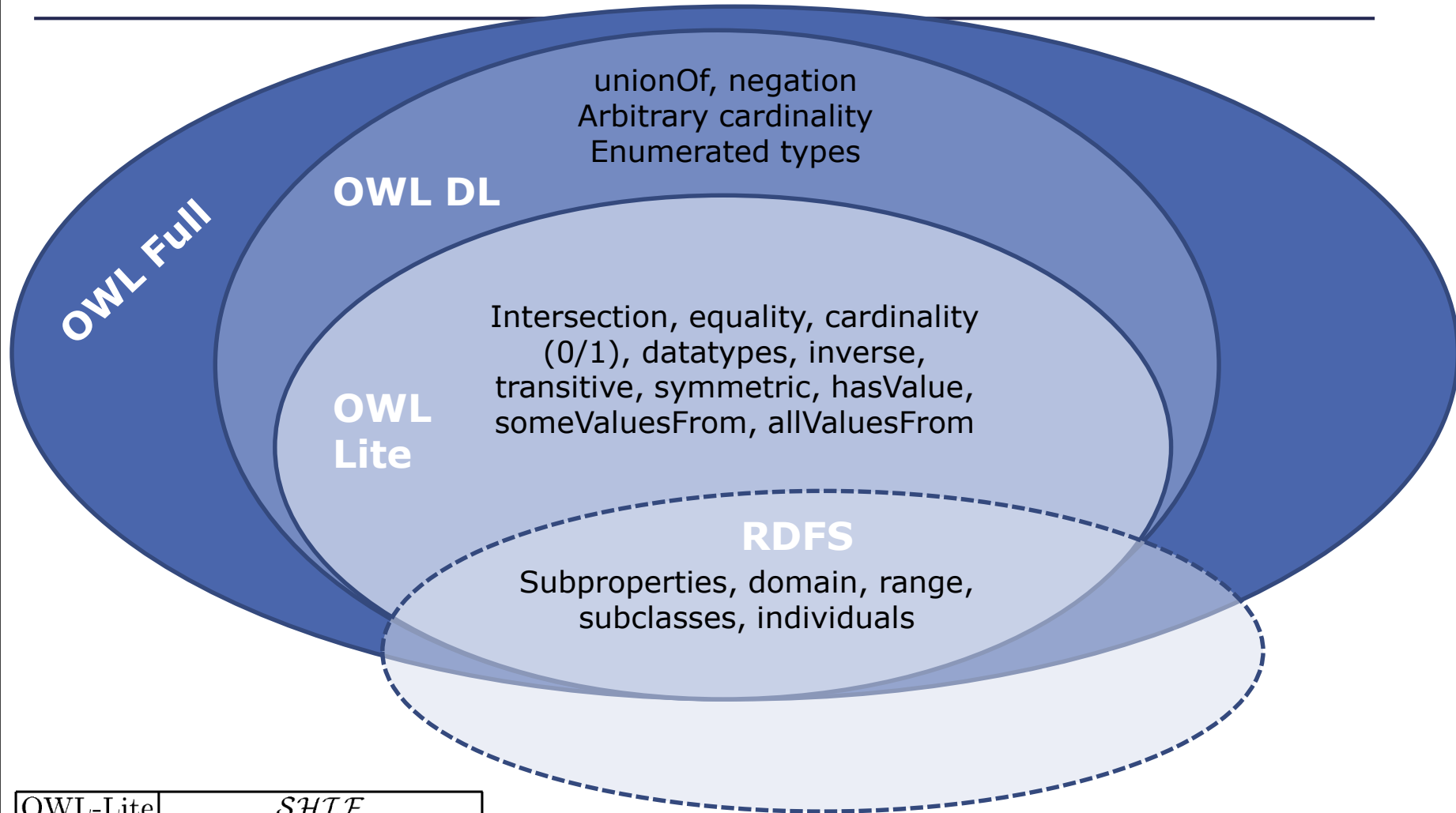
Example of OWL Syntax (II)



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