Ontology Languages: OWL

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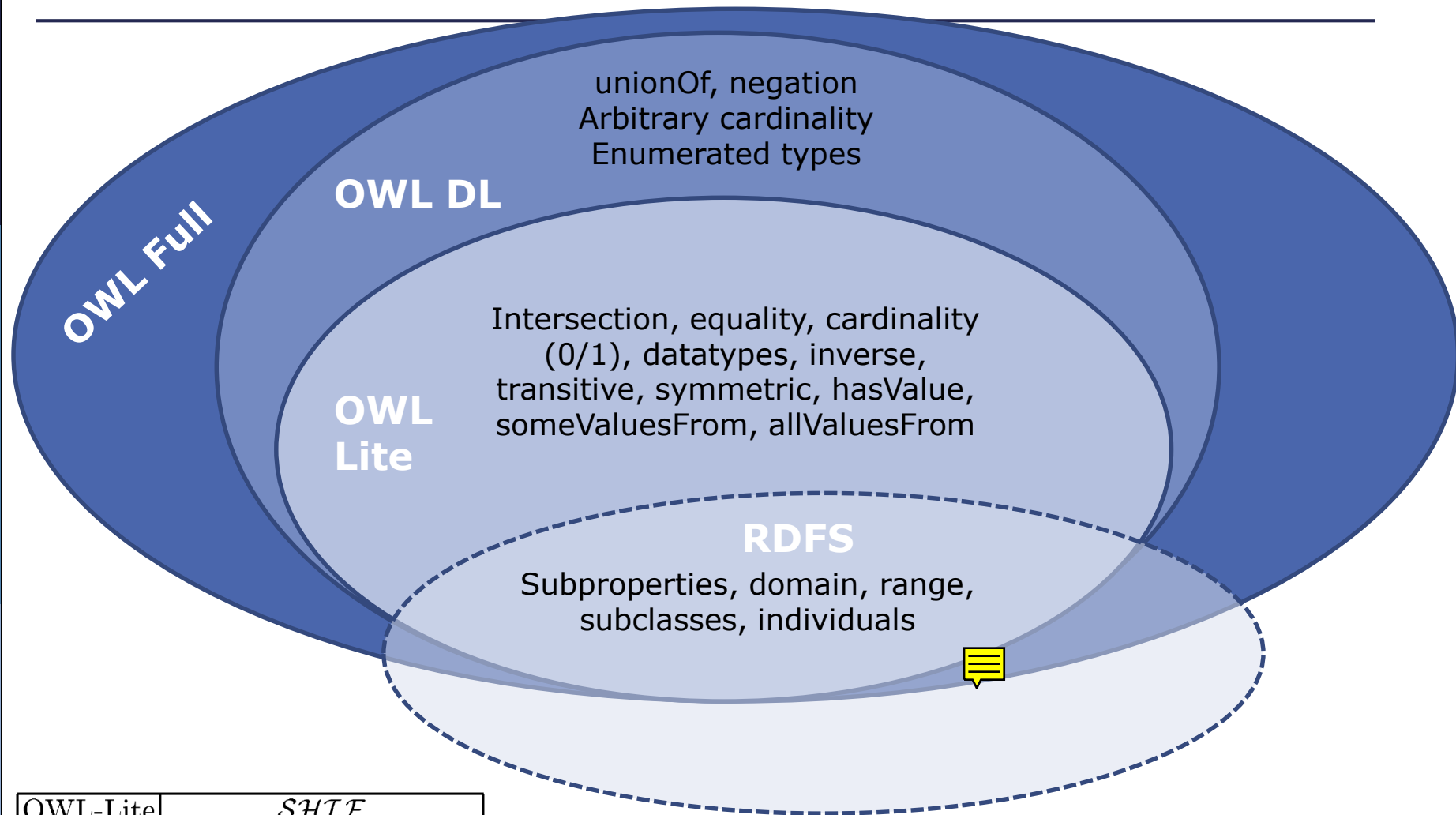
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OWL

- 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 Full

OWL DL

unionOf, negation
Arbitrary cardinality
Enumerated types

OWL Lite

Intersection, equality, cardinality
(0/1), datatypes, inverse,
transitive, symmetric, hasValue,
someValuesFrom, allValuesFrom

RDFS
Subproperties, domain, range,
subclasses, individuals

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	$(\leq n\, P)$	$(\leq 1\, \text{hasChild})$
minCardinality	$(\geq n\, P)$	$(\geq 2\, \text{hasChild})$

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
```
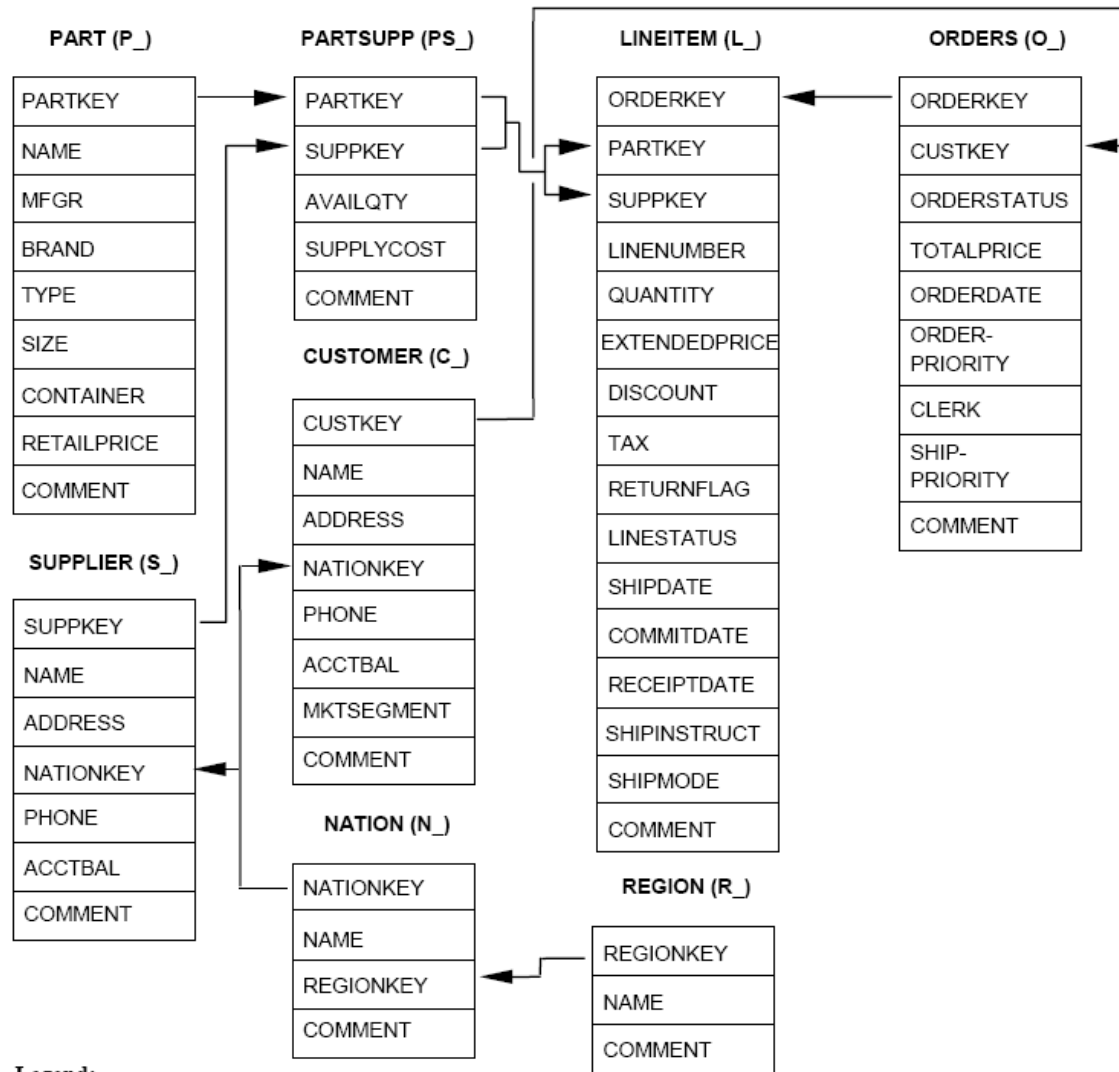
□ How do you express this constraint in DL?

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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;
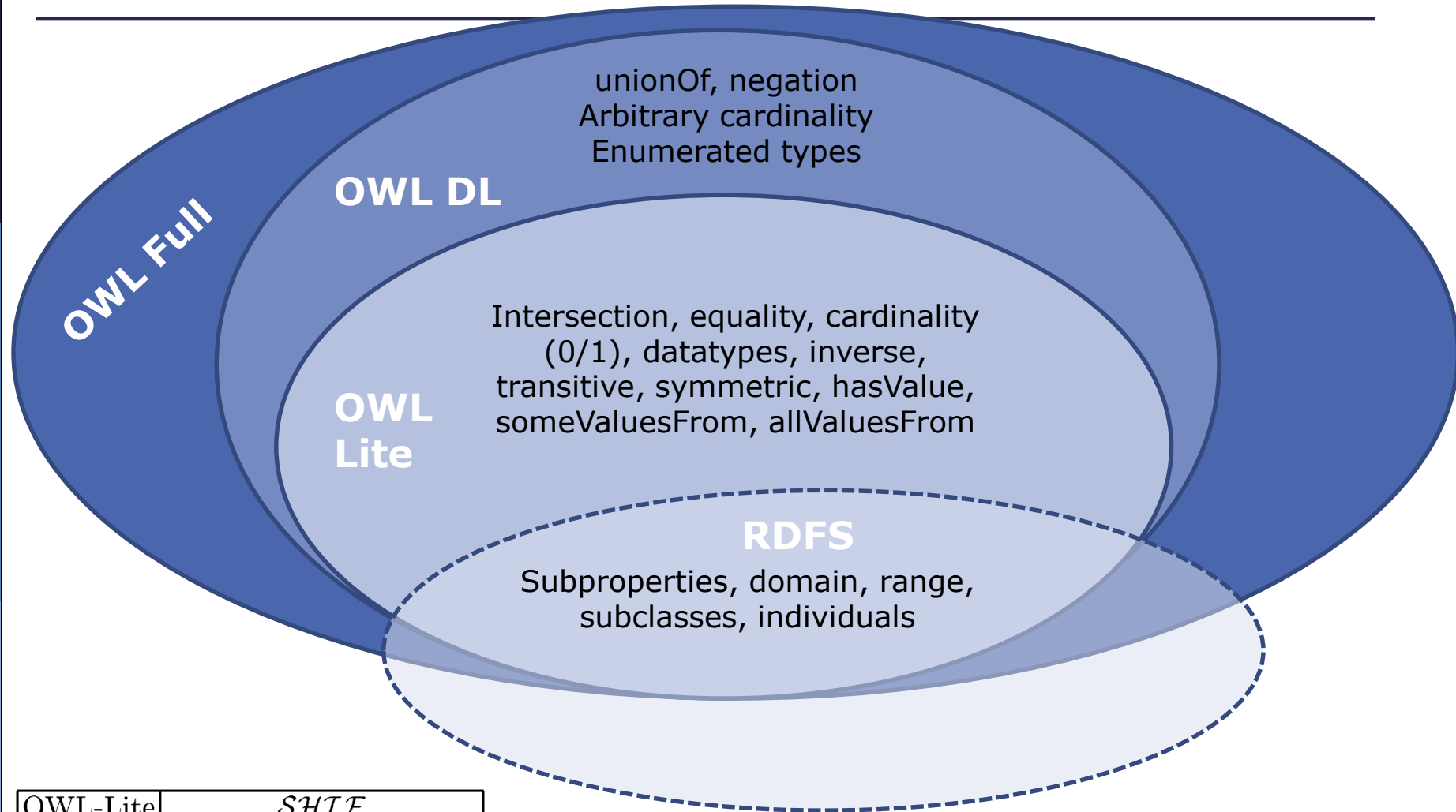
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Example of OWL Syntax (II)

Sample

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

OWL: Recap

unionOf, negation
Arbitrary cardinality
Enumerated types

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OWL DL

OWL Lite

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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