OWL

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OWL

W3C recommendation (2003)

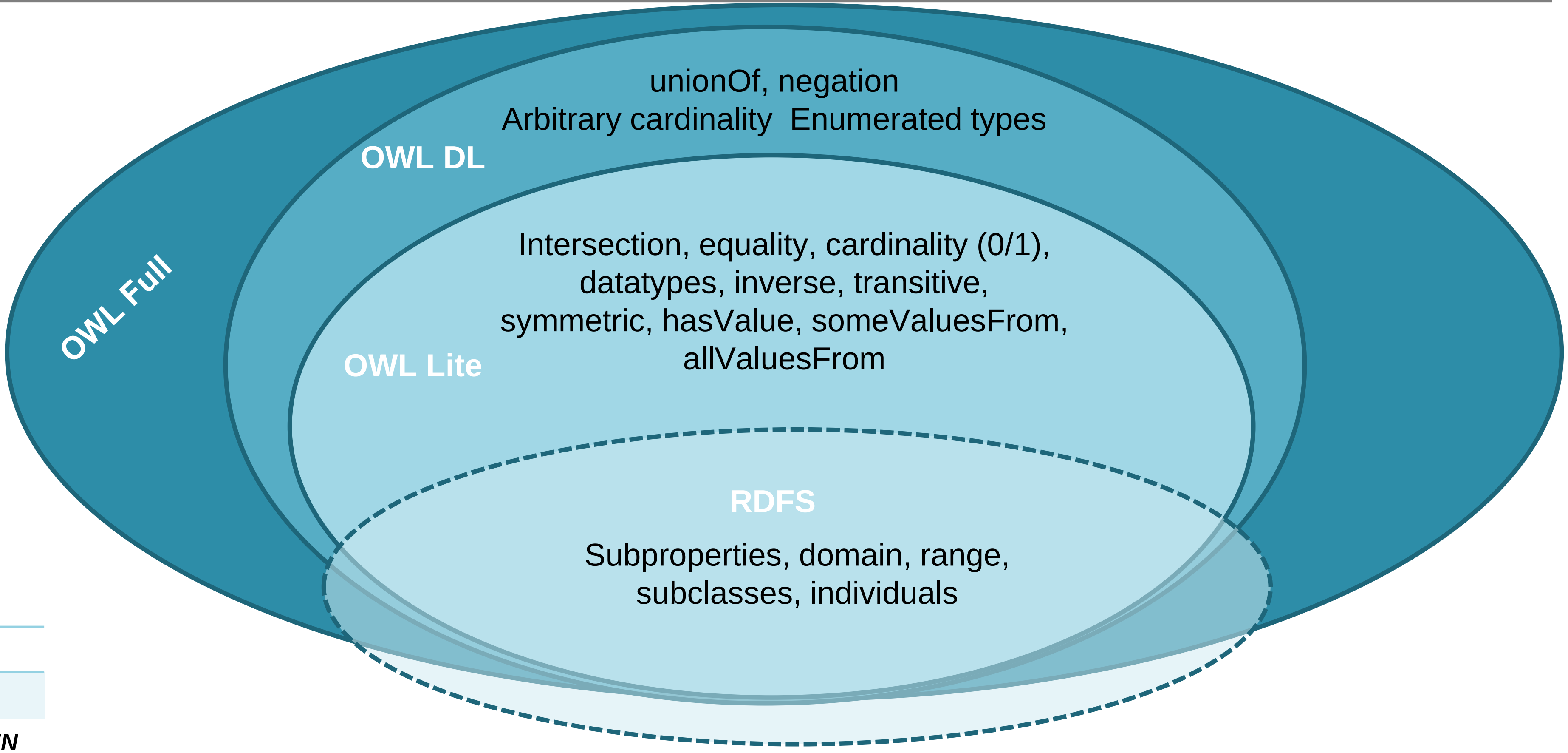
Based on OIL and DAML

OWL allows to express certain Description Logics in the form of Knowledge Graphs

- Uses RDF as underlying representation (and therefore, OWL creates a knowledge graph)
- There were three languages in OWL 1.0 (each mapping to a different description logic):
  - Lite
  - DL
  - Full
- OWL 2.0 eliminates OWL Full and Lite and adds three profiles: RL, QL, EL (all of them mapping, again, to a specific description logic)

Thus, OWL is nothing else than syntactic sugar for Description Logics (!)

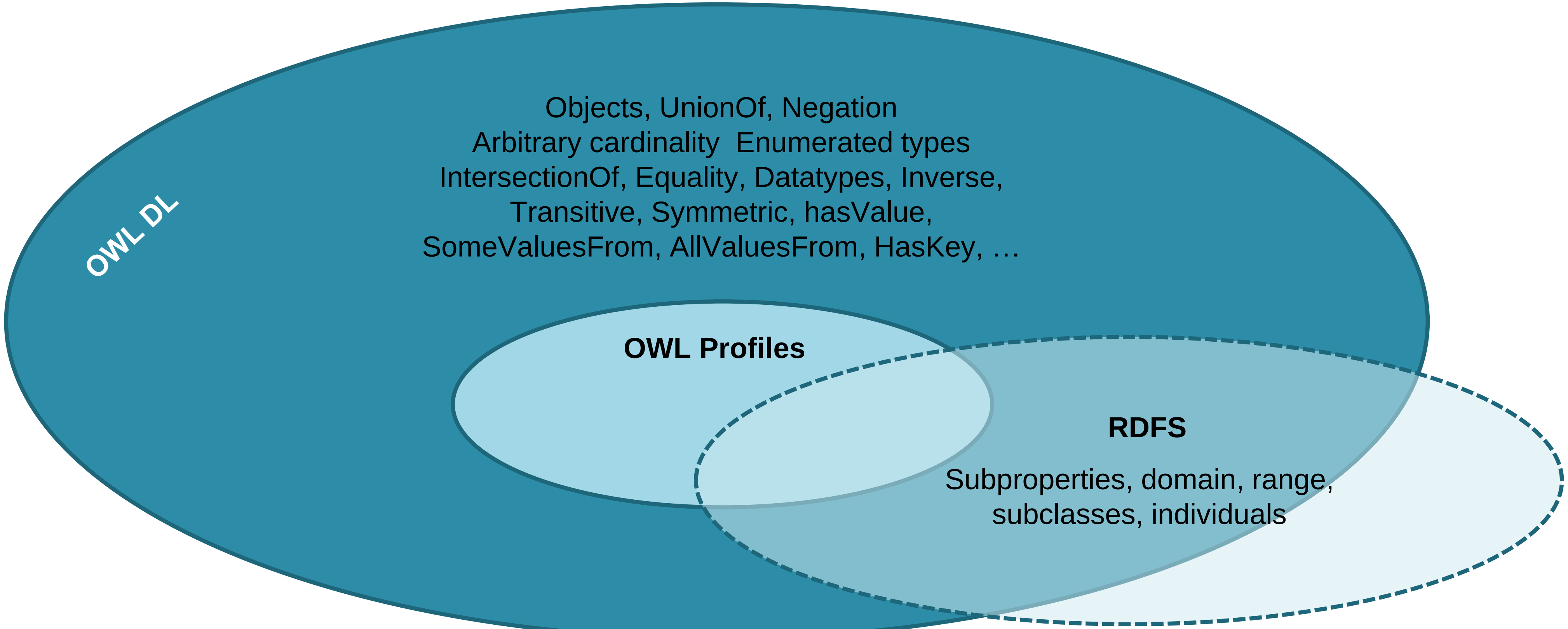
OWL 1.0



OWL-Lite	***SHIF***
OWL-DL	***SHOIN***
OWL-Full	**Unconstrained *SHOIN***

Based on Sven Groppe's Data Management and Query Processing in Semantic Web Databases

OWL 2.0



https://www.w3.org/TR/2012/REC-owl2-direct-semantics-20121211/#Vocabulary

OWL-DL	***SROIQ***

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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

Important: OWL reuses rdfs:subClassOf, rdfs:subPropertyOf but it does not apply the rule-based inference we saw with RDFS but applies DL reasoning (!)

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 Constructs

Most OWL constructs are binary and translate to RDF as <subject, predicate, object>. However, constructs such as *owl:someValuesFrom,owl:allValuesFrom, owl:minCardinality,owl:maxCardinality* are N-ary relationships that require using blank nodes together with *owl:Restriction* (i.e., they use **reification** to express the construct)

Example:

_:a	rdfs:subClassOf	owl:Restriction	_:a is a complex concept
_:a	owl:onProperty	:Leads	denotes the property used to create the complex concept
_:a	owl:allValuesFrom	:Professor	denotes the class expresión related to the property

The class describing the set of individuals for which all range values of the property *:Leads* are instances of the class *:Professor (i.e., this is equivalent to the use of range in RDFS)*

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

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

Complex Constraints (II)

Cardinalities (via constrained 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 axiom?

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

_:a	rdfs:subClassOf	owl:Restriction
_:a	owl:onProperty	P
_:a	owl:someValuesFrom	C

:C_1 rdfs:subClassOf _:a

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?

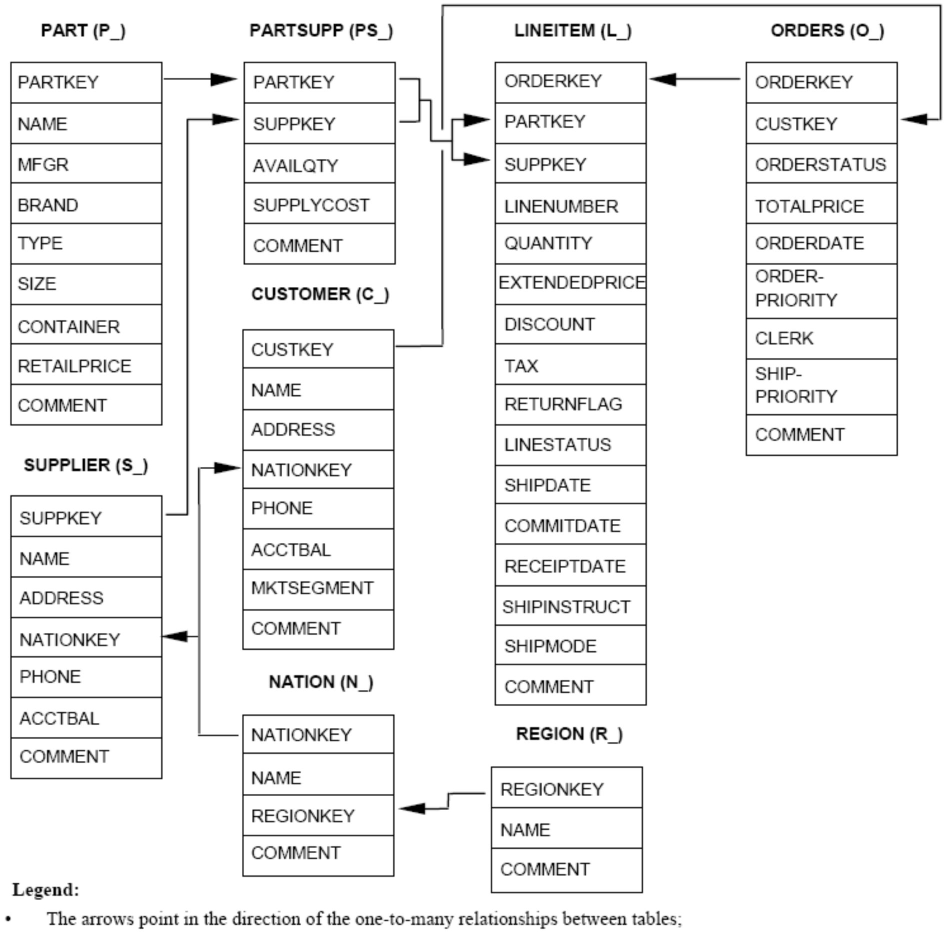
OWL Implementation

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 and the RDFS rule-based inference does not apply in OWL

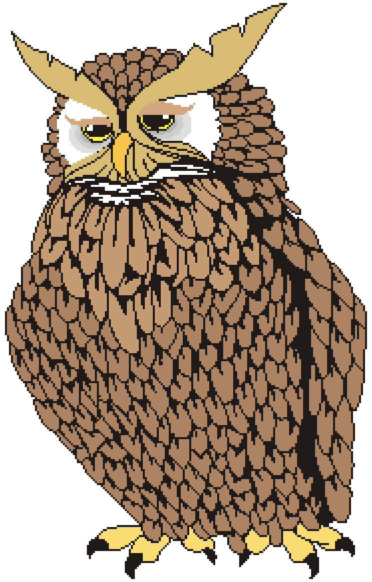
III. OWL adds new properties and classes based on DL and defined at the OWL namespace: http://www.w3.org/2002/07/owl#

Example of OWL Syntax (I) –RDF/XML



Translation to OWL DL

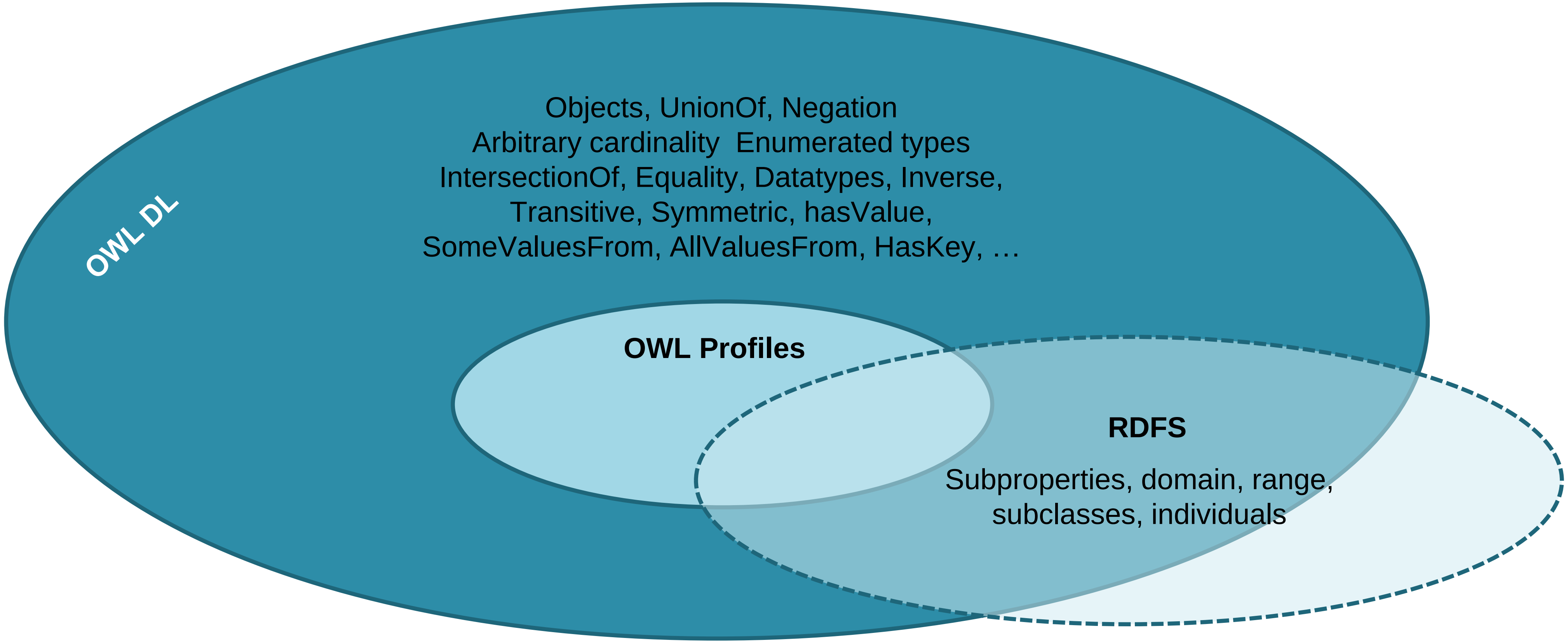
Example of OWL Syntax (II)



Sample

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

OWL 2.0



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OWL-DL	*SROIQ*

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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

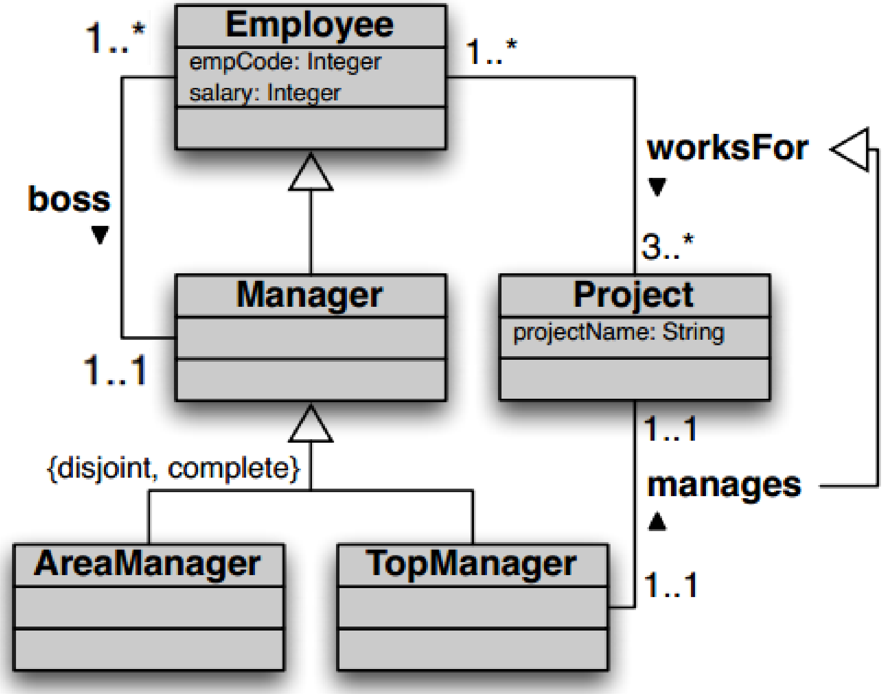
Scalable reasoning without sacrificing much expressivity

Reasoning: Polynomial with regard to the size of the ontology

The expressivity required to capture UML schemas (like the exercise from the previous session) is contained in **OWL 2 QL**!

Exercise

Create a OWL Knowledge Graph capturing as much constraints as possible from the following schema:



Summary

Description Logics

- TBOX
  - Constructs
  - Formal Semantics
- ABOX
- Reasoning

OWL

- Languages
- Profiles