OWL: Ontology Web Language

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https://www.fun-mooc.fr/courses/course-v1:inria+41002+session03/about

Ontology Web Language (OWL)

- W3C recommendation
- provides additional primitives for expressing more complex ontologies
- enables richer class and property definitions
- enables to infer more facts, to perform more inferences

namespaces and prefix to use OWL

http://www.w3.org/2002/07/owl#

- namespace of OWL primitives
- same principle than for RDFS
- usual prefix: `owl` (used in the following)

Course outline

1. Class relationships
2. Property characteristics
3. Equivalences and alignements
4. Property restrictions
5. Ontology management
6. OWL profiles

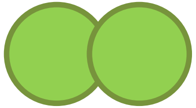
enumerated classes

class defined by enumareting its instances

```
:EyeColor rdf:type owl:Class ;
  owl:oneOf
      ( :Blue :Green :Brown :Black )   .
```

```
<owl:Class rdf:id="EyeColor">
    <owl:oneOf rdf:parseType="Collection">
      <owl:Thing rdf:ID="Blue"/>
      <owl:Thing rdf:ID="Green"/>
      <owl:Thing rdf:ID="Brown"/>
      <owl:Thing rdf:ID="Black"/>
    </owl:oneOf>
</owl:Class>
```

class union

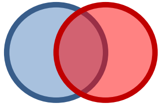


class defined as the set of resources which are instances of at least one of the given classes

```
:LegalAgent rdf:type owl:Class ;
  owl:unionOf ( :Person :Group )   .
```

```
<owl:Class rdf:id="LegalAgent">
   <owl:unionOf rdf:parseType="Collection">
       <owl:Class rdf:about="#Person"/>
       <owl:Class rdf:about="#Group"/>
   </owl:unionOf>
</owl:Class>
```

class intersection

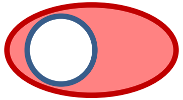


class defined as the set of resources which are instances of all the given classes

```
<owl:Class rdf:id="Man">
   <owl:intersectionOf rdf:parseType="Collection">
       <owl:Class rdf:about="#Person"/>
       <owl:Class rdf:about="#Male"/>
   </owl:intersectionOf>
</owl:Class>
```

```
:Man rdf:type owl:Class ;
  owl:intersectionOf ( :Person :Male )   .
```

class negation



class defined as the set of resources which are not instance of a given class

```
<owl:Class rdf:ID="Inedible">
   <owl:complementOf rdf:resource="#Edible"/>
</owl:Class>
```

```
:Inedible rdf:type owl:Class ;
  owl:complementOf :Edible .
```

disjonction between two classes

A resource cannot belong to both classes

```
<owl:Class rdf:ID="Square">
  <owl:disjointWith rdf:resource="#Circle"/>
</owl:Class>
```

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```
:Square rdf:type owl:Class ;
  owl:disjointWith :Circle .
```

disjonction between several classes

a resource can belong at the most to one of the disjoint classes

```
<owl:AllDisjointClasses>
  <owl:members rdf:parseType="Collection">
    <owl:Class rdf:about="#Square"/>
    <owl:Class rdf:about="#Circle"/>
    <owl:Class rdf:about="#Triangle"/>
  </owl:members>
</owl:AllDisjointClasses>
```

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□≠△

```
[] rdf:type owl:AllDisjointClasses ;
   owl:members
    ( :Square :Circle :Triangle ) .
```

disjoint union

division of a class into a complete partition of subclasses

```
<owl:Class rdf:about="Passenger">
  <owl:disjointUnionOf rdf:parseType="Collection">
    <owl:Class rdf:about="#Adult"/>
    <owl:Class rdf:about="#Child"/>
    <owl:Class rdf:about="#Pet"/>
  </owl:disjointUnionOf>
</owl:Class>
```

```
:Passenger rdf:type owl:Class ;
  owl:disjointUnionOf
  ( :Adult :Child :Pet ) .
```

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1. Class relationships
2. **Property characteristics**
3. Equivalences and alignements
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three different kinds of properties

1. `owl:ObjectProperty`
   relations between resources

2. `owl:DatatypeProperty`
   relations having literal (typed) values

3. `owl:AnnotationProperty`
   relations ignored by reasoners, used to document the ontology or for extensions

symmetric properties

relations which, when they hold, hold in both directions

$x\ R\ y \Rightarrow y\ R\ x$

```
<owl:SymmetricProperty rdf:ID="hasSpouse" />
```

```
:hasSpouse rdf:type owl:SymmetricProperty .
```

asymmetric properties

relations which, when they hold, cannot hold in both directions

$$x \; R \; y \Rightarrow \neg \; y \; R \; x$$

```
<owl:AsymmetricProperty rdf:ID="hasChild" />
```

```
:hasChild a owl:AsymmetricProperty .
```

inverse properties

two relations holding together in the opposite direction

$x\ R_1\ y \Leftrightarrow y\ R_2\ x$

```
<rdf:Property rdf:ID="hasChild">
  <owl:inverseOf rdf:resource="#hasParent" />
</rdf:Property>
```

```
:hasChild owl:inverseOf :hasParent .
```

transitive properties

relations which propagate from one resource to its neighbour

$x\ R\ y\ \&\ y\ R\ z \Rightarrow x\ R\ z$

```
<owl:TransitiveProperty rdf:ID="hasAncestor" />
```

```
:hasAncestor a owl:TransitiveProperty .
```

disjoint properties

relations which cannot hold between the same subject and object

```
<owl:ObjectProperty rdf:about="hasSon">
  <owl:propertyDisjointWith rdf:resource="hasDaughter"/>
</owl:ObjectProperty>
```

```
:hasSon owl:propertyDisjointWith :hasDaughter .
```

reflexive properties

relations which link all their subjects to themselves

```
<owl:ReflexiveProperty rdf:about="hasRelative"/>
```

```
:hasRelative a owl:ReflexiveProperty .
```

irreflexive properties

relations which cannot link a resource to itself

```
<owl:IrreflexiveProperty rdf:about="hasParent"/>
```

```
:hasParent a owl:IrreflexiveProperty .
```

property chains

a chain of relations can imply another relation

$x\ P\ y\ \&\ y\ Q\ z \Rightarrow x\ R\ z$

```
<owl:ObjectProperty rdf:ID="uncle">
  <owl:propertyChainAxiom rdf:parseType="Collection">
    <owl:ObjectProperty rdf:about="#parent"/>
    <owl:ObjectProperty rdf:about="#brother"/>
  </owl:propertyChainAxiom>
</owl:ObjectProperty>
```

```
:uncle a owl:ObjectProperty ;
 owl:propertyChainAxiom (:parent :brother) .
```

functional properties

relations for which a resource can only have a single value

$x \; R \; y \; \& \; x \; R \; z \Rightarrow y = z$

```
<owl:FunctionalProperty rdf:ID="birthDate" />
```

```
:birthDate a owl:FunctionalProperty .
```

inverse functional properties

relations for which the same value implies the same subject

$x \, R \, y \,\&\, z \, R \, y \Rightarrow x = z$

```
<owl:InverseFunctionalProperty
   rdf:ID="socialSecurityNumber" />
```

```
:socialSecurityNumber a owl:InverseFunctionalProperty .
```

identification by keys

two instances having the same key value(s) are the same instance

$$x\ c_1\ v_1\ ;\ c_2\ v_2\ \&\ y\ c_1\ v_1\ ;\ c_2\ v_2 \Rightarrow x = y$$

```
<owl:Class rdf:about="Person">
   <owl:hasKey rdf:parseType="Collection">
     <owl:DataProperty rdf:about="hasSSN"/>
   </owl:hasKey>
</owl:Class>
```

```
:Person owl:hasKey ( :hasSSN ) .
```

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equivalent classes

two classes gathering exactly the same resources

```
ex:Human owl:equivalentClass foaf:Person
```

equivalent properties

two property types expressing exactly the same relation

```
ex:name owl:equivalentProperty my:label
```

same resources

tow URI identifying exactly the same thing

```
ex:Bill owl:sameAs ex:William
```

propagation of the identity (transitivity)

- URI_1 owl:sameAs URI_2
- URI_2 owl:sameAs URI_3

…

- URI_1 owl:sameAs URI_3

different resources

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two URI which are known as identifying two different things

```
ex:Good owl:differentFrom ex:Evil
```

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restriction of property values

for the instances of the defined class, all the values of a given property are of a same given type, i.e. instances of a same given class

```
 <owl:Class rdf:ID="Herbivore">
   <rdfs:subClassOf rdf:resource="#Animal"/>
   <rdfs:subClassOf>
    <owl:Restriction>
     <owl:onProperty rdf:resource="#eats" />
     <owl:allValuesFrom rdf:resource="#Plant" />
    </owl:Restriction>
   </rdfs:subClassOf>
</owl:Class>
```

```
:Herbivore a owl:Class; rdfs:subClassOf
  [ a owl:Restriction ; owl:onProperty :eats;
    owl:allValuesFrom :Plant]
```

restriction of some property values

for the instances of the defined class, at least one value of a given property is instance of a given class

```
<owl:Class rdf:ID="Sportive">
 <owl:equivalentClass>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#hobby" />
   <owl:someValuesFrom rdf:resource="#Sport" />
  </owl:Restriction>
 </owl:equivalentClass>
</owl:Class>
```

```
:Sportive a owl:Class; owl:equivalentClass
  [ a owl:Restriction ; owl:onProperty :hobby;
    owl:someValuesFrom :Sport]
```

restriction to a single property value

the instances of the defined class can only have a given single value for the given property

```
<owl:Class rdf:ID="Bicycle">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#nbWheels" />
   <owl:hasValue>2</owl:hasValue>
  </owl:Restriction>
 </rdfs:subClassOf>
</owl:Class>
```

```
:Bicycle a owl:Class; rdfs:subClassOf
  [ a owl:Restriction ; owl:onProperty :nbWheels ;
    owl:hasValue 2]
```

restriction of a property value to its subject

class defined as the set of instances having themselves as value of a given property

```
:NarcisticPerson rdfs:subClassOf
[ a owl:Restriction ;
   owl:onProperty :love ;
   owl:hasSelf true ]
```

cardinality restriction

constraint on the number of times that a property can be used with different values for a given subject: minimum, maximum, exact number

```
<owl:Class rdf:ID="Person">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#name" />
   <owl:maxCardinality>1</owl:maxCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
</owl:Class>
```

```
:Person a owl:Class; rdfs:subClassOf
  [ a owl:Restriction ; owl:onProperty :name;
    owl:maxCardinality 1]
```

qualified cardinality restriction

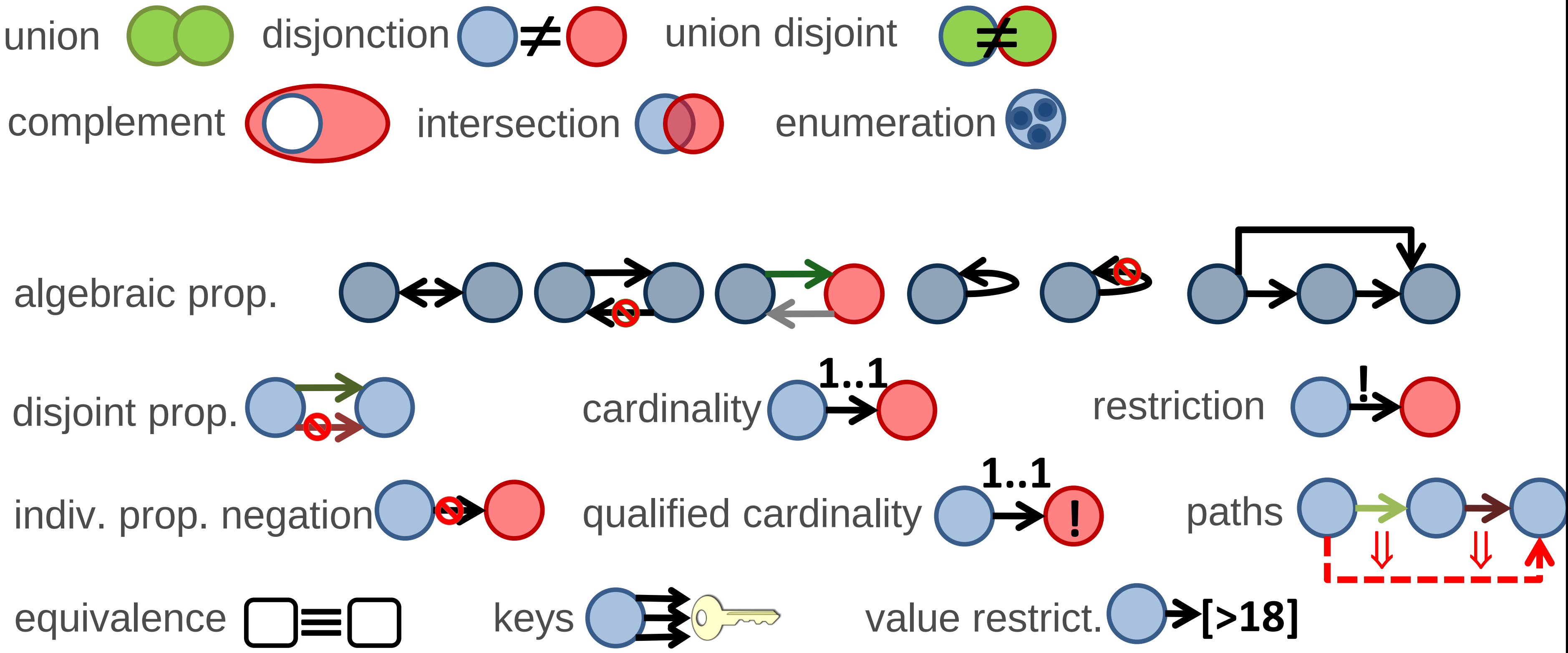
constraint on the number of times that a property can be used with different values of a given type for a given subject: minimum, maximum, exact number

```
<owl:Class rdf:ID="Human">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#hasParent" />
   <owl:onClass rdf:resource="#Male" />
   <owl:qualifiedCardinality>1</owl:qualifiedCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
</owl:Class>
```

```
:Human a owl:Class; rdfs:subClassOf
  [ a owl:Restriction; owl:onProperty :hasParent;
    owl:onClass :Male ; owl:qualifiedCardinality 1]
```

OWL in one…

a graphical view of OWL constructs



union

disjonction

union disjoint

complement

intersection

enumeration

algebraic prop.

disjoint prop.

cardinality

restriction

indiv. prop. negation

qualified cardinality

paths

equivalence

keys

value restrict.

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documenting ontologies

- an ontology is also a resource
- an ontology can be identified by a URI and then be described in RDF
- OWL provides primitives to describe this pecial kind of resources which are ontologies

description of an ontology

one class (`owl:Ontology`) and several properties (`owl:imports`, `owl:versionInfo`, `owl:priorVersion`, `owl:backwardCompatibleWith`, `owl:incompatibleWith`)

```
<rdf:RDF xml:base="http://inria.fr/2005/humans/"
 xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
 xmlns:owl ="http://www.w3.org/2002/07/owl#">

<owl:Ontology rdf:about="http://inria.fr/2005/humans/">





</owl:Ontology>
</rdf:RDF>
```

description of an ontology

one class (`owl:Ontology`) and several properties (`owl:imports`, `owl:versionInfo`, `owl:priorVersion`, `owl:backwardCompatibleWith`, `owl:incompatibleWith`)

```
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 xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
 xmlns:owl ="http://www.w3.org/2002/07/owl#">

<owl:Ontology rdf:about="http://inria.fr/2005/humans/">
 <rdfs:comment>An example OWL ontology</rdfs:comment>



</owl:Ontology>
</rdf:RDF>
```

description of an ontology

one class (owl:Ontology) and several properties (owl:imports, owl:versionInfo, owl:priorVersion, owl:backwardCompatibleWith, owl:incompatibleWith)

```
<rdf:RDF xml:base="http://inria.fr/2005/humans/"
 xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
 xmlns:owl ="http://www.w3.org/2002/07/owl#">

<owl:Ontology rdf:about="http://inria.fr/2005/humans/">
 <rdfs:comment>An example OWL ontology</rdfs:comment>
 <owl:priorVersion
    rdf:resource="http://inria.fr/2004/humans/"/>


</owl:Ontology>
</rdf:RDF>
```

description of an ontology

one class (`owl:Ontology`) and several properties (`owl:imports`, `owl:versionInfo`, `owl:priorVersion`, `owl:backwardCompatibleWith`, `owl:incompatibleWith`)

```
<rdf:RDF xml:base="http://inria.fr/2005/humans/"
 xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
 xmlns:owl ="http://www.w3.org/2002/07/owl#">

<owl:Ontology rdf:about="http://inria.fr/2005/humans/">
 <rdfs:comment>An example OWL ontology</rdfs:comment>
 <owl:priorVersion
    rdf:resource="http://inria.fr/2004/humans/"/>
 <owl:imports rdf:resource="http://cnrs.fr/animals/"/>


</owl:Ontology>
</rdf:RDF>
```

description of an ontology

one class (`owl:Ontology`) and several properties (`owl:imports`, `owl:versionInfo`, `owl:priorVersion`, `owl:backwardCompatibleWith`, `owl:incompatibleWith`)

```
<rdf:RDF xml:base="http://inria.fr/2005/humans/"
 xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
 xmlns:owl ="http://www.w3.org/2002/07/owl#">

<owl:Ontology rdf:about="http://inria.fr/2005/humans/">
 <rdfs:comment>An example OWL ontology</rdfs:comment>
 <owl:priorVersion
    rdf:resource="http://inria.fr/2004/humans/"/>
 <owl:imports rdf:resource="http://cnrs.fr/animals/"/>
 <rdfs:label>Bio Ontology</rdfs:label>
</owl:Ontology>
</rdf:RDF>
```

changes in classes or properties

mark a class or a property as being obsolete

```
<rdf:RDF xml:base="http://inria.fr/2005/humans/"
 xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:owl="http://www.w3.org/2002/07/owl#">

 <owl:DeprecatedClass rdf:ID="mammals"/>
 <owl:DeprecatedProperty rdf:ID="age"/>

</rdf:RDF>
```

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different profiles: different expressivities

- each profile corresponds to a subset of OWL primitives
- choosing a profile means choosing an expressivity to define an ontology
- the higher the expressivity, the more complex the inferences

OWL 1 profiles

- **Lite**: mainly simple hierarchies
- **DL**: more expressive but still with complete reasoning.
- **Full**: maximal expressivity but reasoning may be incomplete

OWL 2 profiles

- **EL:** large ontology, with many properties and/or classes, polynomial time
- **QL:** large dataset, RDB-like conjunctive queries, LOGSPACE
- **RL:** reasoning scaling without loosing too much expressivity; inference rules, polynomial time
- **DL:** the most expressive