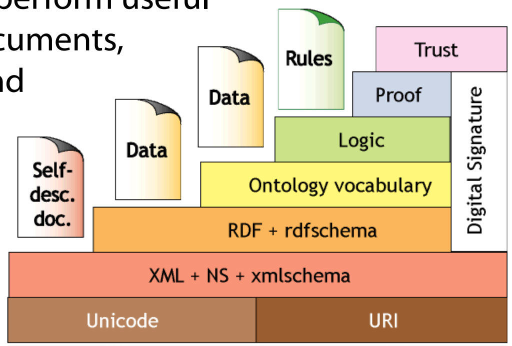
Semi-Automatic Information and Knowledge Systems, Einführung in Semantic Web
:
OWL - Web Ontology Language

Monika Lanzenberger

- Basic Ideas of OWL
- The OWL Language
  - OWL Lite: Simple Classes and Individuals
  - OWL Lite: Property Characteristics and Restrictions
  - OWL Lite: Constructs
  - OWL DL: Complex Classes
- Summary

The Semantic Web is a vision for the future of the Web [...] information is given explicit meaning, [...] machines automatically process and integrate information available on the Web.

If machines are expected to perform useful reasoning tasks on these documents, the language must go beyond the basic semantics of RDF Schema.



[W3Ca, Miller]

Ontology languages allow users to write explicit, formal conceptualizations of domain models.

The main requirements are:

- a well-defined syntax
- efficient reasoning support
- a formal semantics
- sufficient expressive power
- convenience of expression

[Antoniou and van Harmelen, 2004]

Expressive Power or Efficient Reasoning Support

- The richer the language is, the more inefficient the reasoning support becomes.
- Sometimes it crosses the border of noncomputability.
- We need a compromise:
  A language supported by reasonably efficient reasoners.
  A language that can express large classes of ontologies and knowledge.

Reasoning About Knowledge in Ontology Languages

- Class membership
  If **x** is an instance of a class **C**,
  and **C** is a subclass of **D**,
  then we can infer that **x** is an instance of **D**.
- Equivalence of classes
  If class **A** is equivalent to class **B**,
  and class **B** is equivalent to class **C**,
  then **A** is equivalent to **C**, too.

Reasoning About Knowledge in Ontology Languages

- Consistency
  Consider **x** being an instance of classes **A** and **B**,
  but **A** and **B** are disjoint.
  --> Indication of an error in the ontology.
- Classification
  Certain property-value pairs are a sufficient condition for membership in a class **A**; if an individual **x** satisfies such conditions, we can conclude that **x** must be an instance of **A**.

Reasoning in Practice

Reasoning support is important for...
... checking the consistency of the ontology and the knowledge.
... checking for unintended relationships between classes.
... automatically classifying instances in classes.

Checks like the preceding ones are valuable for...
... designing large ontologies, where multiple authors are involved.
... integrating and sharing ontologies from various sources.

- Semantics is a prerequisite for reasoning support
- Formal semantics and reasoning support are usually provided by...
  ... mapping an ontology language to a known logical formalism.
  ... using automated reasoners that already exist for those formalisms.
- OWL is (partially) mapped on a description logic, and makes use of reasoners such as FaCT, RACER, Pellet.
- Description logics are a subset of predicate logic for which efficient reasoning support is possible.

Local scope of properties

- rdfs:range defines the range of a property (e.g. eats) for all classes .
- In RDF Schema we cannot declare range restrictions that apply to some classes only.
- E.g. , we cannot say that cows eat only plants, while other animals may eat meat, too.

Disjointness of classes:

- Sometimes we wish to say that classes are disjoint (e.g., child and adult).

Boolean combinations of classes:

- Sometimes we wish to build new classes by combining other classes using union, intersection, and complement.
- E.g., human is the disjoint union of the classes child and adult.

Cardinality restrictions:

- E.g., a person has exactly two parents, a course is taught by at least one lecturer.

Special characteristics of properties:

- Transitive property (like "greater than")
- Unique property (like "has postcode")
- A property is the inverse of another property (like "eats" and "is eaten by").

- Ideally, OWL would extend RDF Schema, consistent with the layered architecture of the Semantic Web.
- But simply extending RDF Schema would work against obtaining expressive power and efficient reasoning:
  Combining RDF Schema with logic leads to uncontrollable computational properties.
  Restrictions are required.
- Three Species of OWL defined by the W3C's Web Ontology Working Group.

OWL Lite ...

... for classification hierarchies with simple constraints,

... supports cardinality constraints, (only 0 or 1),

... simpler to provide tool support,

... provides a quick migration path for thesauri and other taxonomies,

... has a lower formal complexity than OWL DL.

... restricted: excludes for instance disjointness statements and enumerated classes.

OWL DL ...

... offers maximum expressiveness while retaining computational completeness and decidability.

... includes all OWL language constructs, used under certain restrictions (for example, while a class may be a subclass of many classes, a class cannot be an instance of another class).

OWL Full ...

... offers maximum expressiveness and the syntactic freedom of RDF with no computational guarantees. For example, in OWL Full a class can be treated simultaneously as a collection of individuals and as an individual.

... allows an ontology to augment the meaning of the pre-defined (RDF or OWL) vocabulary.

... is unlikely that any reasoning software will be able to support complete reasoning for every feature of OWL Full.

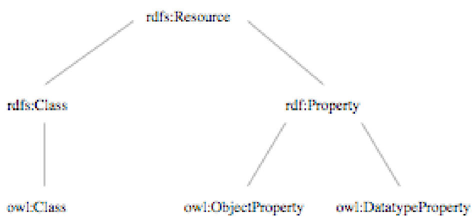
... is fully compatible with RDF (syntactially and semantically) and can be viewed as an extension of RDF, while OWL Lite and OWL DL can be seen as extensions of a restricted view of RDF: Every OWL (Lite, DL, Full) document is an RDF document, and every RDF document is an OWL Full document, but only some RDF documents will be a legal OWL Lite or OWL DL document.

Each of these sublanguages is an extension of its predecessor, both in what can be legally expressed and in what can be validly concluded.

The following set of relations hold:

- Every legal OWL Lite ontology is a legal OWL DL ontology.
- Every legal OWL DL ontology is a legal OWL Full ontology.
- Every valid OWL Lite conclusion is a valid OWL DL conclusion.
- Every valid OWL DL conclusion is a valid OWL Full conclusion.
- Their inverses do not!

- All varieties of OWL use RDF for their syntax
- Instances are declared as in RDF, using RDF descriptions
- and typing information OWL constructors are specialisations of their RDF counterparts



- XML provides a surface syntax for structured documents, but imposes no semantic constraints on the meaning of these documents.
- XML Schema is a language for restricting the structure of XML documents and also extends XML with data types.
- RDF is a data model for objects ("resources") and relations between them, provides a simple semantics for this data model, and these data models can be represented in an XML syntax.
- RDF Schema is a vocabulary for describing properties and classes of RDF resources, with a semantics for generalization-hierarchies of such properties and classes.
- OWL adds more vocabulary for describing properties and classes: among others, relations between classes (e.g. disjointness), cardinality (e.g. "exactly one"), equality, richer typing of properties, characteristics of properties (e.g. symmetry), and enumerated classes.

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  - OWL DL: Complex Classes
- Summary

Simple Named Classes:

`Class`
`rdfs:subClassOf`

```
<owl:Class rdf:ID="Winery"/>
<owl:Class rdf:ID="Region"/>
<owl:Class rdf:ID="ConsumableThing"/>
```

`Individual`

Defining Properties:

`rdf:Property`
subproperties:
`owl:ObjectProperty`
(Instance - Instance)
`owl:DatatypeProperty`
(Instance - `rdfs:Literal` / XML Schema datatypes)
`rdfs:subPropertyOf`
`rdfs:domain`
`rdfs:range`

Properties of Individuals

OWL Lite Constructs: Simple Classes and Individuals 21

Simple Named Classes:

- `Class`
- `rdfs:subClassOf`

```
<owl:Class rdf:ID="Winery"/>
<owl:Class rdf:ID="Region"/>
<owl:Class rdf:ID="ConsumableThing"/>
```

`Individual`

```
...
<!ENTITY vin  "http://www.w3.org/TR/2004/REC-owl-guide-20040210/wine#" >
<!ENTITY food "http://www.w3.org/TR/2004/REC-owl-guide-20040210/food#" >
...
<rdf:RDF xmlns:vin ="http://www.w3.org/TR/2004/REC-owl-guide-20040210/wine#"
         xmlns:food="http://www.w3.org/TR/2004/REC-owl-guide-20040210/food#" ... >
...
```

Defining Properties:

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  - subproperties:
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- `rdfs:subPropertyOf`
- `rdfs:domain`
- `rdfs:range`

Properties of Individuals

OWL Lite Constructs: Simple Classes and Individuals 22

Simple Named Classes:

- `Class`
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```
<owl:Class rdf:ID="Winery"/>
<owl:Class rdf:ID="Region"/>
<owl:Class rdf:ID="ConsumableThing"/>
```

```
<owl:Class rdf:ID="PotableLiquid">
  <rdfs:subClassOf rdf:resource="#ConsumableThing" />
  ...
</owl:Class>
```

`Individual`

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- `rdf:Property`
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- `rdfs:domain`
- `rdfs:range`

Properties of Individuals

OWL Lite Constructs: Simple Classes and Individuals 23

Simple Named Classes:

- `Class`
- `rdfs:subClassOf`

`Individual`

```
<Region rdf:ID="CentralCoastRegion" />
```

```
<owl:Thing rdf:ID="CentralCoastRegion" />

<owl:Thing rdf:about="#CentralCoastRegion">
   <rdf:type rdf:resource="#Region"/>
</owl:Thing>
```

Defining Properties:

- `rdf:Property`
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- `rdfs:domain`
- `rdfs:range`

Properties of Individuals

OWL Lite Constructs: Simple Classes and Individuals 24

Simple Named Classes:

- `Class`
- `rdfs:subClassOf`

`Individual`

```
<owl:Class rdf:ID="Grape">
  ...
</owl:Class>
```

```
<owl:Class rdf:ID="WineGrape">
  <rdfs:subClassOf rdf:resource="&food;Grape" />
</owl:Class>

<WineGrape rdf:ID="CabernetSauvignonGrape" />
```

Defining Properties:

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Properties of Individuals

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- `rdfs:subPropertyOf`
- `rdfs:domain`
- `rdfs:range`

```
<owl:ObjectProperty rdf:ID="madeFromGrape">
  <rdfs:domain rdf:resource="#Wine"/>
  <rdfs:range rdf:resource="#WineGrape"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="course">
  <rdfs:domain rdf:resource="#Meal" />
  <rdfs:range rdf:resource="#MealCourse" />
</owl:ObjectProperty>
```

Properties of Individuals

OWL Lite Constructs: Simple Classes and Individuals

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- `rdfs:subPropertyOf`
- `rdfs:domain`
- `rdfs:range`

```
<owl:Class rdf:ID="WineDescriptor" />

<owl:Class rdf:ID="WineColor">
  <rdfs:subClassOf rdf:resource="#WineDescriptor" />
  ...
</owl:Class>

<owl:ObjectProperty rdf:ID="hasWineDescriptor">
  <rdfs:domain rdf:resource="#Wine" />
  <rdfs:range  rdf:resource="#WineDescriptor" />
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="hasColor">
  <rdfs:subPropertyOf rdf:resource="#hasWineDescriptor" />
  <rdfs:range rdf:resource="#WineColor" />
  ...
</owl:ObjectProperty>
```

Properties of Individuals

OWL Lite Constructs: Simple Classes and Individuals

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Properties of Individuals

OWL Lite Constructs: Simple Classes and Individuals 29

Simple Named Classes:

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`Individual`

Defining Properties:

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`rdfs:subPropertyOf`

`rdfs:domain`

`rdfs:range`

Properties of Individuals

xsd:string	xsd:normalizedString	xsd:boolean	
xsd:decimal	xsd:float	xsd:double	
xsd:integer	xsd:nonNegativeInteger	xsd:positiveInteger	
xsd:nonPositiveInteger	xsd:negativeInteger		
xsd:long	xsd:int	xsd:short	xsd:byte
xsd:unsignedLong	xsd:unsignedInt	xsd:unsignedShort	xsd:unsignedByte
xsd:hexBinary	xsd:base64Binary		
xsd:dateTime	xsd:time	xsd:date	xsd:gYearMonth
xsd:gYear	xsd:gMonthDay	xsd:gDay	xsd:gMonth
xsd:anyURI	xsd:token	xsd:language	
xsd:NMTOKEN	xsd:Name	xsd:NCName	

OWL Lite Constructs: Simple Classes and Individuals 30

Simple Named Classes:

`Class`

`rdfs:subClassOf`

`Individual`

Defining Properties:

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(Instance - Instance)

`owl:DatatypeProperty`
(Instance - `rdfs:Literal` / XML Schema datatypes)

`rdfs:subPropertyOf`

`rdfs:domain`

`rdfs:range`

Properties of Individuals

```
<Region rdf:ID="SantaCruzMountainsRegion">
  <locatedIn rdf:resource="#CaliforniaRegion" />
</Region>

<Winery rdf:ID="SantaCruzMountainVineyard" />

<CabernetSauvignon
  rdf:ID="SantaCruzMountainVineyardCabernetSauvignon" >
  <locatedIn   rdf:resource="#SantaCruzMountainsRegion"/>
  <hasMaker    rdf:resource="#SantaCruzMountainVineyard" />
</CabernetSauvignon>
```


OWL Lite Constructs: Property Characteristics 31

... powerful mechanism for enhanced reasoning about a property ...

`TransitiveProperty`	P(x,y)	and	P(y,z)	implies	P(x,z)
`SymmetricProperty`	P(x,y)	iff	P(y,x)		
`FunctionalProperty`	P(x,y)	and	P(x,z)	implies	y = z
`inverseOf`	P1(x,y)	iff	P2(y,x)		
`InverseFunctionalProperty`	P(y,x)	and	P(z,x)	implies	y = z

```
<owl:ObjectProperty rdf:ID="locatedIn">
  <rdf:type rdf:resource="&owl;TransitiveProperty" />
  <rdfs:domain rdf:resource="&owl;Thing" />
  <rdfs:range rdf:resource="#Region" />
</owl:ObjectProperty>

<Region rdf:ID="SantaCruzMountainsRegion">
  <locatedIn rdf:resource="#CaliforniaRegion" />
</Region>

<Region rdf:ID="CaliforniaRegion">
  <locatedIn rdf:resource="#USRegion" />
</Region>
```


OWL Lite Constructs: Property Characteristics 32

... powerful mechanism for enhanced reasoning about a property ...

`TransitiveProperty`	P(x,y)	and	P(y,z)	implies	P(x,z)
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`InverseFunctionalProperty`	P(y,x)	and	P(z,x)	implies	y = z

```
<owl:ObjectProperty rdf:ID="adjacentRegion">
  <rdf:type rdf:resource="&owl;SymmetricProperty" />
  <rdfs:domain rdf:resource="#Region" />
  <rdfs:range rdf:resource="#Region" />
</owl:ObjectProperty>

<Region rdf:ID="MendocinoRegion">
  <locatedIn rdf:resource="#CaliforniaRegion" />
  <adjacentRegion rdf:resource="#SonomaRegion" />
</Region>
```

OWL Lite Constructs: Property Characteristics

... powerful mechanism for enhanced reasoning about a property ...

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`inverseOf`	P1(x,y)	iff	P2(y,x)		
`InverseFunctionalProperty`	P(y,x)	and	P(z,x)	implies	y = z

```
<owl:Class rdf:ID="VintageYear" />

<owl:ObjectProperty rdf:ID="hasVintageYear">
  <rdf:type rdf:resource="&owl;FunctionalProperty" />
  <rdfs:domain rdf:resource="#Vintage" />
  <rdfs:range  rdf:resource="#VintageYear" />
</owl:ObjectProperty>
```


OWL Lite Constructs: Property Characteristics

... powerful mechanism for enhanced reasoning about a property ...

`TransitiveProperty`	P(x,y)	and	P(y,z)	implies	P(x,z)
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`inverseOf`	P1(x,y)	iff	P2(y,x)		
`InverseFunctionalProperty`	P(y,x)	and	P(z,x)	implies	y = z

```
<owl:ObjectProperty rdf:ID="hasMaker">
  <rdf:type rdf:resource="&owl;FunctionalProperty" />
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="producesWine">
  <owl:inverseOf rdf:resource="#hasMaker" />
</owl:ObjectProperty>
```


OWL Lite Constructs: Property Characteristics

... powerful mechanism for enhanced reasoning about a property ...

`TransitiveProperty`	P(x,y)	and	P(y,z)	implies	P(x,z)
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`InverseFunctionalProperty`	P(y,x)	and	P(z,x)	implies	y = z

```
<owl:ObjectProperty rdf:ID="hasMaker" />

<owl:ObjectProperty rdf:ID="producesWine">
  <rdf:type rdf:resource="&owl;InverseFunctionalProperty" />
  <owl:inverseOf rdf:resource="#hasMaker" />
</owl:ObjectProperty>
```


OWL Lite Constructs: Property Restrictions

Values:

- **`owl:allValuesFrom`**
  - e.g., For all wines, if they have makers, all the makers are wineries.
- `owl:someValuesFrom`
  - e.g. For all wines, they have at least one maker that is a winery.

```
<owl:Class rdf:ID="Wine">
  <rdfs:subClassOf rdf:resource="&food;PotableLiquid" />
  ...
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="#hasMaker" />
      <owl:allValuesFrom rdf:resource="#Winery" />
    </owl:Restriction>
  </rdfs:subClassOf>
  ...
</owl:Class>
```

Cardinalities (only 0 or 1):

- `owl:minCardinality`
- `owl:maxCardinality`
- `owl:cardinality`

OWL Lite Constructs: Property Restrictions 37

Values:

`owl:allValuesFrom`

e.g., For all wines, if they have makers, all the makers are wineries.

`owl:someValuesFrom`

e.g. For all wines, they have at least one maker that is a winery.

```
<owl:Class rdf:ID="Wine">
  <rdfs:subClassOf rdf:resource="&food;PotableLiquid" />
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="#hasMaker" />
      <owl:someValuesFrom rdf:resource="#Winery" />
    </owl:Restriction>
  </rdfs:subClassOf>
  ...
</owl:Class>
```

Cardinalities (only 0 or 1):

`owl:minCardinality`
`owl:maxCardinality`
`owl:cardinality`

[W3Ca, W3Cb]

OWL Lite Constructs: Property Restrictions 38

Values:

`owl:allValuesFrom`

e.g., For all wines, if they have makers, all the makers are wineries.

`owl:someValu`

e.g. For all wi

at least one

winery.

```
<owl:Class rdf:ID="Vintage">
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="#hasVintageYear"/>
      <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
    </owl:Restriction>
  </rdfs:subClassOf>
</owl:Class>
```

Cardinalities (only 0 or 1):

`owl:minCardinality`
`owl:maxCardinality`
`owl:cardinality`

[W3Ca, W3Cb]

OWL Lite Language Constructs: (In)Equality 39

`owl:equivalentClass`
`owl:equivalentProperty`
`owl:sameAs`
`owl:differentFrom`
`owl:AllDifferent, owl:distinctMembers`

```
<owl:Class rdf:ID="Wine">
  <owl:equivalentClass rdf:resource="&vin;Wine"/>
</owl:Class>
```

```
<owl:Class rdf:ID="TexasThings">
  <owl:equivalentClass>
    <owl:Restriction>
      <owl:onProperty rdf:resource="#locatedIn" />
      <owl:someValuesFrom rdf:resource="#TexasRegion" />
    </owl:Restriction>
  </owl:equivalentClass>
</owl:Class>
```

subClassOf	TexasThings(x) implies locatedIn(x,y) and TexasRegion(y)
equivalentClass	TexasThings(x) implies locatedIn(x,y) and TexasRegion(y) locatedIn(x,y) and TexasRegion(y) implies TexasThings(x)

[W3Ca, W3Cb]

OWL Lite Language Constructs: (In)Equality 40

`owl:equivalentClass`
`owl:equivalentProperty`
`owl:sameAs`
`owl:differentFrom`
`owl:AllDifferent, owl:distinctMembers`

[W3Ca, W3Cb]

OWL Lite Language Constructs: (In)Equality

owl:equivalentClass
owl:equivalentProperty
owl:sameAs
owl:differentFrom
owl:AllDifferent, owl:distinctMembers

```
<Wine rdf:ID="MikesFavoriteWine">
  <owl:sameAs rdf:resource="#StGenevieveTexasWhite" />
</Wine>
```

```
<owl:Thing rdf:about="#BancroftChardonnay">
  <hasMaker rdf:resource="#Bancroft" />
  <hasMaker rdf:resource="#Beringer" />
</owl:Thing>
```


OWL Lite Language Constructs: (In)Equality

owl:equivalentClass
owl:equivalentProperty
owl:sameAs
owl:differentFrom
owl:AllDifferent, owl:distinctMembers

```
<WineSugar rdf:ID="Dry" />

<WineSugar rdf:ID="Sweet">
  <owl:differentFrom rdf:resource="#Dry"/>
</WineSugar>

<WineSugar rdf:ID="OffDry">
  <owl:differentFrom rdf:resource="#Dry"/>
  <owl:differentFrom rdf:resource="#Sweet"/>
</WineSugar>
```


OWL Lite Language Constructs: (In)Equality

owl:equivalentClass
owl:equivalentProperty
owl:sameAs
owl:differentFrom
owl:AllDifferent, owl:distinctMembers

```
<owl:AllDifferent>
  <owl:distinctMembers rdf:parseType="Collection">
    <vin:WineColor rdf:about="#Red" />
    <vin:WineColor rdf:about="#White" />
    <vin:WineColor rdf:about="#Rose" />
  </owl:distinctMembers>
</owl:AllDifferent>
```


OWL DL Language Constructs: Complex Classes

owl:intersectionOf
owl:unionOf
owl:complementOf
owl:oneOf
owl:disjointWith

```
<owl:Class rdf:ID="WhiteWine">
  <owl:intersectionOf rdf:parseType="Collection">
    <owl:Class rdf:about="#Wine" />
    <owl:Restriction>
      <owl:onProperty rdf:resource="#hasColor" />
      <owl:hasValue rdf:resource="#White" />
    </owl:Restriction>
  </owl:intersectionOf>
</owl:Class>
```

OWL DL Language Constructs: Complex Classes

owl:intersectionOf
owl:unionOf
owl:complementOf
owl:oneOf
owl:disjointWith

```
<owl:Class rdf:about="#Burgundy">
  <owl:intersectionOf rdf:parseType="Collection">
    <owl:Class rdf:about="#Wine" />
    <owl:Restriction>
      <owl:onProperty rdf:resource="#locatedIn" />
      <owl:hasValue rdf:resource="#BourgogneRegion" />
    </owl:Restriction>
  </owl:intersectionOf>
</owl:Class>
```


OWL DL Language Constructs: Complex Classes

owl:intersectionOf
owl:unionOf
owl:complementOf
owl:oneOf
owl:disjointWith

```
<owl:Class rdf:ID="WhiteBurgundy">
  <owl:intersectionOf rdf:parseType="Collection">
    <owl:Class rdf:about="#Burgundy" />
    <owl:Class rdf:about="#WhiteWine" />
  </owl:intersectionOf>
</owl:Class>
```


OWL DL Language Constructs: Complex Classes

owl:intersectionOf
owl:unionOf
owl:complementOf
owl:oneOf
owl:disjointWith

```
<owl:Class rdf:ID="Fruit">
  <owl:unionOf rdf:parseType="Collection">
    <owl:Class rdf:about="#SweetFruit" />
    <owl:Class rdf:about="#NonSweetFruit" />
  </owl:unionOf>
</owl:Class>
```

```
<owl:Class rdf:ID="Fruit">
  <rdfs:subClassOf rdf:resource="#SweetFruit" />
  <rdfs:subClassOf rdf:resource="#NonSweetFruit" />
</owl:Class>
```


OWL DL Language Constructs: Complex Classes

owl:intersectionOf
owl:unionOf
owl:complementOf
owl:oneOf
owl:disjointWith

```
<owl:Class rdf:ID="ConsumableThing" />

<owl:Class rdf:ID="NonConsumableThing">
  <owl:complementOf rdf:resource="#ConsumableThing" />
</owl:Class>
```

OWL DL Language Constructs: Complex Classes

owl:intersectionOf
owl:unionOf
owl:complementOf
owl:oneOf
owl:disjointWith

```
<owl:Class rdf:ID="NonFrenchWine">
  <owl:intersectionOf rdf:parseType="Collection">
    <owl:Class rdf:about="#Wine"/>
    <owl:Class>
      <owl:complementOf>
        <owl:Restriction>
          <owl:onProperty rdf:resource="#locatedIn" />
          <owl:hasValue rdf:resource="#FrenchRegion" />
        </owl:Restriction>
      </owl:complementOf>
    </owl:Class>
  </owl:intersectionOf>
</owl:Class>
```


OWL DL Language Constructs: Complex Classes

owl:intersectionOf
owl:unionOf
owl:complementOf
owl:oneOf
owl:disjointWith

```
<owl:Class rdf:ID="WineColor">
  <rdfs:subClassOf rdf:resource="#WineDescriptor"/>
  <owl:oneOf rdf:parseType="Collection">
    <owl:Thing rdf:about="#White"/>
    <owl:Thing rdf:about="#Rose"/>
    <owl:Thing rdf:about="#Red"/>
  </owl:oneOf>
</owl:Class>
```

```
<owl:Class rdf:ID="WineColor">
  <rdfs:subClassOf rdf:resource="#WineDescriptor"/>
  <owl:oneOf rdf:parseType="Collection">
    <WineColor rdf:about="#White" />
    <WineColor rdf:about="#Rose" />
    <WineColor rdf:about="#Red" />
  </owl:oneOf>
</owl:Class>
```


OWL DL Language Constructs: Complex Classes

owl:intersectionOf
owl:unionOf
owl:complementOf
owl:oneOf
owl:disjointWith

```
<owl:Class rdf:ID="WineColor">
  <rdfs:subClassOf rdf:resource="#WineDescriptor"/>
  <owl:oneOf rdf:parseType="Collection">
    <WineColor rdf:about="#White" />
    <WineColor rdf:about="#Rose" />
    <WineColor rdf:about="#Red" />
  </owl:oneOf>
</owl:Class>
```

```
<WineColor rdf:about="#White">
  <rdfs:label>White</rdfs:label>
</WineColor>
```


OWL DL Language Constructs: Complex Classes

owl:intersectionOf
owl:unionOf
owl:complementOf
owl:oneOf
owl:disjointWith

```
<owl:DatatypeProperty rdf:ID="tennisGameScore">
  <rdfs:range>
    <owl:DataRange>
      <owl:oneOf>
        <rdf:List>
          <rdf:first rdf:datatype="&xsd;integer">0</rdf:first>
          <rdf:rest>
            <rdf:List>
              <rdf:first rdf:datatype="&xsd;integer">15</rdf:first>
              <rdf:rest>
                <rdf:List>
                  <rdf:first rdf:datatype="&xsd;integer">30</rdf:first>
                  <rdf:rest>
                    <rdf:List>
                      <rdf:first rdf:datatype="&xsd;integer">40</rdf:first>
                      <rdf:rest rdf:resource="&rdf;nil" />
                    </rdf:List>
                  </rdf:rest>
                </rdf:List>
              </rdf:rest>
            </rdf:List>
          </rdf:rest>
        </rdf:List>
      </owl:oneOf>
    </owl:DataRange>
  </rdfs:range>
</owl:DatatypeProperty>
```

owl:intersectionOf
owl:unionOf
owl:complementOf
owl:oneOf
owl:disjointWith

```
<owl:Class rdf:ID="Pasta">
  <rdfs:subClassOf rdf:resource="#EdibleThing"/>
  <owl:disjointWith rdf:resource="#Meat"/>
  <owl:disjointWith rdf:resource="#Fowl"/>
  <owl:disjointWith rdf:resource="#Seafood"/>
  <owl:disjointWith rdf:resource="#Dessert"/>
  <owl:disjointWith rdf:resource="#Fruit"/>
</owl:Class>
```


owl:intersectionOf
owl:unionOf
owl:complementOf
owl:oneOf
owl:disjointWith

```
<owl:Class rdf:ID="SweetFruit">
  <rdfs:subClassOf rdf:resource="#EdibleThing" />
</owl:Class>

<owl:Class rdf:ID="NonSweetFruit">
  <rdfs:subClassOf rdf:resource="#EdibleThing" />
  <owl:disjointWith rdf:resource="#SweetFruit" />
</owl:Class>

<owl:Class rdf:ID="Fruit">
  <owl:unionOf rdf:parseType="Collection">
    <owl:Class rdf:about="#SweetFruit" />
    <owl:Class rdf:about="#NonSweetFruit" />
  </owl:unionOf>
</owl:Class>
```


Outline

- Basic Ideas of OWL
- The OWL Language
  - OWL Lite: Simple Classes and Individuals
  - OWL Lite: Property Characteristics and Restrictions
  - OWL Lite: Constructs
  - OWL DL: Complex Classes
- **Summary**

Summary

OWL ...

... is a Web Ontology Language designed for use by applications that need to process the content of information instead of just presenting information to humans.

... is the proposed standard for Web ontologies.

... is used to explicitly represent the meaning of terms in vocabularies and the relationships between those terms -> Ontology.

OWL ...

... facilitates greater machine interpretability of Web content than XML, RDF, and RDF Schema (RDF-S) by providing additional vocabulary along with a formal semantics.

... is a revision of the DAML+OIL web ontology language and builds upon RDF and RDF Schema:

- (XML-based) RDF syntax is used.
- Instances are defined using RDF descriptions.
- Most RDFS modeling primitives are used.

... has three increasingly-expressive sublanguages: OWL Lite, OWL DL, and OWL Full.

OWL ...

... provides formal semantics and reasoning support through the mapping of OWL on logics.

... is sufficiently rich to be used in practice, extensions are in the making: They will provide further logical features, including rules.

... needs user-friendly tool-support for automatic or semi-automatic generation of OWL-code.

[W3Ca] OWL Web Ontology Language Overview,
http://www.w3.org/TR/2004/REC-owl-features-20040210/,
W3C Recommendation 10 February 2004, (checked online 29. Sep. 2006)

[W3Cb] OWL Web Ontology Language Guide,
http://www.w3.org/TR/2004/REC-owl-guide-20040210/,
W3C Recommendation 10 February 2004, (checked online 29. Sep. 2006)

[Miller] Miller, Eric: W3C Layer Cake,
http://www.w3.org/2001/09/06-ecdl/slide17-0.html
(checked online 29. Sep. 2006)

[Antoniou and van Harmelen, 2004] Grigoris Antoniou and Frank van Harmelen, A Semantic Web Primer, MIT Press, Massachusetts, 2004.

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Hours: Tuesday, 10-11h

next: Examples, OWL in practice, Protégé & Ontology Engineering

...Grigoris Antoniou and
...Frank van Harmelen

for making nice slides of their presentations available.