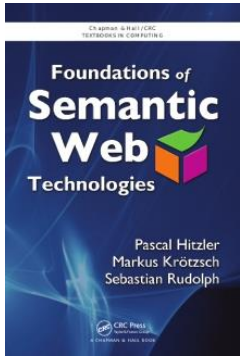
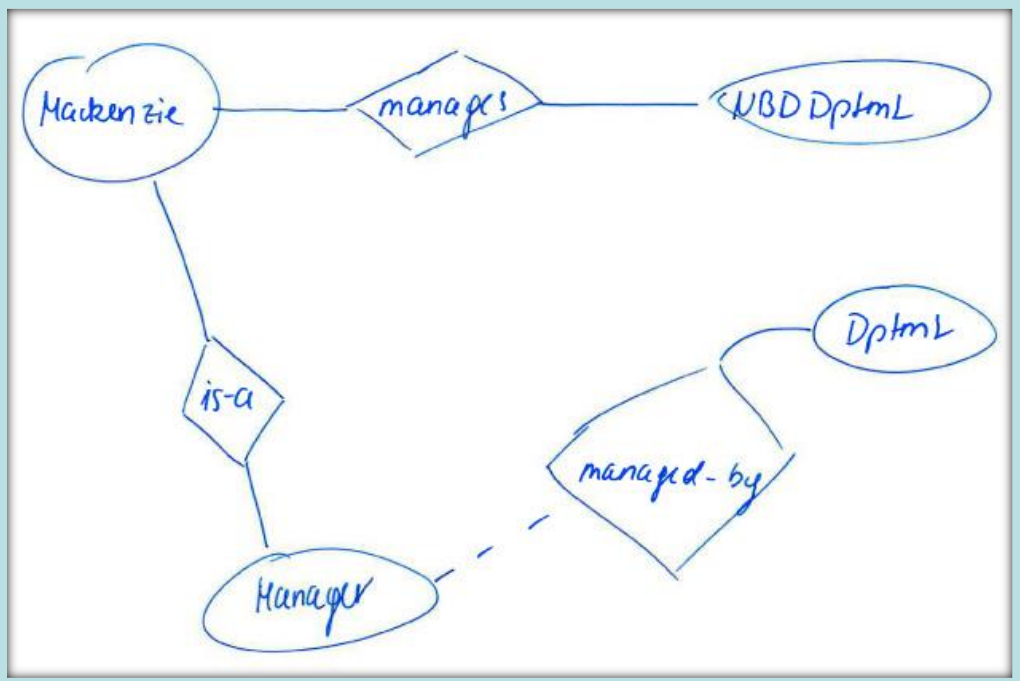
RDFS and OWL

With Thanks to Pascal Hitzler, his course website http://www.semantic-web-book.org/page/KR4SW-12 from where many examples especially concerning RDF(S) are taken from, and the Foundations of the Semantic Web Book (http://www.semantic-web-book.org).

I have also made use of other online resources that are linked to in each section for further reading.

All errors that appear in THIS slide set are naturally mine, and additionally consider that this course does not go as much into depth as the slides, book and sites referred to.





Extenc s ucture

Extenc s bility (URIs as e n

Expres aw…):

- Mackenzie manages the New Business Development department
- Mackenzie is a manager.
- Departments are managed by managers.

RDF

… good for expressing facts (assertional knowledge)

… lacks the ability to express general knowledge (terminological knowledge).

Enter: RDFS and OWL (2)

RDFS = RDF Schema

- Defines an additional vocabulary with pre-defined semantics
- Every RDFS document is a valid RDF document

OWL2 = Web Ontology Language, Version 2

- Defines an additional vocabulary with pre-defined semantics
- Every OWL2 ontology serialised in RDFXML is a valid RDF(S) document, but entailments may differ if computed according to RDF(S) or OWL2 semantics.

RDFS - Classes

Classes are sets of instances (rdfs:Class)

- rdfs:Resource (class of all URIs, all other classes are subclasses)
- rdf:Property (class of all properties)
- rdfs:Literal (class of all literals)
- rdf:XMLLiteral
- rdfs:Datatype (class of all datatypes)
- rdfs:Container (super-class of rdf:Alt, rdf:Bag, rdf:Seq)
- rdfs:ContainerMembershipProperty (rdf:_1, rdf:_2, …)
- rdf:List

All these classes are instances of rdfs:Class!

RDFS - Properties

- rdfs:subClassOf (transitive)
- rdfs:subPropertyOf (transitive)
- rdf:type
- rdfs:domain
- rdfs:range
- rdfs:label
- rdfs:comment
- rdfs:member

All these properties are instances of the class ???

What is the domain, what is the range of rdfs:subClassOf? (and of the other properties)

RDFS Axiomatic Triples

```
rdf:type rdfs:domain rdfs:Resource .
rdfs:domain rdfs:domain rdf:Property .
rdfs:range rdfs:domain rdf:Property .
rdfs:subPropertyOf rdfs:domain rdf:Property .
rdfs:subClassOf rdfs:domain rdfs:Class .
rdf:subject rdfs:domain rdf:Statement .
rdf:predicate rdfs:domain rdf:Statement .
rdf:object rdfs:domain rdf:Statement .
rdfs:member rdfs:domain rdfs:Resource .
rdf:first rdfs:domain rdf:List .
rdf:rest rdfs:domain rdf:List .
rdfs:seeAlso rdfs:domain rdfs:Resource .
rdfs:isDefinedBy rdfs:domain rdfs:Resource .
rdfs:comment rdfs:domain rdfs:Resource .
rdfs:label rdfs:domain rdfs:Resource .
rdf:value rdfs:domain rdfs:Resource .

rdf:type rdfs:range rdfs:Class .
rdfs:domain rdfs:range rdfs:Class .
rdfs:range rdfs:range rdfs:Class .
rdfs:subPropertyOf rdfs:range rdf:Property .
rdfs:subClassOf rdfs:range rdfs:Class .
rdf:subject rdfs:range rdfs:Resource .
rdf:predicate rdfs:range rdfs:Resource .
rdf:object rdfs:range rdfs:Resource .
rdfs:member rdfs:range rdfs:Resource .
rdf:first rdfs:range rdfs:Resource .
rdf:rest rdfs:range rdf:List .
rdfs:seeAlso rdfs:range rdfs:Resource .
rdfs:isDefinedBy rdfs:range rdfs:Resource .
rdfs:comment rdfs:range rdfs:Literal .
rdfs:label rdfs:range rdfs:Literal .
rdf:value rdfs:range rdfs:Resource .
```

```
rdf:Alt rdfs:subClassOf rdfs:Container .
rdf:Bag rdfs:subClassOf rdfs:Container .
rdf:Seq rdfs:subClassOf rdfs:Container .
rdfs:ContainerMembershipProperty rdfs:subClassOf rdf:Property
.
rdfs:isDefinedBy rdfs:subPropertyOf rdfs:seeAlso .

rdf:XMLLiteral rdf:type rdfs:Datatype .
rdf:XMLLiteral rdfs:subClassOf rdfs:Literal .
rdfs:Datatype rdfs:subClassOf rdfs:Class .

rdf:_1 rdf:type rdfs:ContainerMembershipProperty .
rdf:_1 rdfs:domain rdfs:Resource .
rdf:_1 rdfs:range rdfs:Resource .
rdf:_2 rdf:type rdfs:ContainerMembershipProperty .
rdf:_2 rdfs:domain rdfs:Resource .
rdf:_2 rdfs:range rdfs:Resource .
```

Exercise 1

1. Express in RDFS:

- Mackenzie manages the New Business Development department
- Mackenzie is a manager.
- Departments are managed by managers.

2. Does „ex:TextBook rdfs:SubClassOf ex:Publication“ follow from these 2 triples?

ex:TextBook rdfs:subClassOf ex:Book

ex:Book rdfs:subClassOf ex:Publication

3. Of what type(s) is „ex:Manager“ given the triple below?

ex:Mackenzie rdf:type ex:Manager

Exercise 2

1. What is the type of „ex:Grings“ according to the following 3 triples?

   ex:companyStrange ex:produces ex:Grings

   ex:produces rdfs:range ex:SpaceSuit

   ex:produces rdfs:range ex:SpaceAccessory

2. How could we express, in RDFS, that „ex:Grings“ is an ex:SpaceSuit or an ex:SpaceAccessory but not necessarily both?

3. Is it a problem to say the following? What does it mean? What was intended?

   ex:produces rdfs:domain ex:Company

   ex:NBDDepartment ex:produces ex:Grings

Read more about RDFS…

http://www.w3.org/TR/rdf-schema/

http://www.semantic-web-book.org/w/images/5/5c/W2012-03-rdfs.pdf

OWL2

- Defines an additional (to RDF and RDFS) vocabulary with pre-defined semantics
- Entity names are IRIs

- Can be mapped to description logic SROIQ (fragment of FOL)
- Every OWL2 ontology serialised in RDFXML is a valid RDF(S) document, but entailments may differ if computed according to RDF(S) or OWL2 semantics.

OWL2 - Syntaxes

RDFXML Syntax

- Mandatory for OWL2 tools

OWLXML, **Functional**, Manchester, Turtle syntax

- Optional for OWL2 tools

Sublanguages:

- OWL 2 EL: less expressive, more performant reasoning
- OWL 2 QL: lightweight ontologies but many data
- OWL 2 RL: lightweight ontologies, many data, direct operations on RDF

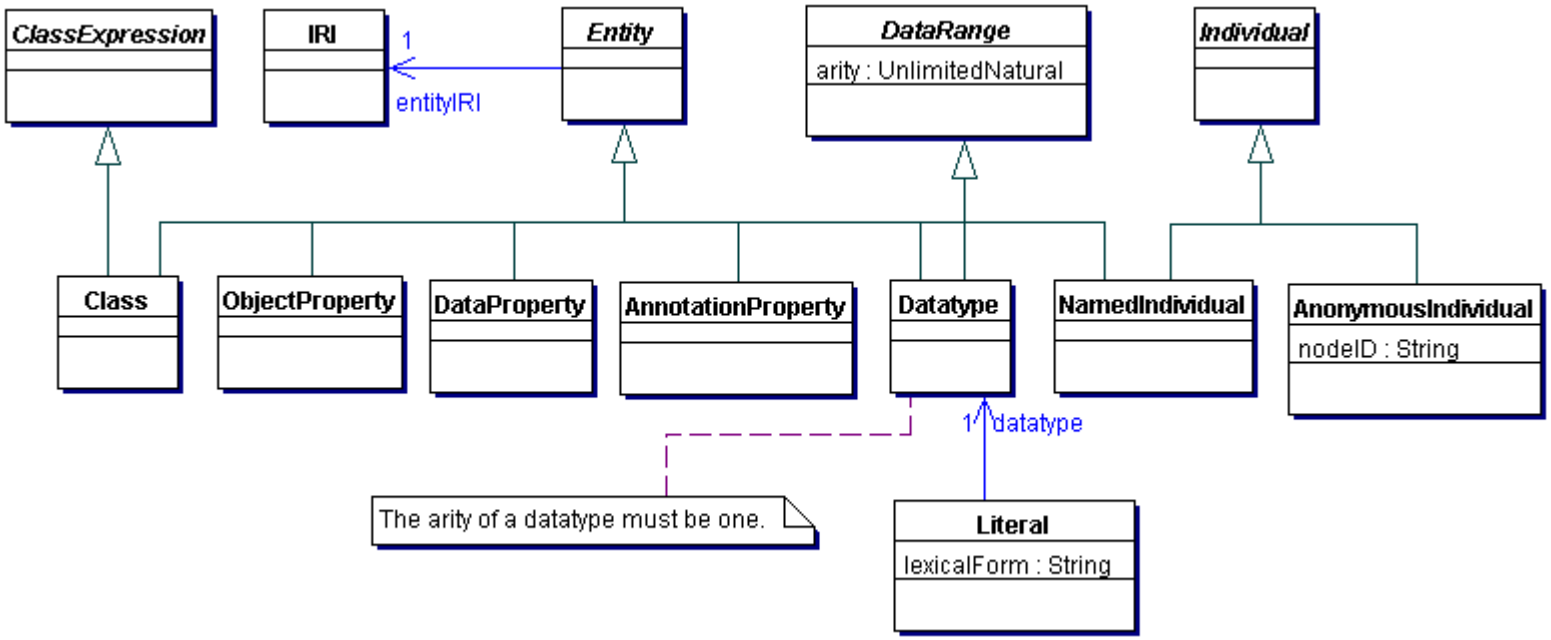
OWL2 Ontologies

- Every ontology has an IRI
- Ontologies can be versioned
- Ontologies can import other ontologies
- Ontologies can have metadata (annotations) using e.g., RDFS vocabulary

```
Prefix(xsd:=<http://www.w3.org/2001/XMLSchema#>)
Prefix(owl:=<http://www.w3.org/2002/07/owl#>)
Prefix(:=<http://www.semanticweb.org/ontologies/2012/10/Ontology1352809960
588.owl#>)
Prefix(xml:=<http://www.w3.org/XML/1998/namespace>)
Prefix(rdf:=<http://www.w3.org/1999/02/22-rdf-syntax-ns#>)
Prefix(rdfs:=<http://www.w3.org/2000/01/rdf-schema#>)


Ontology(<http://www.semanticweb.org/ontologies/2012/10/Ontology135280996
0588.owl>
Import(<http://www.xfront.com/owl/ontologies/camera/>)
Annotation(rdfs:label "My Test Ontology")
Annotation(owl:versionInfo "0.9")
Annotation(owl:priorVersion "0.75")
```

OWL2 Entities and Assertions



http://www.w3.org/TR/2009/REC-owl2-syntax-20091027/#Entities.2C_Literals.2C_and_Anonymous_Individuals

Declarations and Assertional Axioms

Declarations: are nonlogical axioms (~statements). They serve to ensure that IRIs are not used for various types of entities (datatype properties, classes, etc.).

Assertional Axioms: Assert facts or annotations about individuals

```
Declaration(NamedIndividual(:NBDD))
Declaration(NamedIndividual(:Mackenzie))
ClassAssertion(:Manager :Mackenzie)
ObjectPropertyAssertion(:manages :Mackenzie :NBDD)

AnnotationAssertion(rdfs:label :NBDD "New Business Development Department"^^xsd:string)
```

OWL2 Declarations and Metamodelling (Punning)

Declarations are nonlogical axioms (~statements). They serve to ensure that IRIs are not used for various types of entities (datatype properties, classes, etc.).

Exception: Classes/Properties and Individuals can be „mixed“ (Metamodelling or Punning, see also type separation above)

```
ClassAssertion(:SpaceShip :Orion)
ObjectPropertyAssertion (researches :Mackenzie
:SpaceShip)
```

Why not use an annotation?

Rule of Thumb:

- Metamodeling: information attached to entities is part of the domain.
- Annotations: information attached to entities should not contribute to the logical consequences of an ontology.

OWL 2 Terminological Axioms

Subclasses and Subproperties

```
SubClassOf(:SpaceAccessory :Product)
SubClassOf(:SpaceSuit :Product)
SubObjectPropertyOf(:sellOnline :sell)
SubObjectPropertyOf(:sellDirect :sell)
```

Equivalent classes and properties

```
EquivalentClasses(:OrganisationalUnit ObjectUnionOf(:Division :Department))
```

Further:

- Disjoint classes and properties
- Properties can be functional, transitive, etc.
- Property range and domain axioms (shorthand)

OWL2 Classes

- Class – A class is a set of individuals
- ObjectIntersectionOf (C1…Cn) - intersection
- ObjectUnionOf (C1…Cn) - union
- ObjectComplementOf (C) - negaton
- ObjectOneOf (a1…an) – enumeration class
- ObjectSomeValuesFrom(P C) – existential quantification
- ObjectAllValuesFrom(P C) – universal quantification
- ObjectMinCardinality(n P C) – qualified minimum cardinality
- ObjectMaxCardinality(n P C) – qualified maximum cardinality

Most expressions below can also be stated for datatype properties, for brevity we only discuss expressions involving object properties:

Read more about OWL2…

http://www.w3.org/TR/2009/REC-owl2-syntax-20091027/

This is about OWL Version 1 (some language constructs missing compared to OWL 2) but very nice to read:

http://www.co-ode.org/resources/tutorials/intro/slides/OWLFoundationsSlides.pdf

Exercise 3

Express in OWL 2 (use Protege 4.1)

- Mackenzie manages the New Business Development department
- Mackenzie is a manager.
- Departments are managed by managers (use domain and range restrictions)
  - A Department is managed by at least one and at most two managers (Use ObjectMin/MaxCardinality to express this)
- Managers work in some Department (use ObjectSomeValuesFrom to express this)
- strangeCompany is a Company
- strangeCompany produces SpaceSuits and SpaceAccessories
  - use a range restriction on „produces“ and think how to phrase the class that contains both SpaceSuits and SpaceAccessories (restricts the property „produces“ globally)
  - or define a type for strangeCompany that expresses the above