

## 13 – RDFS and SPARQL

- Main characteristics of RDF:
  - Abstract syntax based on *triples* (subj-pred-obj)
  - The data model is a *graph*, instead of a *tree*
  - *Resources* (identified by URIs) vs *literals* (xsd datatypes)
- Building patterns:
  - Blank nodes
  - Reification
- Serializations
  - RDF/XML, N3 family, RDFa
  - *NOTE:* RDF→ser→RDF returns the original RDF, while ser→RDF→ser does not necessarily return the same serialization!

## ■ Shakespeare wrote Hamlet

```
lit:Shakespeare lit:wrote lit:Hamlet .
```

```
lit:Hamlet lit:author lit:Shakespeare .
```

## ■ Shakespeare wrote Hamlet in 1601

```
bio:n1 bio:author lit:Shakespeare ;  
      bio:title "Hamlet" ;  
      bio:publicationDate 1601 .
```

## ■ Wikipedia says that Shakespeare wrote Hamlet

```
q:n1 rdf:subject lit:Shakespeare ;  
     rdf:predicate lit:wrote ;  
     rdf:object lit:Hamlet .
```

```
web:Wikipedia m:says q:n1 .
```

- RDF Schema is a semantic extension of RDF which defines *classes* and *properties* that may be used to describe classes, properties and other resources
- RDFS provides mechanisms for describing groups of related resources and the relationships between these resources
- RDFS vocabulary descriptions are written in RDF
  - Similar to XML Schema wrt XML
- Similarities with OOP
  - No real inheritance, but subclassing (an instance of a subclass is also an instance of the parent class)
  - Nothing similar to method override
- RDF Schema defines *meaning* in terms of possible *inferences*

- Just as Semantic Web modeling in RDF is about graphs, Semantic Web modeling in the RDF Schema Language (RDFS) is about sets.
- What do we gain by specifying explicitly that something is a set?
  - We gain a description of the meaning of membership in a set
- How can we specify what we mean by set membership?
  - In RDFS, we express meaning through the mechanism of *inference*

# RDF Schema at a glance

## ■ Classes

- `rdfs:Resource`
- `rdfs:Class`
- `rdfs:Literal`
- `rdfs:Datatype`
- `rdf:XMLLiteral`
- `rdf:Property`

## ■ Reification vocabulary

- `rdf:Statement`
- `rdf:subject`
- `rdf:predicate`
- `rdf:object`

## ■ Properties

- `rdfs:domain`
- `rdfs:range`
- `rdf:type`
- `rdfs:subClassOf`
- `rdfs:subPropertyOf`
- `rdfs:label`
- `rdfs:comment`

## ■ Utility properties

- `rdfs:SeeAlso`
- `rdfs:isDefinedBy`
- `rdf:value`

# Type and Relationship propagation

## ■ `rdfs:subClassOf`

- If we have triples of the form

```
A rdfs:subClassOf B.  
r rdf:type A.
```

then we can infer

```
r rdf:type B.
```

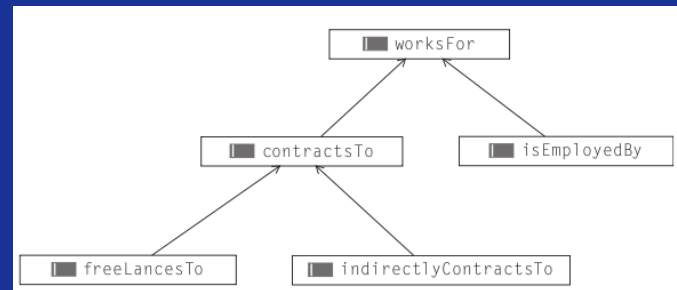
## ■ `rdfs:subPropertyOf`

- If we have triples of the form

```
P rdfs:subPropertyOf R.
```

then, if we have the triple "a P b", we can infer

```
a R b.
```

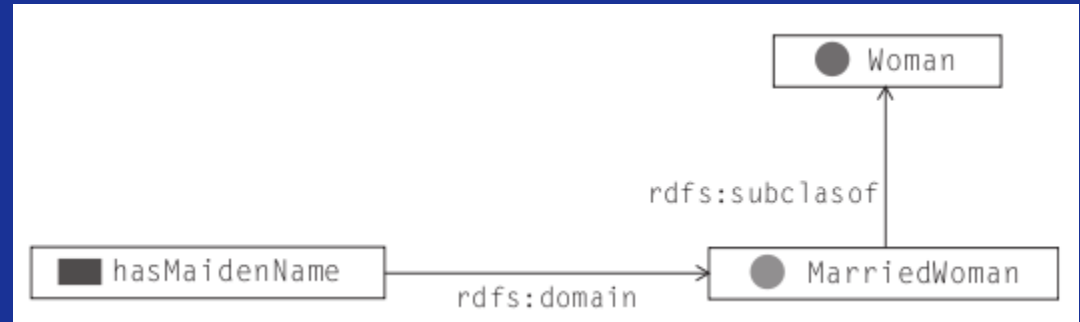


## ■ `rdfs:domain`

```
IF
P rdfs:domain D .
and
x P y .
THEN
x rdf:type D .
```

## ■ `rdfs:range`

```
IF
P rdfs:range R .
and
x P y .
THEN
y rdf:type R .
```





- In RDFS, there is no way to assert that a particular individual is not a member of a particular class
  - no notion of an incorrect or inconsistent inference
- Unlike the case of XML Schema, an RDF Schema will never proclaim an input as invalid; it will simply infer appropriate type information

## ■ Set intersection

```
C rdfs:subClassOf A.  
C rdfs:subClassOf B.  
x rdf:type C.
```

Then:

```
x rdf:type B.  
x rdf:type A.
```

## ■ Property intersection

```
:lodgedIn rdfs:subPropertyOf :billedFor.  
:lodgedIn rdfs:subPropertyOf :assignedTo.  
:Marcus :lodgedIn :Room101.
```

Then:

```
:Marcus :billedFor :Room101.  
:Marcus :assignedTo :Room101.
```

## ■ Set union

```
A rdfs:subClassOf C .  
B rdfs:subClassOf C .
```

Writing "x rdf:type A ." or "x rdf:type B ." implies:

```
x rdf:type C .
```

## ■ Property union

```
P rdfs:subPropertyOf R.  
Q rdfs:subPropertyOf R.
```

Writing "x P y ." or "x Q y ." implies:

```
x R y .
```

# Non-modeling properties

- **rdfs:label**
  - provides a readable/printable name for any resource
- **rdfs:seeAlso**
  - used for cross-referencing
- **rdfs:isDefinedBy**
  - provides a link to the primary source of information about a resource. This allows modelers to specify where the definitional description of a resource can be found
  - **rdfs:subPropertyOf** of **rdfs:seeAlso**.
- **rdfs:comment**
  - model documentation

- SPARQL is a *recursive acronym* that stands for SPARQL Protocol And RDF Query Language
- Features:
  - Graph patterns
  - Optional values
  - Matching alternatives
  - Multiple RDF graphs as data sources
  - ORDER BY, DISTINCT, OFFSET, LIMIT
  - Filters on returned values
- Let's try it! Go to <http://sparql.org>

# Our first SPARQL query

- Go to <http://www.sparql.org/query.html> and type the following:

```
PREFIX books:    <http://example.org/book/>
PREFIX dc:       <http://purl.org/dc/elements/1.1/>
PREFIX vcard:    <http://www.w3.org/2001/vcard-rdf/3.0#>
SELECT ?s ?p ?o
WHERE
    { ?s ?p ?o }
```

- The meaning is (after a sequence of namespace declarations):
  - for all the triples “subject – predicate – object”
  - show me the subject, the predicate, and the object
- ?s, ?p, and ?o are *variables* that are filled with the results that satisfy your query (in this case, all the triples in the graph)
- Use the *construct* option to create an RDF you can validate and display using the W3C validation service!

## ■ Another basic query:

```
PREFIX books:    <http://example.org/book/>
PREFIX dc:       <http://purl.org/dc/elements/1.1/>
SELECT ?book ?title
WHERE
{
  ?book dc:title ?title .
  ?book dc:creator "J.K. Rowling"
}
```

## ■ It reads like follows:

- there is a *?book* whose title is *?title*
- the same *?book* has a creator which is "J.K. Rowling"
- show me the list of book-title pairs you have (that is, give me all the books by J.K. Rowling)

## ■ NOTE: SPARQL builds a *graph* out of your query and tries to match it with the data inside the KB

# SPARQL queries with anonymous nodes

## ■ A more complex query on the books dataset:

```
PREFIX books:    <http://example.org/book/>
PREFIX dc:       <http://purl.org/dc/elements/1.1/>
PREFIX vcard:    <http://www.w3.org/2001/vcard-rdf/3.0#>
SELECT DISTINCT ?name
WHERE
{
  ?s dc:creator ?o .
    ?o vcard:N ?n .
    ?n vcard:Given ?name
}
```

## ■ It reads like follows:

- there is a *?s* whose creator is *?o*
- this *?o* has a full name which is *?n*
- this *?n* has a first/given name which is *?name*
- show me all the distinct *?names* you have



# SPARQL queries with *OPTIONAL* clause

```
PREFIX books:    <http://example.org/book/>
PREFIX dc:       <http://purl.org/dc/elements/1.1/>
SELECT ?book ?title
WHERE
{
  ?book dc:title ?title .
  ?book dc:creator "J.K. Rowling"
}
```

- What if there are books for which the creator has not been specified? Check the difference:

```
PREFIX books:    <http://example.org/book/>
PREFIX dc:       <http://purl.org/dc/elements/1.1/>
SELECT ?book ?title
WHERE
{
  ?book dc:title ?title .
  optional {?book dc:creator "J.K. Rowling"}
}
```

# SPARQL queries with anonymous nodes

## ■ A more complex query on the books dataset:

```
PREFIX books:    <http://example.org/book/>
PREFIX dc:       <http://purl.org/dc/elements/1.1/>
PREFIX vcard:    <http://www.w3.org/2001/vcard-rdf/3.0#>
SELECT ?book ?title ?creator
WHERE
{
  {?book dc:title ?title .
   ?book dc:creator "J.K. Rowling"}
  UNION
  {?book dc:title ?title .
   ?book dc:creator ?creator .
   ?creator vcard:FN "J.K. Rowling"}
}
```

## ■ NOTE: this technique is very useful to merge information coming from different schemas

# Changing datasets on SPARQLer

## ■ Three steps:

- choose “general purpose SPARQL processor”
- specify the target graph URI (for instance, try with [http://rdf.freebase.com/rdf/en.arnold\\_schwarzenegger](http://rdf.freebase.com/rdf/en.arnold_schwarzenegger))
- write a query, for instance:

```
PREFIX fb:    <http://rdf.freebase.com/ns/>
select ?film
where{
    ?s fb:film.performance.film ?film
}
```

- NOTE: to get the name of the properties, you can always send an SPO (?s ?p ?o) query!

# More advanced queries on Freebase data

## ■ Get the list of movies and the characters:

```
PREFIX fb:    <http://rdf.freebase.com/ns/>
PREFIX rdf:   <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

select ?filmtitle ?character
where{
    ?film a fb:film.performance .
    ?film fb:film.performance.film ?filmtitle .
    ?film fb:film.performance.character ?character
}
```

## ■ Get the list of related webpages:

```
PREFIX fb:    <http://rdf.freebase.com/ns/>
PREFIX rdf:   <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

select ?o
where{
    ?s fb:common.webpage.uri ?o
}
```

## ■ Some Web references:

- RDF Primer: <http://www.w3.org/TR/REC-rdf-syntax>
- RDF Schema: <http://www.w3.org/TR/rdf-schema>
- Dean Allemang, Jim Hendler: "Semantic Web for the Working Ontologist".  
<http://workingontologist.org>

## ■ Tools:

- W3C RDF Validator: <http://www.w3.org/RDF/Validator>
- Morla RDF editor: <http://www.morlardf.net>