

INFO/CS 4302

Web Information Systems

FT 2012

Week 9 : Linked Data Technologies (RDF/S, OWL)

- Bernhard Haslhofer -

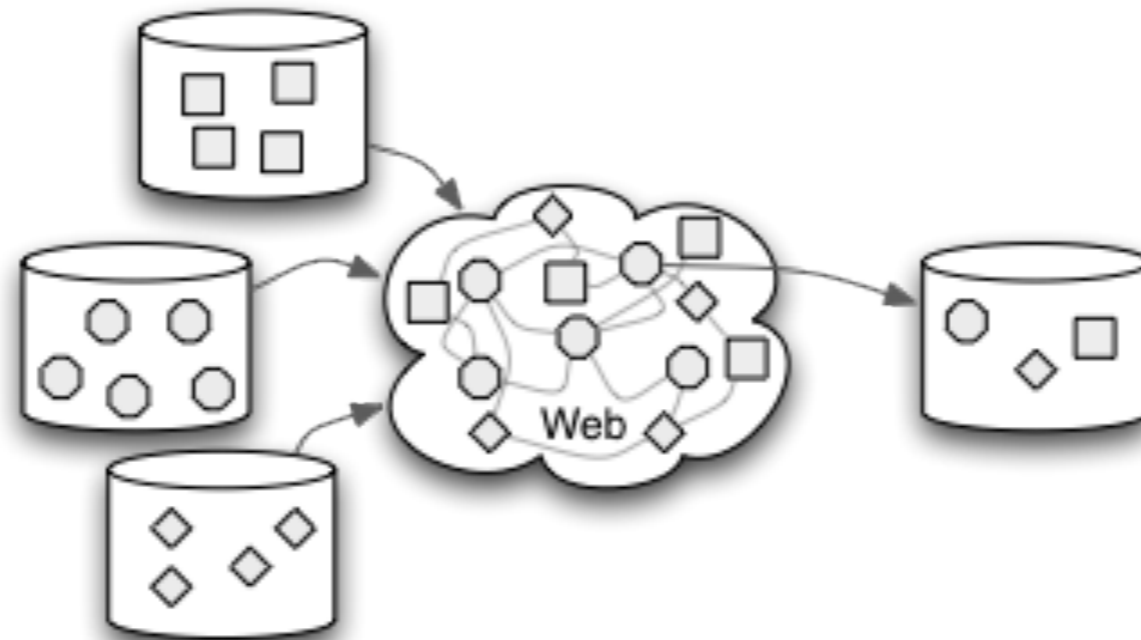
Plan for today...

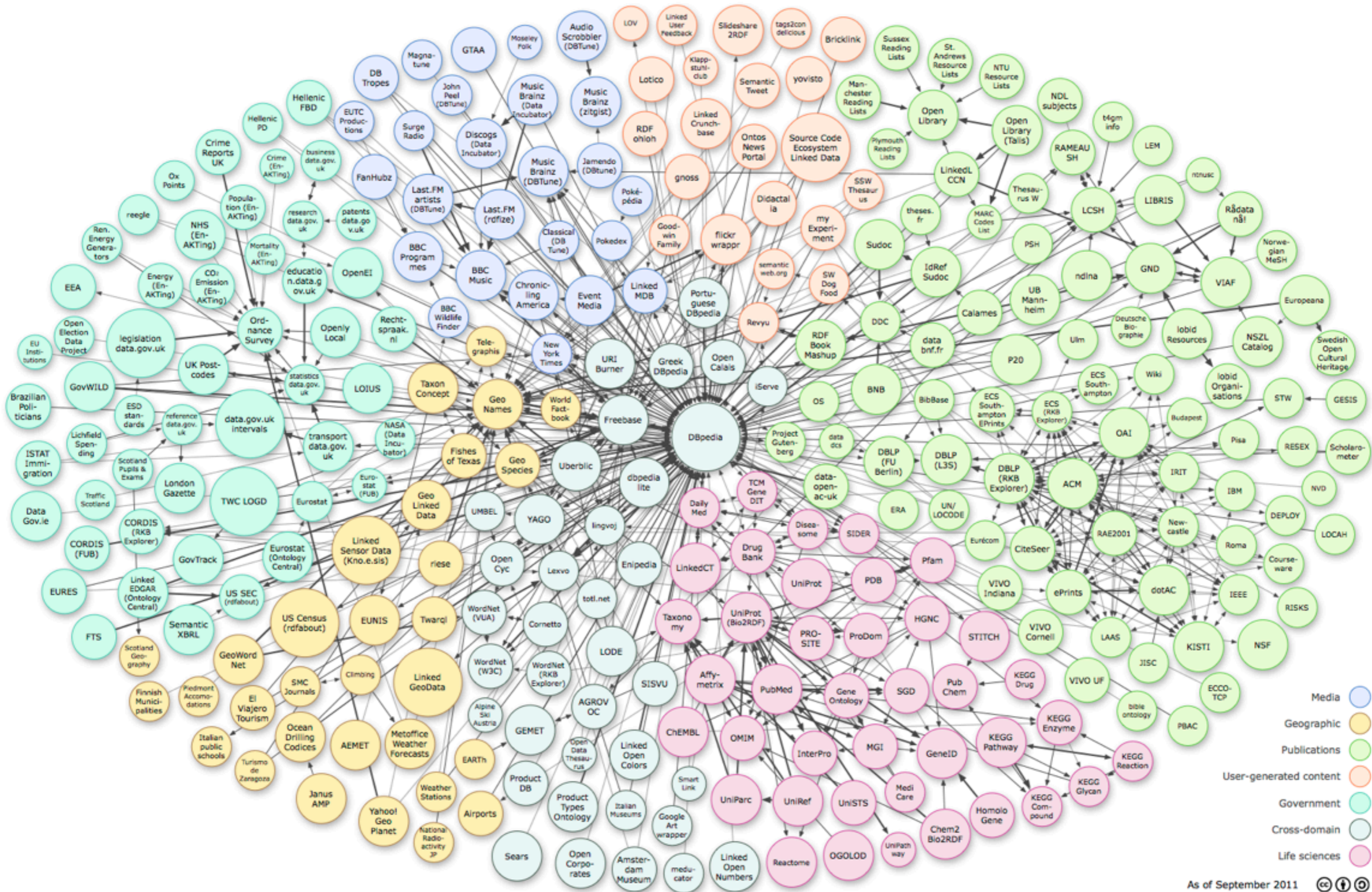
- Linked Data Technologies Overview
- RDF
- RDFS, OWL
- Groupwork: movie data in RDF
- Questions, Housekeeping, ...

LINKED DATA TECHNOLOGIES OVERVIEW

What is Linked Data?

- A method to build a **Web of Data**
- Architectural style, set of standards





As of September 2011

URI

- **Name** and **identify** things (resources)
- **Dereferencable** HTTP URIs

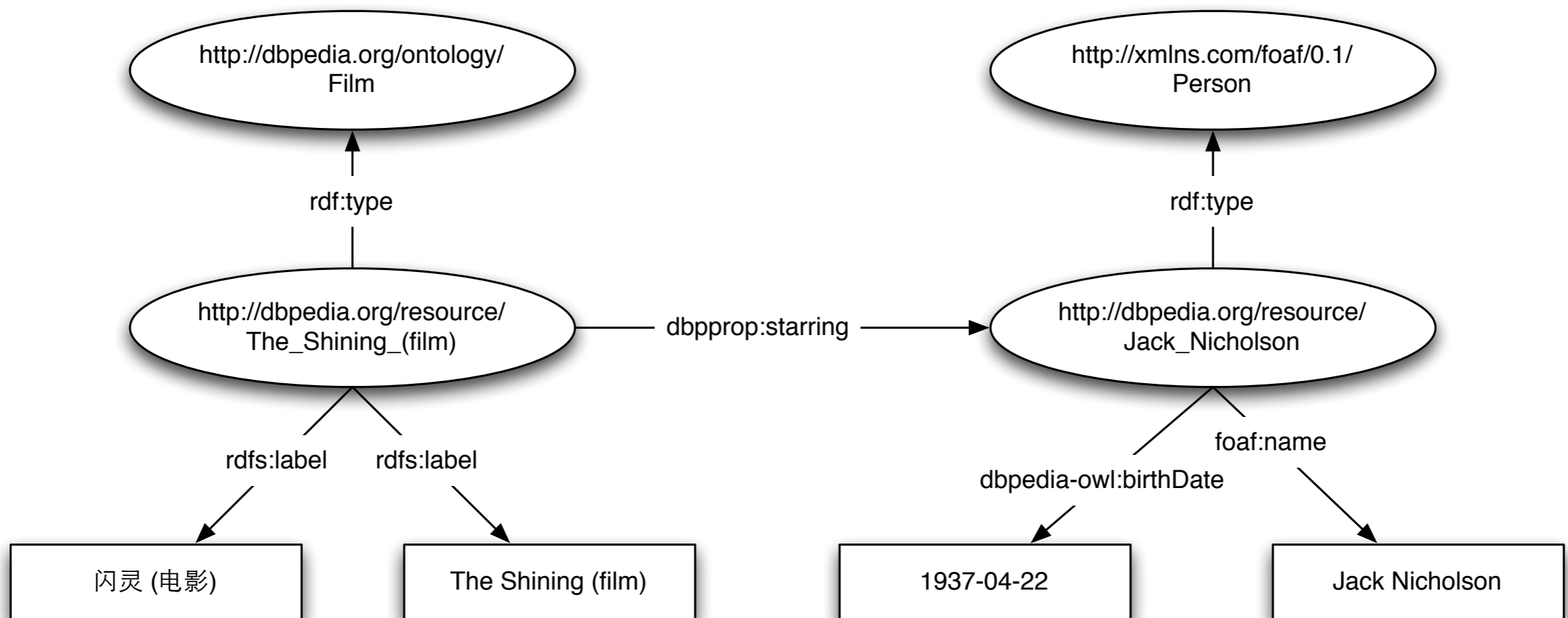
[http://data.linkedmdb.org/
resource/film/2014](http://data.linkedmdb.org/resource/film/2014)

[http://dbpedia.org/resource/
The_Shining_\(film\)](http://dbpedia.org/resource/The_Shining_(film))

[http://rdf.freebase.com/ns/m/
04fjzv](http://rdf.freebase.com/ns/m/04fjzv)

RDF

- A **data model** for representing data on the **Web**
- Several **statements** (triples) form a **graph**



RDF/XML, N3, Turtle, etc.

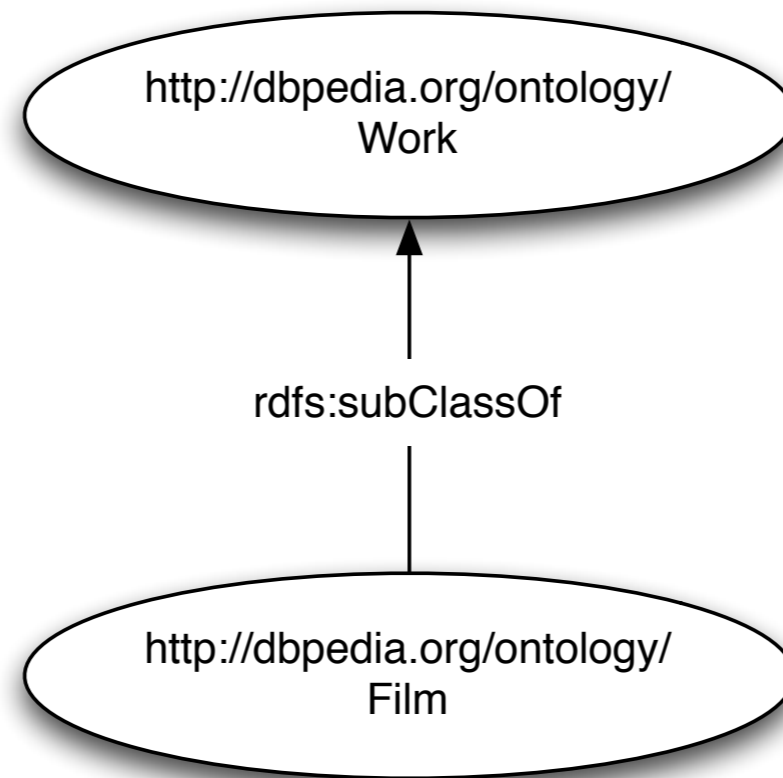
- **Data formats** for RDF resource representations
- Used to transfer RDF data between apps

```
The_Shining_(film).rdf
<?xml version="1.0" encoding="utf-8" ?>
<rdf:RDF
  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#"
  xmlns:dbpedia-owl="http://dbpedia.org/ontology/"
  xmlns:foaf="http://xmlns.com/foaf/0.1/"
  xmlns:dcterms="http://purl.org/dc/terms/"
  xmlns:dbpprop="http://dbpedia.org/property/"
  xmlns:ns7="http://www.w3.org/ns/prov#"
  xmlns:ns8="http://dbpedia.org/ontology/Work/"
  >
  <rdf:Description rdf:about="http://dbpedia.org/resource
    <rdf:type rdf:resource="http://dbpedia.org/class/yago
    <rdf:type rdf:resource="http://dbpedia.org/class/yago
    <rdf:type rdf:resource="http://dbpedia.org/class/yago
    <rdf:type rdf:resource="http://schema.org/CreativeWor
    <rdf:type rdf:resource="http://umbel.org/umbel/rc/Mov
    <rdf:type rdf:resource="http://dbpedia.org/class/yago
    <rdf:type rdf:resource="http://www.w3.org/2002/07/owl
    <rdf:type rdf:resource="http://dbpedia.org/class/yago
    <rdf:type rdf:resource="http://dbpedia.org/class/yago
    <rdf:type rdf:resource="http://dbpedia.org/class/yago
```

```
The_Shining_(film).n3
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
<http://en.wikipedia.org/wiki/The_Shining_(film)> foaf:primaryTopic
.
<http://dbpedia.org/resource/The_Shining_(film)> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
<http://mpii.de/yago/resource/The_Shining_%28film%29> owl:sameAs
.
<http://dbpedia.org/resource/The_Shining_(film)> .
@prefix dbpedia-owl: <http://dbpedia.org/ontology/> .
@prefix dbpedia: <http://dbpedia.org/resource/> .
dbpedia:Switched-On_Brandenburgs dbpedia-owl:subsequentWork
.
<http://dbpedia.org/resource/The_Shining_(film)> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix yago: <http://dbpedia.org/class/yago/> .
<http://dbpedia.org/resource/The_Shining_(film)> rdf:type yago:English-1
.
.
yago:NonlinearNarrativeFilms .
yago:FilmsAboutAlcoholism .
@prefix ns6: <http://schema.org/> .
<http://dbpedia.org/resource/The_Shining_(film)> rdf:type ns6:CreativeWo
.
yago:PinewoodFilms .
@prefix ns7: <http://umbel.org/umbel/rc/>
```

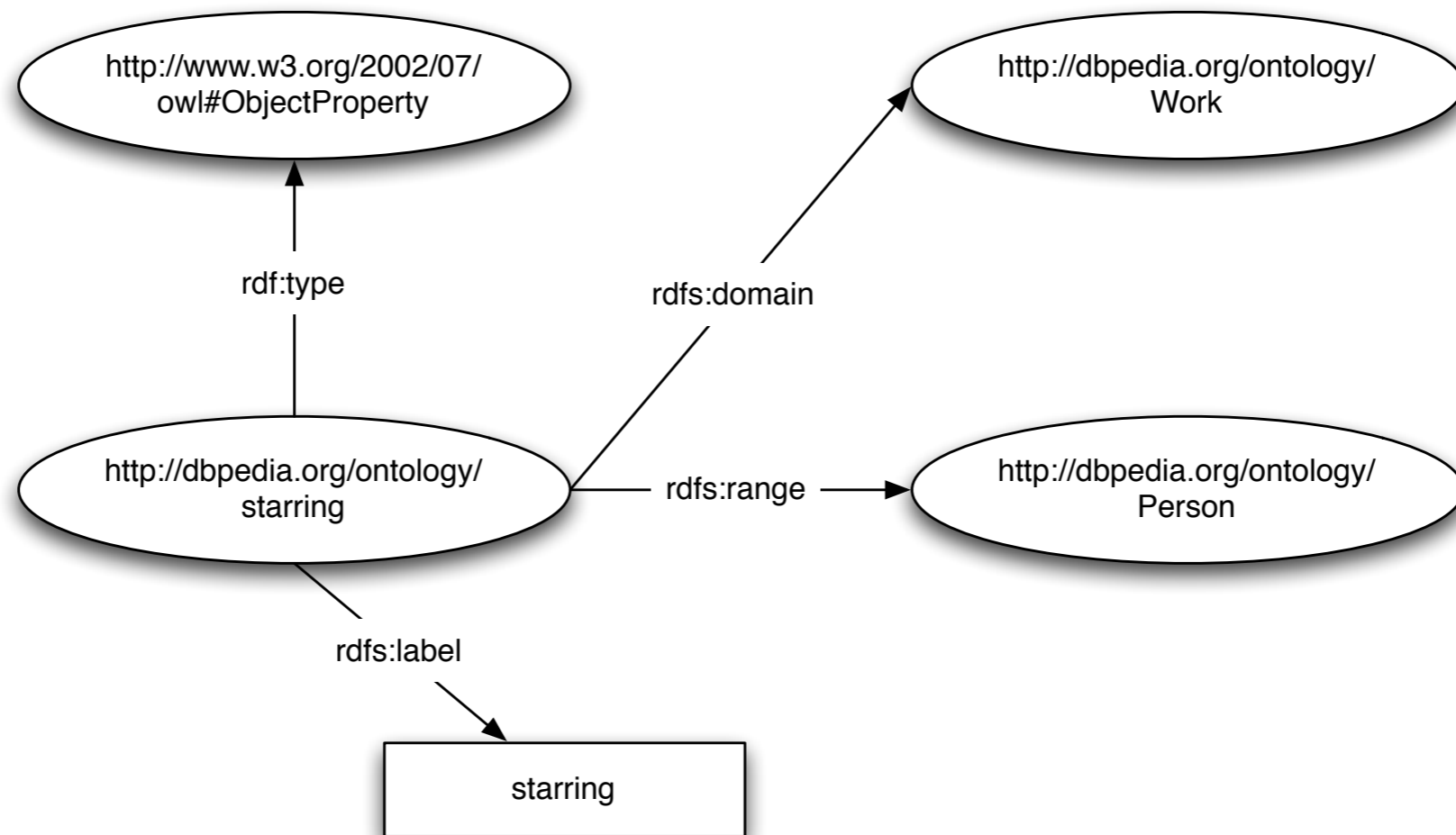

RDFS

- A **language** for describing the syntax and semantics of **vocabularies** in a machine-understandable way



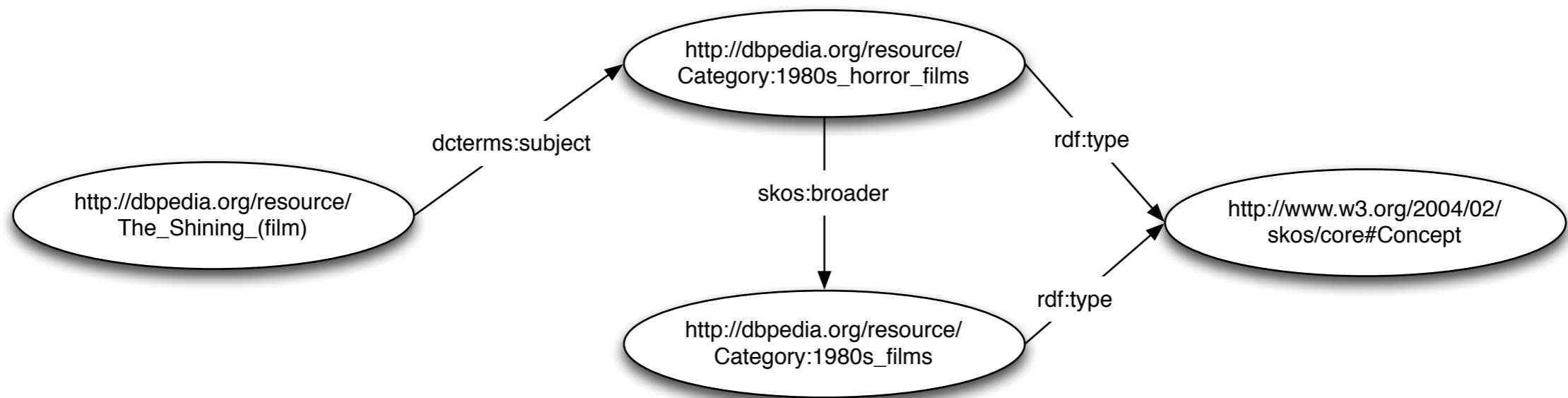
OWL

- A more expressive (formal) **language** for defining the syntax and semantics of **vocabularies**
- Solves RDFS shortcomings but introduces quite some complexity



SKOS

- A **language** for describing **controlled vocabularies** (taxonomies, thesauri, classification schemes)




SPARQL

- A **query language** and **protocol** for accessing RDF data on the Web

```
SELECT DISTINCT ?x
WHERE {
    ?x dct:subject
    <http://dbpedia.org/resource/Category:1980s_horror_films> .
}
```

Database Systems Analogy...

Purpose	Relational Database Management Systems (RDBMS)	Linked Data Technologies
Query		
Schema Definition Language		
Data Representation		
Identifiers		

Database Systems Analogy...

Purpose	Relational Database Management Systems (RDBMS)	Linked Data Technologies
Query	SQL	SPARQL
Schema Definition Language	SQL DDL	RDFS / OWL
Data Representation	Relational Model / Tables	RDF / Graph
Identifiers	Primary Keys (numeric sequences)	URI

RDF

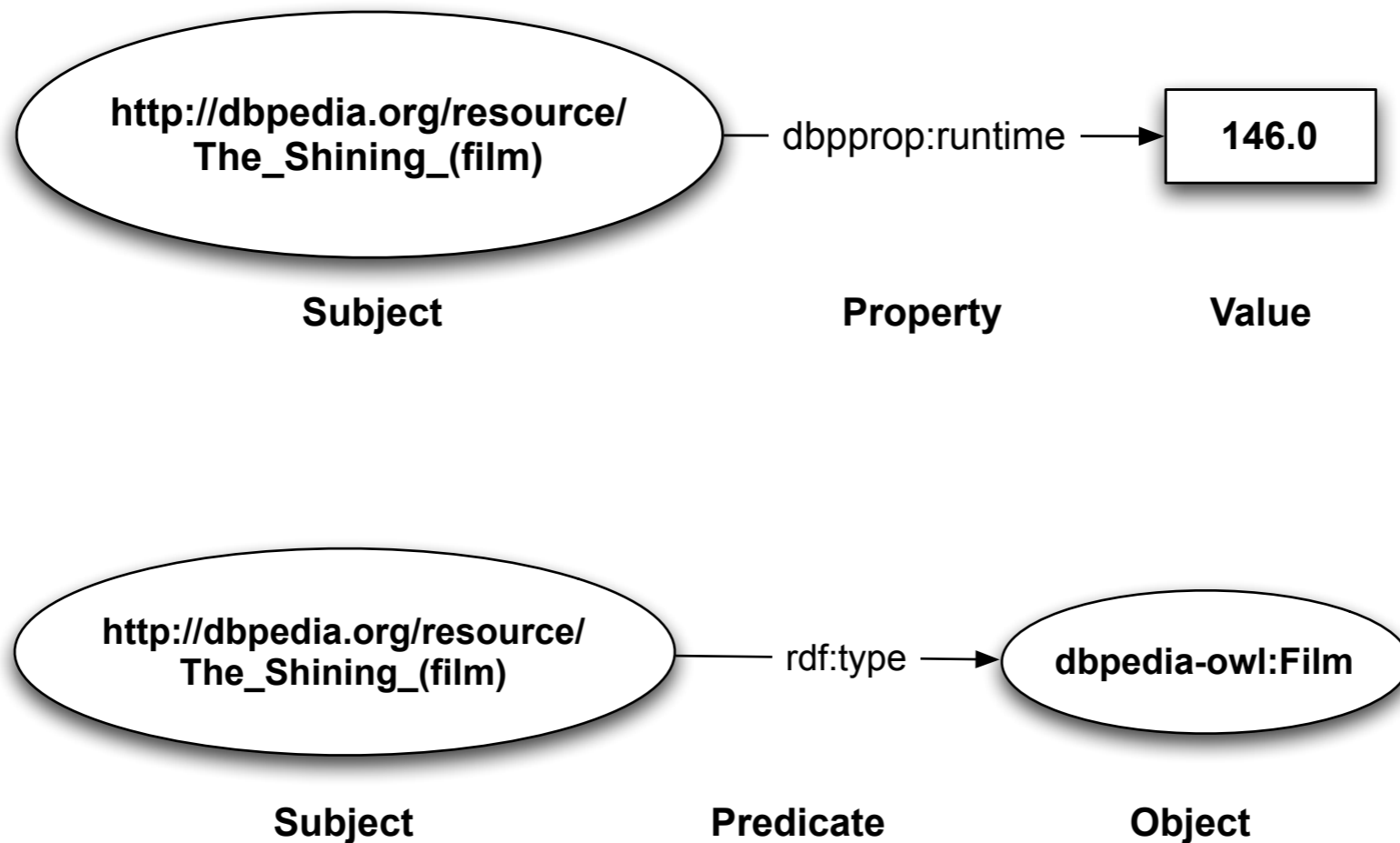
RDF



- Resource Description Framework
- A **graph-based data model** to represent data on the **Web**
- Machine-readability
- Uses **URIs** to name and identify things

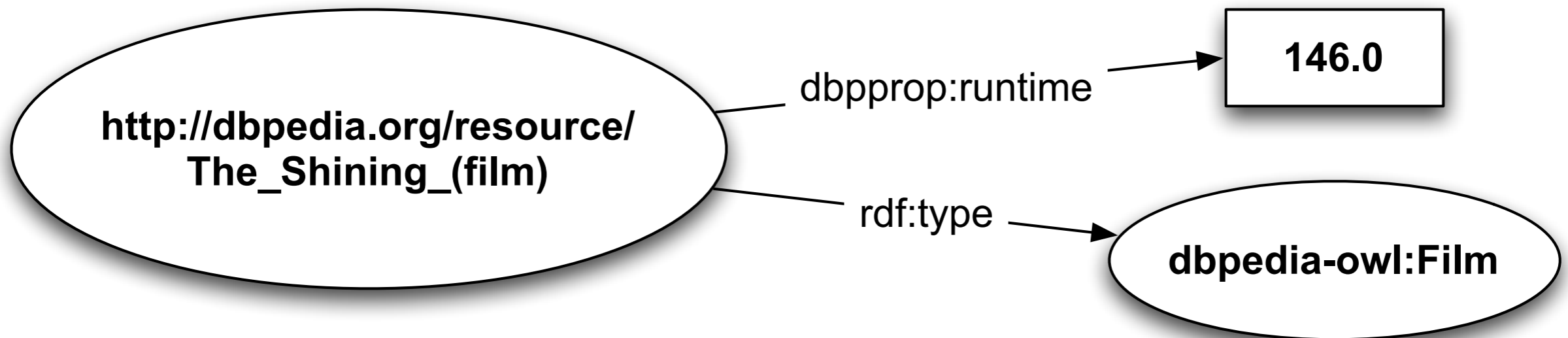
RDF Statements / Triples

- The basic structural element of RDF is the **statement / triple**



RDF Statements / Triples

- RDF triples can be merged into a set of triples, constituting a directed **graph structure**



URIs in RDF

- The labels of graph nodes or edges in these slides are either full URIs or use **prefixes**
- Example:
 - **dbprop:runtime** is a shorthand using the prefix dbprop
 - dbprop stands for <http://dbpedia.org/property>
 - dbprop:runtime therefore qualifies to <http://dbpedia.org/property/runtime>
- Both are equivalent to each other

RDF Serialization

- RDF can be serialized using various **syntax formats**:
 - NTriples
 - N3/Turtle
 - RDF/XML
 - JSON-LD
 -
- The following examples convey the same information

```
<?xml version="1.0" encoding="utf-8" ?>
```

```
<rdf:RDF
```

```
  > 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#"

```

```
  > xmlns:dbpedia-owl="http://dbpedia.org/ontology/"

```

```
  > xmlns:foaf="http://xmlns.com/foaf/0.1/"

```

```
  > xmlns:dcterms="http://purl.org/dc/terms/"

```

```
  > xmlns:dbpprop="http://dbpedia.org/property/"

```

```
  > xmlns:ns7="http://www.w3.org/ns/prov#"

```

```
  > xmlns:ns8="http://dbpedia.org/ontology/Work/"

```

```
<rdf:Description rdf:about="http://dbpedia.org/resource/The_Shining_(film)"

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/English-languageFilms" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/NonlinearNarrativeFilms" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/FilmsAboutAlcoholism" />

```

```
  <rdf:type rdf:resource="http://schema.org/CreativeWork" />

```

```
  <rdf:type rdf:resource="http://umbel.org/umbel/rc/Movie_CW" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/PinewoodFilms" />

```

```
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#Thing" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/GhostFilms" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/FilmsAboutWriters" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/FilmsBasedOnStephenKing'sWorks" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/FilmsBasedOnHorrorNovels" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/HauntedHouseFilms" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/ontology/Film" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/Movie106613686" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/SupernaturalHorrorFilms" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/ontology/Work" />

```

```
  <rdf:type rdf:resource="http://schema.org/Movie" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/1980sHorrorFilms" />

```

```
  <rdf:type rdf:resource="http://dbpedia.org/class/yago/1980sAmericanFilms" />

```

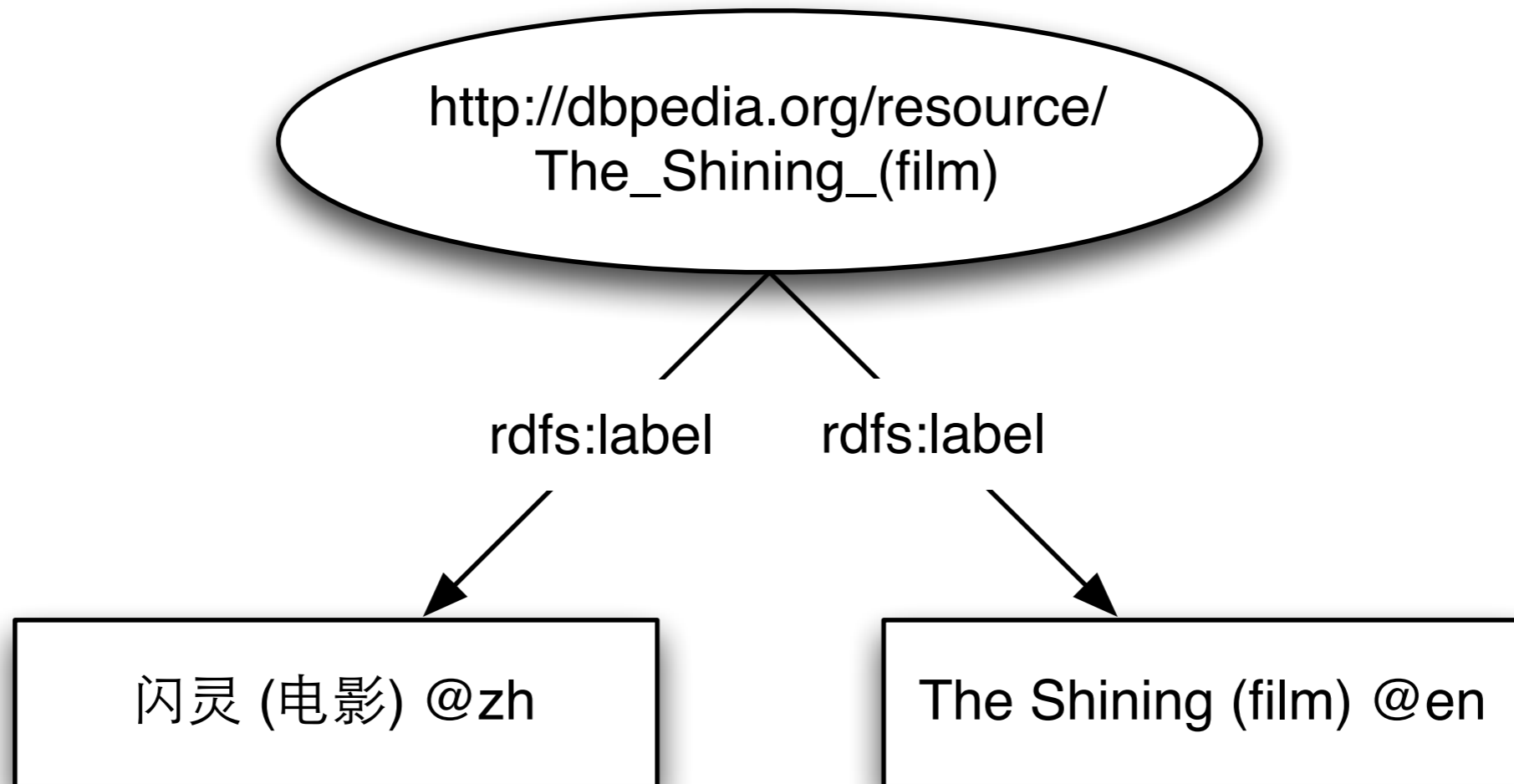
```

@prefix foaf: <http://xmlns.com/foaf/0.1/> .-
<http://en.wikipedia.org/wiki/The_Shining_(film)> foaf:primaryTopic >
<http://dbpedia.org/resource/The_Shining_(film)> .-
@prefix owl: <http://www.w3.org/2002/07/owl#> .-
<http://mpii.de/yago/resource/The_Shining_%28film%29> owl:sameAs >
<http://dbpedia.org/resource/The_Shining_(film)> .-
@prefix dbpedia-owl: <http://dbpedia.org/ontology/> .-
@prefix dbpedia: <http://dbpedia.org/resource/> .-
dbpedia:Switched-On_Brandenburgs dbpedia-owl:subsequentWork >
<http://dbpedia.org/resource/The_Shining_(film)> .-
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .-
@prefix yago: <http://dbpedia.org/class/yago/> .-
<http://dbpedia.org/resource/The_Shining_(film)> rdf:type yago:English-languageFilms , -
> yago:NonlinearNarrativeFilms , -
> yago:FilmsAboutAlcoholism .-
@prefix ns6: <http://schema.org/> .-
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@prefix ns7: <http://umbel.org/umbel/rc/> .-
<http://dbpedia.org/resource/The_Shining_(film)> rdf:type ns7:Movie_CW , -
> owl:Thing , -
> yago:GhostFilms , -
> yago:FilmsAboutWriters , -
> <http://dbpedia.org/class/yago/FilmsBasedOnStephenKing\u0027sWorks> , -
> yago:FilmsBasedOnHorrorNovels , -
> yago:HauntedHouseFilms , -
> dbpedia-owl:Film , -
> yago:Movie106613686 , -
> yago:SupernaturalHorrorFilms , -
> dbpedia-owl:Work , -
> ns6:Movie , -

```

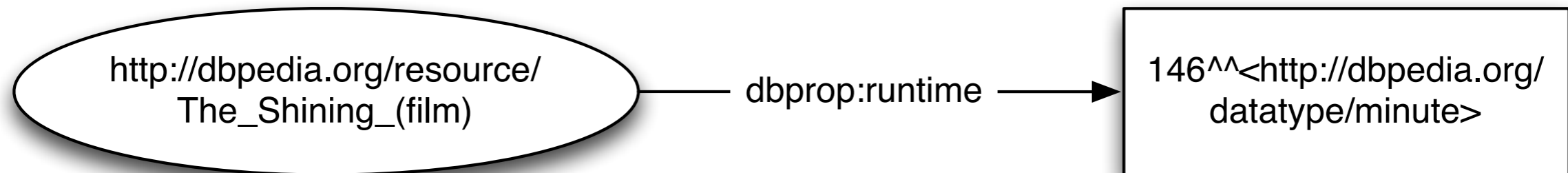
Language Tags

- Literals may carry language tags (@en, @zh)



Typed Literals

- Literals can be typed using **arbitrary datatypes**
 - XML Schema datatypes
 - custom datatypes



Other RDF features

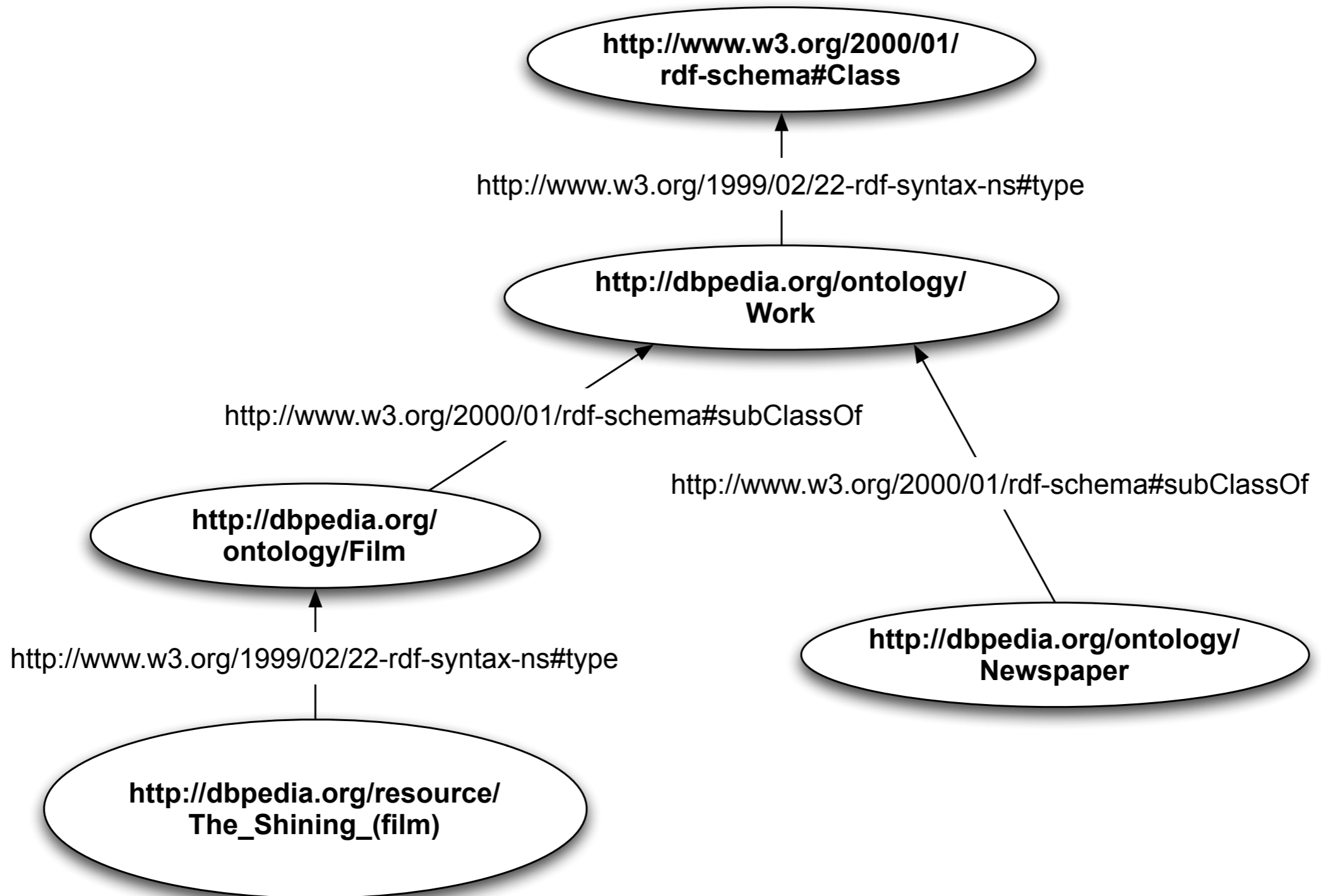
- Blank Nodes → „Non-URI nodes“
- Containers → „Grouping of resources“
- Collections → „Linked Lists“
- Reification → „Statements about statements“

RDFS, OWL

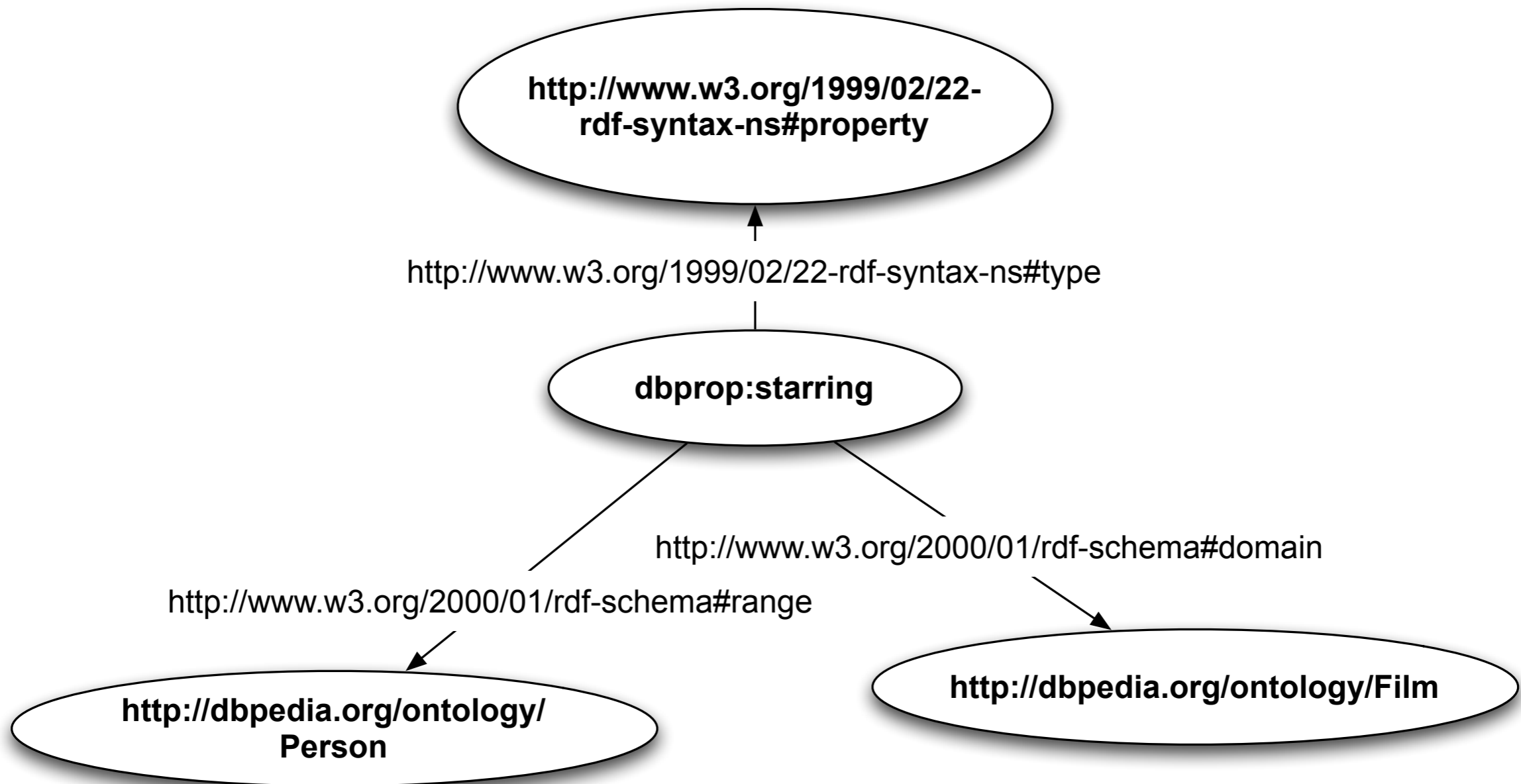
RDF Vocabulary Description Language (RDFS)

- Extends RDF with the possibility to define
 - **classes** and associated
 - **properties**
- Allows different applications to agree on common **information models (vocabularies)**
- RDF Schema is based on RDF → every RDF Schema document is an RDF document

Classes



Properties



Other RDFS features

- **rdfs:subPropertyOf**: hierarchical properties
- **rdfs:comment**: human-readable comments
- **rdfs:label**: Human-readable names for resources
- **rdfs:seeAlso**
- **rdfs:isDefinedBy**

RDFS Shortcomings

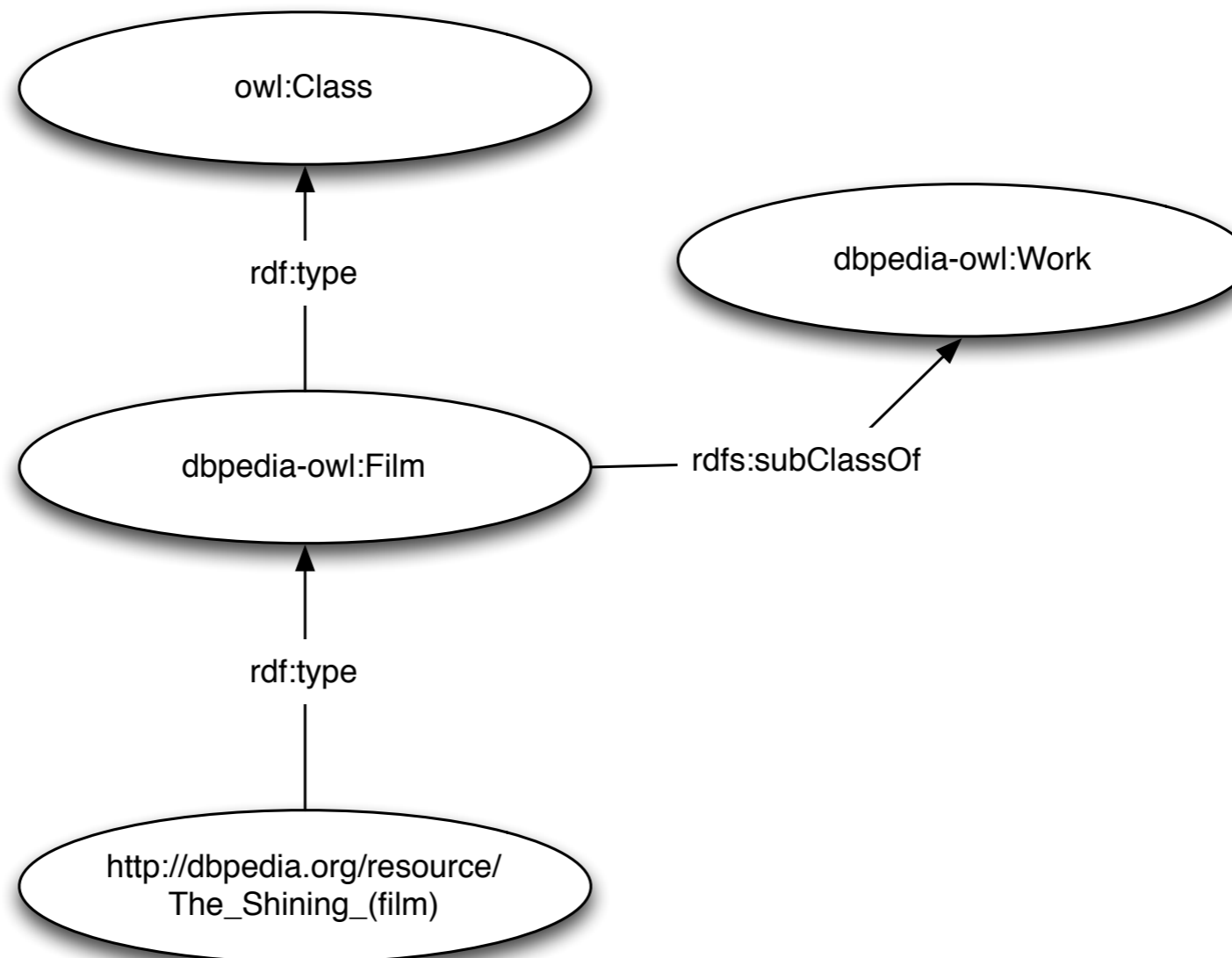
- No distinction between
 - attributes
 - relationships
 - No cardinality constraints (min, max)
- OWL tries to solve RDFS shortcomings

Web Ontology Language (OWL)

- A language designed to represent rich and complex knowledge about things
- Logic-based
 - verify consistency of defined knowledge
 - make implicit knowledge explicit (inference)
 - driven by AI community
- OWL models can be exchanged as RDF documents

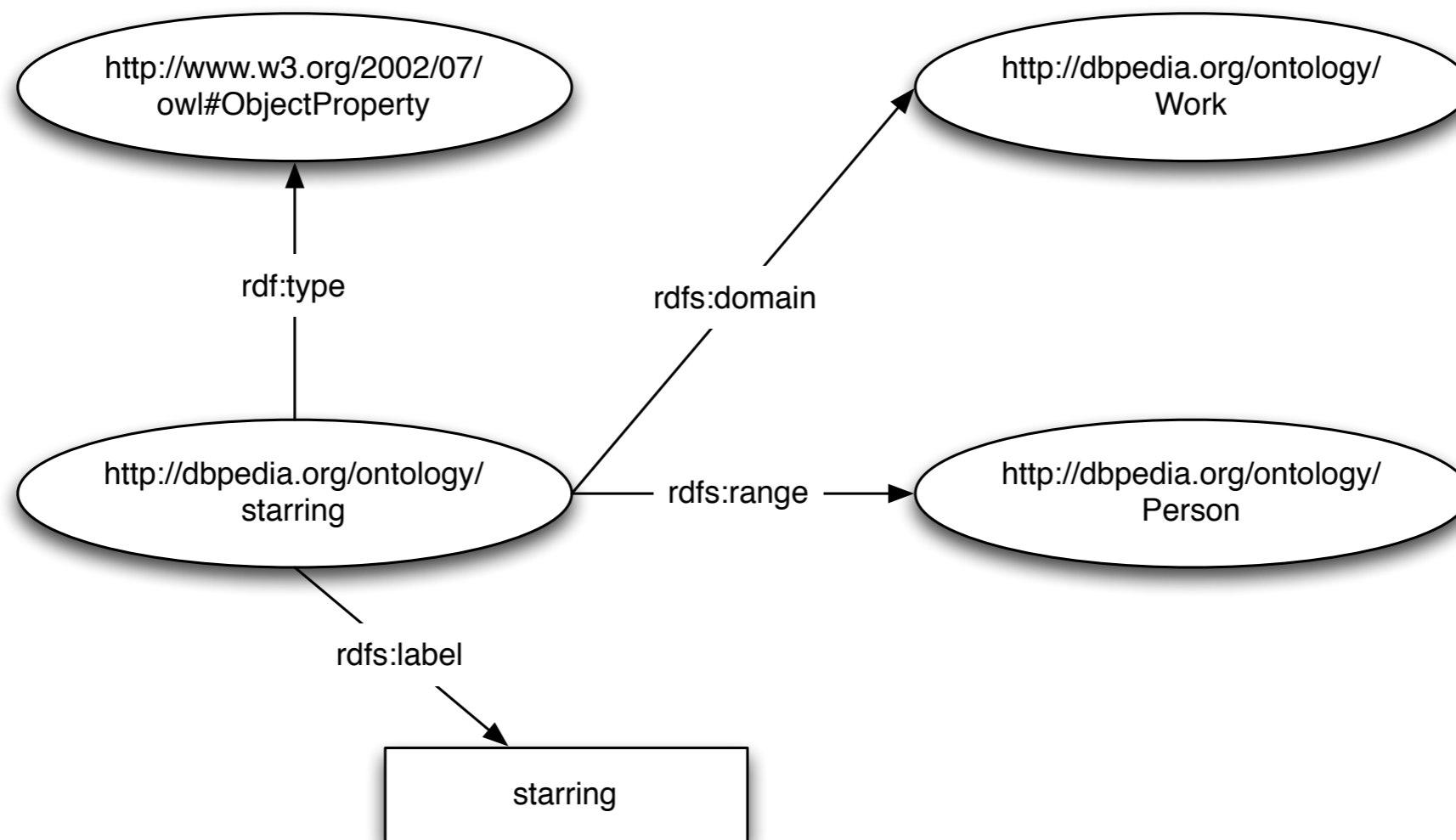
OWL Class

- **owl:Class**: defines a group of individuals that belong together because of shared properties



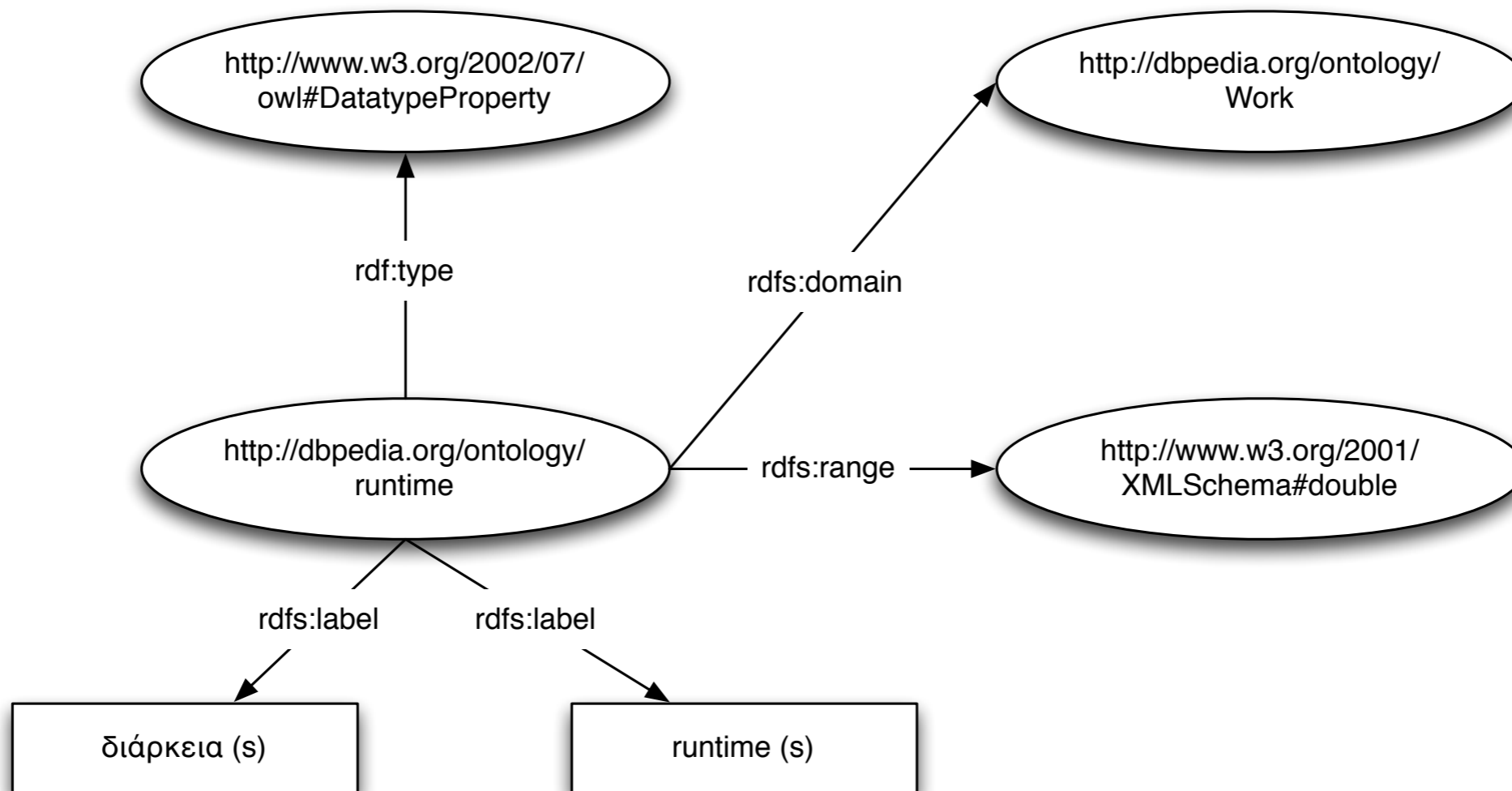
OWL Object Properties

- **owl:ObjectProperty**: properties whose value is an **individual**



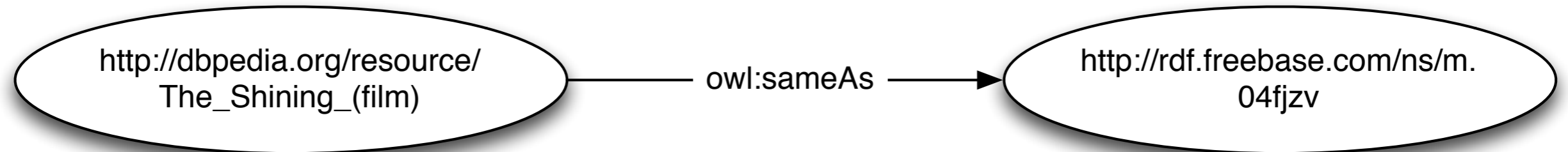
OWL Datatype Properties

- **owl:DatatypeProperty**: properties whose value is a **literal**



Equality of Individuals

- **owl:sameAs**: Two individuals may be stated to be the same
 - used to **link** data across data sources
 - controversy on the notion of „sameness“



Class Equivalence

- **owl:equivalentClass**: classes may refer to the same set of individuals
 - used to map between schemas/vocabularies



Property Equivalence

- **owl:equivalentProperty**: two properties may be stated to be equivalent
 - used to map between schemas/vocabularies



Other OWL Features

- We scratched OWL just on the surface
- More details at:
<http://www.w3.org/TR/owl2-primer/>
- A good starting point:
<http://protege.stanford.edu/doc/owl/getting-started.html>

How to represent data in RDF

- Design an **information model** expressing
 - the **resource types** in your dataset (= RDFS/OWL classes)
 - their **attributes** (= RDF/OWL properties)
 - the **relationships** between them (= properties)
- Assign **names** (URIs) to model entities, either by
 - reusing existing terms or
 - defining new, proprietary terms
- Create **resources**, assign names (URIs), describe them with attributes, and connect them via relationships

How to find vocabulary terms?

- Dublin Core terms:
<http://dublincore.org/documents/dcmi-terms/>
- Friend of a Friend:
<http://xmlns.com/foaf/spec/>
- GoodRelations:
<http://www.heppnetz.de/projects/goodrelations/>
- Bibliographic Ontology:
<http://bibliontology.com/>
- BBC Programmes Ontology:
<http://www.bbc.co.uk/ontologies/programmes/2009-09-07.shtml>
- schema.org:
<http://schema.org>

GROUPWORK: MOVIE DATA IN RDF

Instructions

- Form groups of 3
- Take one example movie from the HW dataset (e.g, „The Godfather“)
- Discuss how to represent this movie, its attributes and relationships in RDF
- Draw a diagram at:
<http://bit.ly/infocs4302-movie-rdf>

USEFUL APIS / TOOLS

RDF APIs

- Java
 - Jena Semantic Web Framework (<http://openjena.org/>)
 - Sesame RDF API (<http://www.openrdf.org/>)
- PHP
 - ARC (<http://arc.semsol.org/>)
- Ruby
 - RDF.rb: Linked Data for Ruby (<http://rdf.rubyforge.org/>)
- Python
 - RDFLib (<http://www.rdfliib.net/>)
- C
 - Redland RDF Libraries (<http://librdf.org/>)

Linked Data debugging

using cURL:

```
curl -iH "Accept: application/rdf+xml"  
http://dbpedia.org/resource/The\_Shining\_\(film\)
```

```
curl -LH "Accept: application/rdf+xml"  
http://dbpedia.org/resource/The\_Shining\_\(film\)
```

```
curl -iH "Accept: text/n3"  
http://dbpedia.org/resource/The\_Shining\_\(film\)
```

Linked Data debugging

using raptor (<http://librdf.org/raptor/>):

```
raper -o rdfxml  
http://dbpedia.org/resource/The\_Shining\_\(film\)
```

```
raper http://dbpedia.org/resource/The\_Shining\_\(film\)  
> ~/Desktop/the_shining.nt
```

QUESTIONS & HOUSEKEEPING