INFO216: **Advanced Modelling**

Theme, spring 2018:

Modelling and Programming the Web of Data

Andreas L. Opdahl
<Andreas.Opdahl@uib.no>

Session S06: RDFS Plus

- Themes:
  - what and why?
  - basic OWL constructs (“RDFS-Plus”)
- Programming:
  - Jena *OntModel* class
  - *OntClass, Individual, ObjectProperty, DatatypeProperty*
  - *OWL* class that defines OWL-terms / IRIs
  - *OntModelSpec* class that defines reasoner types

Readings

- Allemang & Hendler (2011):
  Semantic Web for the Working Ontologist
  - chapter 8 (“RDFS Plus”)
- Forum links (cursory):
  - OWL 2 Overview:
    http://www.w3.org/TR/owl-overview/
  - OWL 2 Primer:
    http://www.w3.org/TR/owl-primer/
    - show: Turtle and Manchester syntax
    - hide: other syntaxes

Web Ontology Language (OWL)

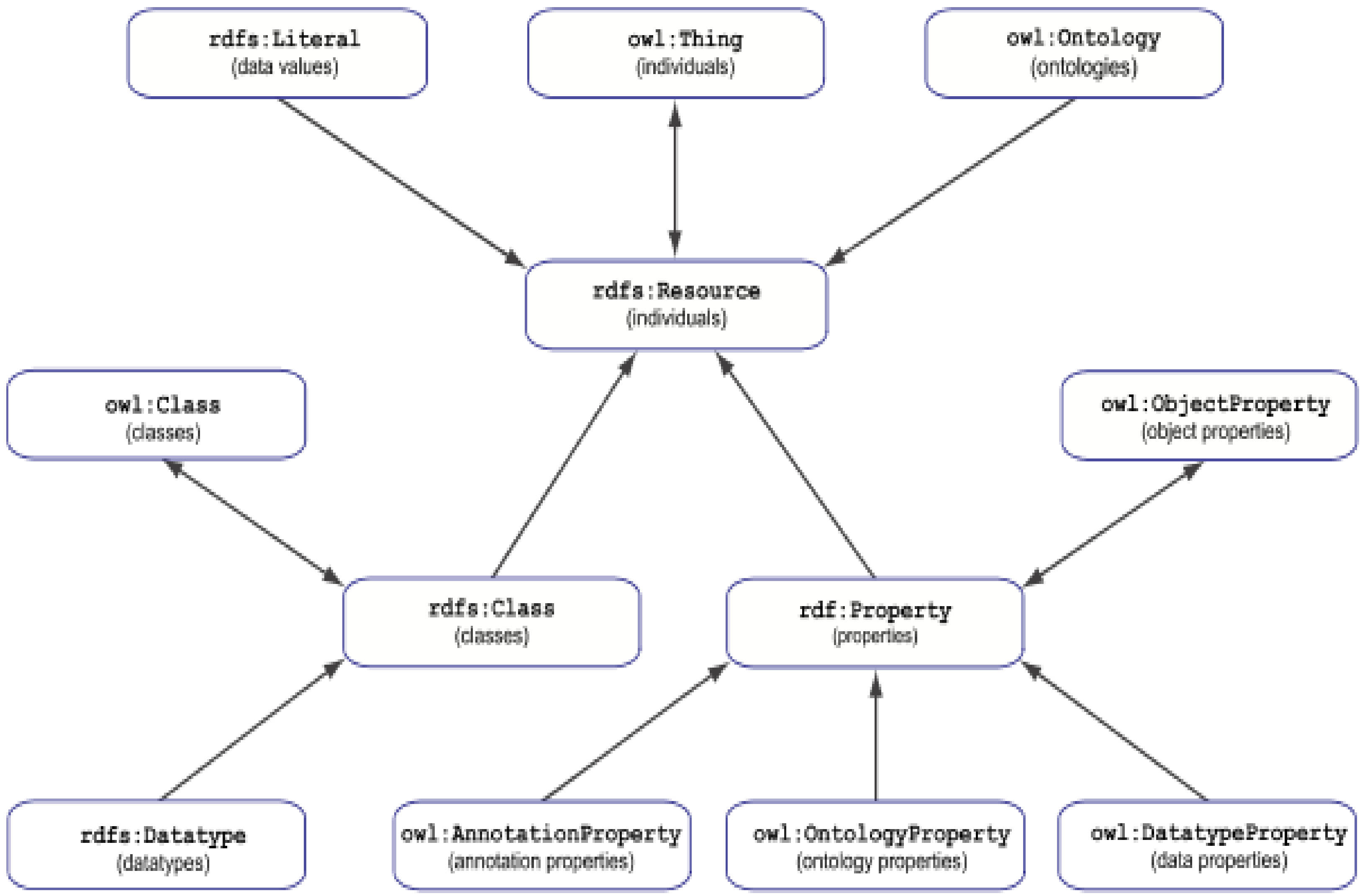
RDFS is a useful starting point...

- But there's lots of simple stuff it cannot express, e.g.:
  - “every ancestor of an ancestor is an ancestor too”
  - “the BirthNumber of a Person is unique”
  - “a Republic has exactly one President”
  - “a FootballTeam has 11 activePlayers, a VolleyballTeam 6”
  - “a StringQuartet has two violins but only one viola and one cello”
  - “classes with different IRIs actually represent the same class”
  - “resources with different IRIs represent the same resource”
  - “properties with different IRIs are actually the same”
  - “two individuals are different”, “two classes are disjoint”
  - “a class is a union (or intersection) of other classes”
  - “a class is a negation of another class”
- *OWL expresses all this and more!*

Basic idea

- Web Ontology Language (OWL):
  - builds on RDF and RDFS
  - uses classes and properties from RDF and RDFS
  - adds precision and formality
- Basic OWL-concepts:
  - owl:Class rdfs:subClassOf rdfs:Class .
  - "owl:Property" rdfs:subClassOf rdf:Property .
  - "owl:Individual" rdfs:subClassOf rdfs:Resource .

    good practice: keep these three *disjoint*, i.e., no resource has more than one of them as *rdf:type*
    - *"owl:Individual" is actually called owl:Thing*



http://www.w3.org/TR/owl2-rdf-based-semantics/

What does OWL offer?

- Extensions of RDFS, e.g.:
  - more *specific types* of properties
  - *identical and different* classes, properties, individuals
  - *defining new classes*:
    - complex classes (union, intersection, complement)
    - property restrictions, enumeration of individuals
  - *defining new properties* based on existing ones
  - *mathematical formality* (for large parts of OWL)
    - (more on this later)

Reuses or specialises RDFS

- *Reused* in OWL:
  - rdf:type, rdf:Property, rdfs:subClassOf, rdfs:subPropertyOf, rdfs:domain, rdfs:range
  - ...and lots of other stuff...
- *Renamed* by OWL:
  - owl:Thing owl:sameAs rdfs:Resource .
- *Specialised* by OWL:
  - everything else in OWL *specialises* something in RDFS

Basic OWL
(“RDFS-Plus”)

Inverse properties

- Properties can be each other's reverses (with subject and object swapped), e.g.,
  - rex:HaakonMagnus fam:hasParent rex:Harald .
  - rex:Harald fam:hasChild rex:HaakonMagnus .
- P1 owl:inverseOf P2:
  - fam:hasParent owl:inverseOf fam:hasChild .
  - owl:inverseOf owl:inverseOf owl:inverseOf .
  - owl:inverseOf a owl:ObjectProperty .
- “Entailment rules”:
  - if *P1 owl:inverseOf P2* then
    - *P2 owl:inverseOf P1 .*
  - if *S P1 O* . *P1 owl:inverseOf P2* then
    - O P2 S .

Symmetric properties

- Some properties are their own inverse, e.g.,
  - rex:Harald fam:marriedTo rex:Sonja .
  - rex:Sonja fam:marriedTo rex:Harald .
- P rdf:type owl:SymmetricProperty:
  - fam:marriedTo a owl:SymmetricProperty .
  - owl:inverseOf a owl:SymmetricProperty .
  - owl:SymmetricProperty rdfs:subClassOf owl:ObjectProperty .
- Entailment rules:
  - if *P a owl:SymmetricProperty* then
    - P owl:inverseOf P .
  - if *S P O . P a owl:SymmetricProperty* then
    - O P S .

Asymmetric, reflexive, irreflexive properties

- New in OWL2:
  - both *symmetric* and *asymmetric* properties:
    - fam:marriedTo rdf:type owl:SymmetricProperty .
    - fam:hasChild rdf:type owl:AsymmetricProperty .
    - *many properties are neither!*
  - both *reflexive* and *irreflexive* properties:
    - owl:sameAs rdf:type owl:ReflexiveProperty .
    - fam:hasChild rdf:type owl:IrreflexiveProperty .
    - *many properties are neither!*

Asymmetric, reflexive, irreflexive properties

- New in OWL2:
  - both *symmetric* and *asymmetric* properties:
    - fam:marriedTo a owl:SymmetricProperty .
      - "fam:marriedTo is always mutual (two-way)"
    - fam:hasChild a owl:AsymmetricProperty .
      - "no resources can be fam:hasChild of each other"
    - *many properties are neither!*
  - both *reflexive* and *irreflexive* properties:
    - owl:sameAs a owl:ReflexiveProperty .
      - "every resource is owl:sameAs itself"
    - fam:hasChild a owl:IrreflexiveProperty .
      - "no resource can be fam:hasChild of itself"
    - *many properties are neither!*

Transitive properties

- Some properties can form chains so that the result is the property itself, e.g.:
  - rex:HaakonMagnus fam:hasAncestor rex:Harald .
  - rex:Harald fam:hasAncestor rex:Olav .
  - rex:HaakonMagnus fam:hasAncestor rex:Olav .
- P a owl:TransitiveProperty:
  - fam:hasAncestor a owl:TransitiveProperty .
  - rdfs:subClassOf a owl:TransitiveProperty .
  - rdfs:subPropertyOf a owl:TransitiveProperty .
- Entailment rules:
  - "if *S P X . X P O . P a owl:TransitiveProperty* then
    - S P O ."

Functional properties

- Each subject *can only have one* object value for the functional property, e,g.,
  - fam:mother a owl:FunctionalProperty .
  - fam:birthdate a owl:FunctionalProperty .
  - owl:FunctionalProperty rdfs:subClassOf “owl:Property” .
- “Entailment rule”:
  - if *S P O1 . S P O2 . P a owl:FunctionalProperty* then
    - *O1 owl:sameAs O2 .*
  - ...for owl:ObjectProperties
    - similar rule for owl:DatatypeProperties

Inverse functional properties

- Two different subjects cannot have the same object for an inverse functional property, i.e.,
  - fam:persNum a owl:InverseFunctionalObjectProperty .
  - fam:persNum a owl:FunctionalProperty .
  - owl:FunctionalProperty
    owl:inverseOf owl:InverseFunctionalObjectProperty .
- Inverse functional properties are *unique* for each individual
  - used for *identifiers* in OWL 1
  - OWL 2 has a built-in *owl:hasKey* property for identifiers:
    - similar to inverse functional object properties
    - can only be used with OWL 2's *owl:NamedIndividuals*
    - ...not for anonymous *owl:Individuals*

Summary: more specific properties

- owl:inverseOf
- owl:SymmetricProperty, owl:AsymmetricProperty
- owl:ReflexiveProperty, owl:IrreflexiveProperty
- owl:TransitiveProperty
- owl:FunctionalProperty, owl:InverseFunctionalProperty
- owl:hasKey
- Also:
  - negated properties (later)
  - chained properties, e.g.:

```
fam:hasGrandparent
        owl:propertyChainAxiom  ( :hasParent  :hasParent ) .
```

Individual equivalence

- Two individuals (with different IRI-s) may represent the same thing:
  - http://dbpedia.org/resource/Amanda_Plummer
  - http://yago-knowledge.org/resource/Amanda_Plummer
  - http://data.linkedmdb.org/resource/actor/34880
- I1 owl:sameAs I2:
  - owl:sameAs a owl:ReflexiveProperty .
  - owl:sameAs a owl:SymmetricProperty .
  - owl:sameAs a owl:TransitiveProperty .
- owl:sameAs is an *equivalence relation*:
  - because it is *reflexive*, *symmetric* and *transitive*

Unique Name Assumption (UNA)

- If two resources have different names, do they necessarily represent different things?
- RDF and OWL does *not* assume this!
  - *in RDF and OWL, we do not know whether resources with different names represent different things or not*
- We can use
  - owl:sameAs – two resources represent the same thing!
  - owl:differentFrom – they represent different things!
- Some ICT-languages and technologies use UNA, others do not!

Individual difference

- A *pair* of individuals with different names (IRI-s) may represent different things, e.g.,
  - cal:Spring owl:differentFrom cal:Summer .

Individual difference

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  - cal:Spring owl:differentFrom cal:Summer .
- A *group* of individuals with different names (IRI-s) may represent different things, e.g.,
  - [a owl:AllDifferent] owl:distinctMembers (
      cal:Spring cal:Summer cal:Autumn cal:Winter
) .

Individual difference

- A *pair* of individuals with different names (IRI-s) must represent different things, e.g.,
  - cal:Spring owl:differentFrom cal:Summer .
- A *group* of individuals with different names (IRI-s) must represent different things, e.g.,
  - [a owl:AllDifferent] owl:distinctMembers (
    cal:Spring cal:Summer cal:Autumn cal:Winter
) .
  - *owl:AllDifferent* and *owl:distinctMembers* are special constructs in OWL
    - they must always be used together
  - ...corresponds to pairwise *owl:differentFrom* between *all* individuals in the *owl:distinctMembers*-list

Equivalent classes

- Two classes (with different IRI-s) represent the same class:
- C1 owl:equivalentClass C2:
  - owl:equivalentClass a owl:ReflexiveProperty .
  - owl:equivalentClass a owl:SymmetricProperty .
  - owl:equivalentClass a owl:TransitiveProperty .
- owl:equivalentClass is another *equivalence relation*:
  - it is *reflexive*, *symmetric* and *transitive*
- means the same as
  - *C1 rdfs:subClassOf C2* and *C2 rdfs:subClassOf C1*

Disjoint classes

- Some classes cannot have the same individual as a member,
  - fam:Male owl:disjointWith fam:Female .
  - owl:disjointWith a owl:SymmetricProperty .
    - ...but it is *not* transitive
- I.e., no individual can have both classes as its rdf:type
  - ...corresponds to owl:differentFrom between *all* pairs of individuals in fam:Male and fam:Female
- Preferred in *formal* versions of OWL (no “punning”):
  - owl:Class owl:disjointWith “owl:Property” .
  - owl:Class owl:disjointWith “owl:Individual” .
  - “owl:Property” owl:disjointWith owl:Individual .

Equivalent properties

- Two properties (with different IRI-s) represent the same property:
- P1 owl:equivalentProperty P2:
  - owl:equivalentProperty a owl:ReflexiveProperty .
  - owl:equivalentProperty a owl:SymmetricProperty .
  - owl:equivalentProperty a owl:TransitiveProperty .
- owl:equivalentProperty is another *equivalence relation*:
  - it is *reflexive*, *symmetric* and *transitive*
- *Also disjoint properties:*
  - :hasParent owl:propertyDisjointWith :hasSpouse .

Summary: sameness and difference

- Individuals:
  - pairwise: owl:sameAs, owl:differentFrom
  - groupwise difference: owl:AllDifferent
- Classes:
  - pairwise: owl:equivalentClass, owl:disjointWith
  - groupwise difference: owl:AllDisjointClasses
- Properties:
  - pairwise: equivalentProperty, propertyDisjointWith
  - groupwise difference: owl:AllDisjointProperties
- Membership in the groups:
  - owl:distinctMembers *(preferred)* or owl:members