# Ontology Engineering - The basics of OWL

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# Outline

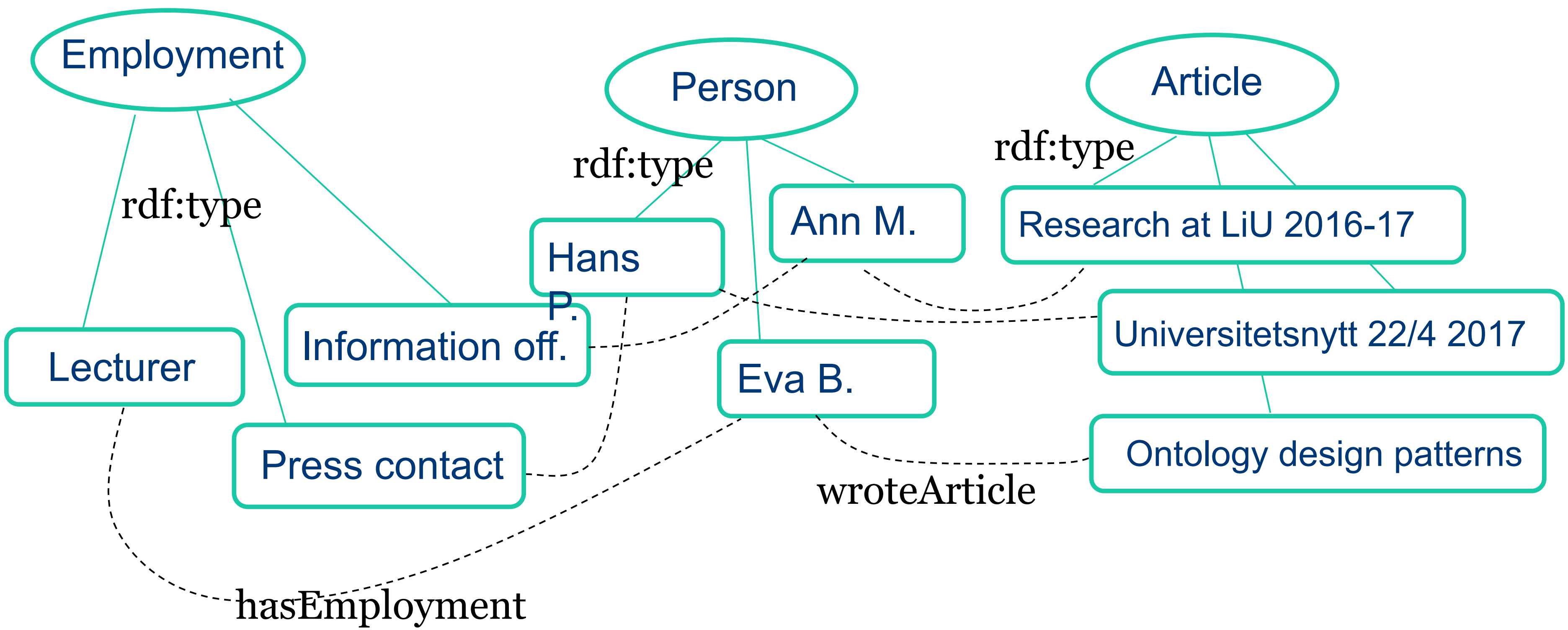
- Recap from the ontology intro & DL lecture
- OWL
  - What does the OWL language contain?
  - Common misconceptions
- How to model OWL ontologies using Protégé

# Reminders from ontology intro & DL lecture

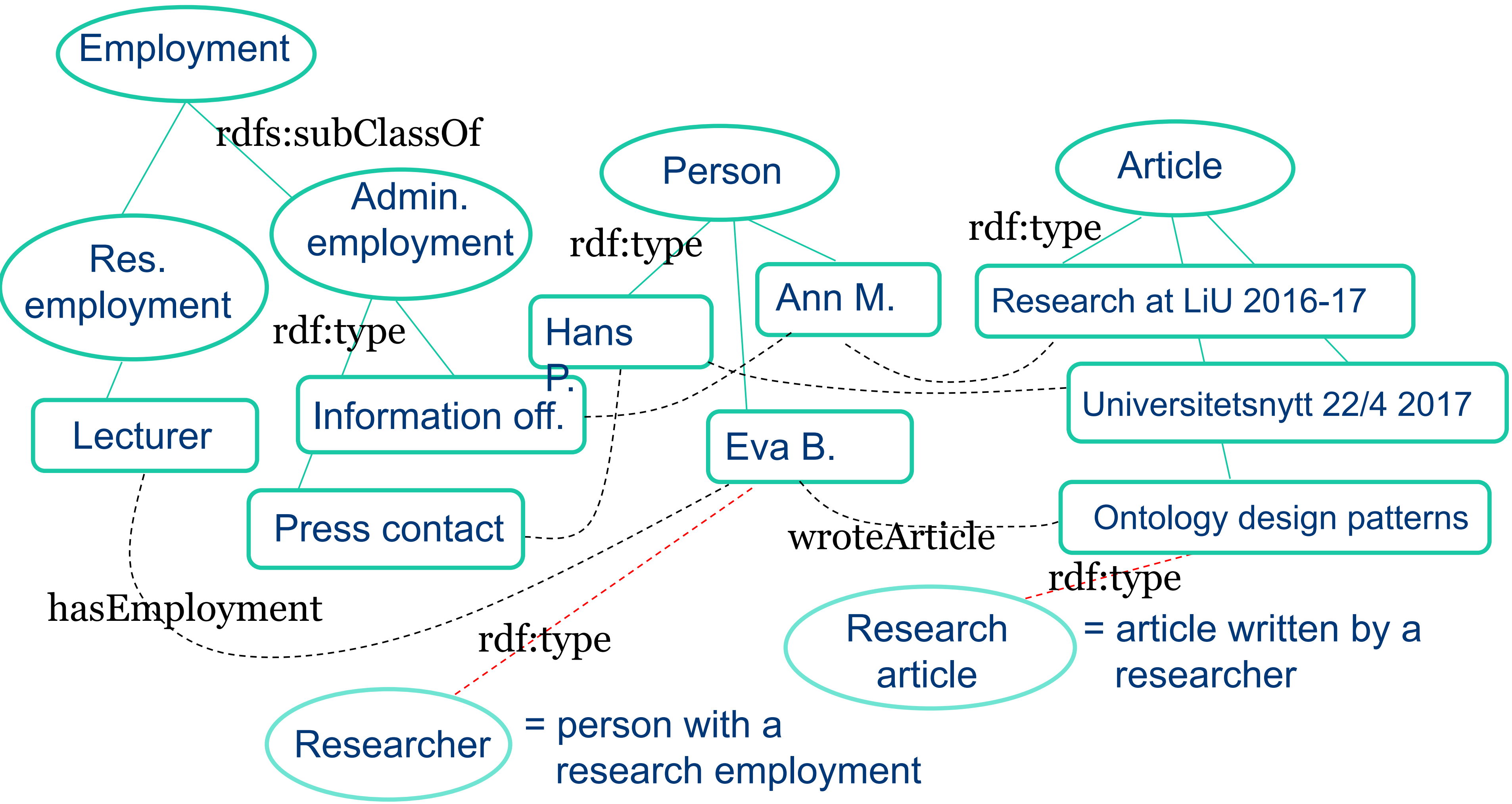
# Components

- concepts = *classes* in OWL
  - represent **a set** or class of entities in a domain
- instances = *individuals* in OWL
  - represent **the members of a set**
- relations = (binary) *properties* in OWL
- axioms

# Example (reminder)



# Example (reminder)



# OWL ontologies as vocabularies for RDF data

- The most common use case for ontologies on the Semantic Web
  - Classes that represent the types of instances in the data
  - Properties that can be used as predicates in our RDF triples

  Then we can add more… IF we need to

- In this course we focus on task-oriented ontologies, i.e. ontologies that serves a specific purpose, fulfils a certain set of requirements

# RDF(S): RDF Schema

- RDF gives a data representation format and ways to serialize, but it does not give any special meaning to vocabulary such as “subClassOf” or “range”

- Triple interpretation is an arbitrary binary relation

- RDF Schema extends RDF with a modelling vocabulary
  – Classes as types for individuals: rdfs:Class, rdfs:Literal, rdfs:Datatype, rdf:type and rdfs:subClassOf, etc.
  – Properties as relations: rdf:Property, rdfs:subPropertyOf, rdfs:range, rdfs:domain, etc.
  – Annotations: rdfs:label, rdfs:comment, etc.

# RDF/RDF(S) "Liberality"

- No distinction between classes and instances (individuals)
- Properties can themselves have properties
- No distinction between language constructors and ontology vocabulary, so constructors can be applied to themselves/each other

# What does RDF(S) give us?

- Ability to use simple schema/vocabularies when describing our resources
- Consistent vocabulary use and sharing
- Simple inference, e.g. inheritance in a taxonomy
- But…
  - In some cases too weak to describe resources in sufficient detail
  - **Not formally based on any logic**

# OWL

- DL-based language
- OWL2 is the latest version of the standard (https://www.w3.org/TR/owl2-primer/ )
- Different language profiles exist
  - OWL EL
    - Intended for large ontologies with many classes, mainly used for classification tasks
    - Example use: biomedical ontologies
    - Not allowed: negation, disjunction, inverse properties, universal quantification on properties
  - OWL QL
    - Covers most features of UML and ER-models, so is suitable for use with relational data
    - Example use: ontologies used to access relational data
  - OWL RL
    - Reasoning can be implemented as rules
    - Does not allow expressions that assume an anonymous individual

# Basic OWL modelling using Protégé

# OWL syntaxes

- Abstract syntax
  - Used in the definition of the language
- Manchester syntax
- "OWL in RDF"
  - RDF/XML presentation
  - Turtle
- …

# OWL Class Constructors

| Constructor | Example, Turtle syntax | Example, Manchester syntax |
|---|---|---|
| <Classes> | :Human rdf:type owl:Class | Class: Human |
| intersectionOf | owl:intersectionOf ( :Human :Male ) | Human and Male |
| unionOf | owl:unionOf ( :Male :Female ) | Female or Male |
| complementOf | owl:complementOf ( :Male ) | not Male |
| oneOf | owl:oneOf ( :John :Mary ) | {John, Mary} |

# OWL Individual Axioms

| **Axiom** | **Example,<br>Turtle syntax** | **Example,<br>Manchester syntax** |
|---|---|---|
| <Individual> | :Mary rdf:type :Human | Individual: Mary<br>Types: Human |
| <Fact> | :Mary :worksWith :John | Individual: John<br>Facts: worksWith Mary |
| differentFrom | :Mary owl:differentFrom :John | Individual: Mary<br>DifferentFrom: John |
| sameAs | :Mary owl:sameAs :May | Individual: Mary<br>SameAs: May |

# OWL Class Axioms

| Axiom | Example, Turtle syntax | Example, Manchester syntax |
|---|---|---|
| subClassOf | :Woman rdfs:subClassOf :Human | Class: Woman<br>SubClassOf: Human |
| equivalentClass | :Person owl:equivalentClass :Human | Class: Person<br>EquivalentTo: Human |
| disjointClass | [] rdf:type owl:AllDisjointClasses ;<br>owl:members ( :Woman :Man ) . | DisjointClasses:<br>Woman, Man |

# OWL Class Constructors (cont.)

| Constructor | Example,<br>Turtle syntax | Example,<br>Manchester syntax |
|---|---|---|
| someValuesFrom | owl:onProperty :hasChild ;<br>owl:someValuesFrom :Male | hasChild some Male |
| allValuesFrom | owl:onProperty :hasChild ;<br>owl:allValuesFrom :Female | hasChild only Female |
| minCardinality | owl:minQualifiedCardinality "2"^^xsd:nonNegativeInteger ;<br>owl:onProperty :hasChild | hasChild min 2 |
| maxCardinality | owl:maxQualifiedCardinality "2"^^xsd:nonNegativeInteger ;<br>owl:onProperty :hasChild | hasChild max 2 |

# OWL Property Axioms

| Axiom | Example, Turtle syntax | Example, Manchester syntax |
|---|---|---|
| subPropertyOf | :hasSon rdfs:subPropertyOf :hasChild | ObjectProperty: hasSon<br>SubPropertyOf: hasChild |
| domain | :hasChild rdfs:domain :Parent | ObjectProperty: hasChild<br>Domain: Parent |
| range | :hasSon rdfs:range :Man | ObjectProperty: hasSon<br>Range: Man |
| symmetric | :worksWith rdf:type owl:SymmetricProperty | ObjectProperty: worksWith<br>Characteristics: Symmetric |
| transitive | :hasAncestor rdf:type owl:TransitiveProperty | ObjectProperty: hasAncestor<br>Characteristics: Transitive |
| inverseOf | :hasParent owl:inverseOf :hasChild | ObjectProperty: hasParent<br>InverseOf: hasChild |

# Other useful OWL constructs

- XML namespaces and prefixes
  - Turtle: @prefix : <http://example.com/owl/families/> .
    @prefix owl: <http://www.w3.org/2002/07/owl#> .
  - Manchester: Prefix: : <http://example.com/owl/families/>
    Prefix: owl: <http://www.w3.org/2002/07/owl#>
- Datatype properties and XML schema datatypes
  - Turtle: :John :hasAge 33
  - Manchester: Individual: John
    Facts: hasAge "33"^^xsd:integer
- Property chains and keys
- owl:imports
- owl:Ontology
- Annotation properties
  - rdfs:label, rdfs:comment, …

# Common misconceptions

- Disjointness
- Properties do not "belong" to classes
- Interpreting domain and range
- And and or
- Quantification
- Closed and open worlds

# Disjointness

- By default, primitive classes are not disjoint.
- Unless we explicitly say so, the description (Animal and Vegetable) is not an unsatisfiable class
- Similarly with individuals – the so-called Unique Name Assumption does not hold, and individuals are not considered to be distinct unless explicitly asserted to be so.

# Properties

- Unlike frame-based languages, UML and many other common modelling languages, in OWL properties do not "belong" to any specific class
- To "connect" a property to a class we can
  - Add domain and range axioms of the property
  - Add restrictions on the class
- But neither is necessary for it to be a valid OWL ontology!

# Domain and Range

- Note domain and range are NOT interpreted as a constraint as you might expect
- Domain and range assertions allow us to make inferences about individuals
- Example

```
:hasChild rdfs:domain :Parent
:Mary :hasChild :Bob
```

  - If we haven't said anything else about Mary or Bob, this is not an error. But we can now infer that Mary is a Parent

# And/Or and quantification

- The logical connectives *and* and *or* often cause confusion
  - Milk and sugar? Tea or coffee? – think carefully of the meaning when modeling
  - intersection vs. union
- Quantification can be contrary to our intuition.
  - Universal quantification over an empty set is true
  - `:John` may belong to the class `:OnlyDaughterParent` if he has no child at all and we describe that class as:

```
:OnlyDaughterParent  rdf:type    owl:Class ;
    owl:equivalentClass  [
        rdf:type             owl:Restriction ;
        owl:onProperty       :hasChild ;
        owl:allValuesFrom    :Female
    ] .
```

  - Existential quantification may imply the existence of an individual that we don't know the name of (c.f OWA on next slide)

# Closed and open world assumptions

- The standard semantics of OWL makes an Open World Assumption (OWA)
  - We cannot assume that all information is known about all the individuals in a domain
  - Negation only through contradiction
    - Anything might be true unless it can be proven false

- Closed World Assumption (CWA)
  - Named individuals are the only individuals in the domain
  - Negation as failure
    - If we don't know that x is of type C, then we assume that x is NOT of type C

Let’s do some modelling...

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