IN3067/INM713 Semantic Web Technologies and Knowledge Graphs

Laboratory 3: Modelling OWL 2 Ontologies with Protégé

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Contents

1 First steps with ontology modelling

Task 3.1: Create an axiom (or axioms) for each of the following modelling tasks. Use DL or Manchester syntax to define the axioms (on paper):

1. All Mexican restaurants are restaurants.
2. Cities and countries are locations.
3. United Kingdom is a country.
4. An instance cannot be a pizza and a location at the same time.
5. Restaurants are located in cities.
6. Ernesto works for City, University of London
7. If a person teaches a module and that module belongs to a university then that person works for the university.
8. A vegan pizza contains only vegan ingredients.
9. A pizza with meat as ingredient is a meaty pizza.
10. A super veggie pizza contains at least 5 vegetarian ingredients.

2 The Pizza ontology

The pizza ontology and its tutorial are well-known resources in the Semantic Web community. They were developed for educational purposes by the University of Manchester. The tutorial have been recently updated by Michael DeBellis.

The pizza ontology and the tutorial are found at:

- `https://tinyurl.com/NewPizzaTutorialV3-2`
- `http://protege.stanford.edu/ontologies/pizza/pizza.owl`

In the following exercises we are going to explore the Pizza ontology and the ontology editor Protégé.[1]

Task 3.2: Open the pizza ontology in Protégé (*File menu and open from URL*). Take some time to browse the class hierarchy, the property hierarchies and the individuals and note how the ontology describes the domain of pizzas.

Task 3.3: Find `Margherita` and see how it is defined as a pizza with only cheese and tomato topping. Look at the definition of `VegetarianPizza`. Is a `MargheritaPizza` a vegetarian pizza? Why / why not?

[1] Some additional documentation can be found here: `http://protegeproject.github.io/protege/`. The `Protégé` demo video from Lab 2 may also be helpful.

Task 3.4: Find `hasIngredient`. What is the domain and range of this property? What are the subproperties of `hasIngredient`? What is the inverse property of `hasIngredient`? What property characteristics does `hasIngredient` have?

Task 3.5: Classify the ontology by choosing a reasoner (*e.g.*, HermiT) and then "classify/start reasoner" in the reasoner menu. In the entities/classes tab we can chose between the asserted classification and inferred classification (as a results of reasoning).

- In the "Inferred class hierarchy" two classes show up as subclasses of `owl:Nothing`. What does it mean for a class to be a subclass of `owl:Nothing`? Why these two classes appear as subclasses of `owl:Nothing`?
- Find Margherita in the inferred class hierarchy and see which classes are inferred as superclasses of Margherita.

Task 3.6: Add a new class `RomanoPizza` as a subclass of `NamedPizza`. Define `RomanoPizza` as a pizza with:

- `hasTopping some AnchoviesTopping`,
- `hasTopping some TomatoTopping` and
- `hasTopping some MozzarellaTopping`.

Classify the ontology. What superclasses are inferred as superclass of `RomanoPizza`? Why?

Task 3.7: Use the tutorial `https://tinyurl.com/NewPizzaTutorialV3-2` (also available in moodle). Chapters 1-3 give an overview of what we saw in the lecture. Chapters 4-8 give step by step instruction to create a version of the Pizza ontology.

3 Some important considerations

There are some combinations of OWL 2 axioms that may make your ontology to fall outside OWL 2 DL, and thus falling into undecidability (*e.g.*, the reasoner will give an error in `Protégé`). For example, OWL 2 DL does not allow cardinality restrictions on transitive properties, but you can create this combination of axioms in `Protégé`.

Task 3.8: Read more about non-allowed combination of axioms in *Modeling in OWL 2 without Restrictions*: `https://arxiv.org/pdf/1212.2902.pdf`. You may encounter these issues when creating the ontology for the coursework Part 1.

4 Real-world ontologies

There are a large number of ontologies that are being currently applied in real-world solutions. Prominent examples are the ontologies in life sciences. For example, BioPortal (`https://bioportal.bioontology.org/`) contains $\geq 1,000$ ontologies.

SNOMED CT ontology is one of the largest ($\geq 300,000$) and most important ontologies. SNOMED CT vocabulary has been adopted by the NHS. There are also other smaller ontologies with a more focused scope (*e.g.*, CMR-QA, an ontology I developed in the past, `https://bioportal.bioontology.org/ontologies/CMR-QA`).

Ontologies can also be found in many other domains (*e.g.*, Food: `https://foodon.org/`, Oil&Gas: `https://gitlab.com/logid/npd-factpages`).

Task 3.9: (Optional) Explore some of the above ontologies with Protégé.

5 Solutions

Task 3.1:

1. All Mexican restaurants are restaurants.

   $\texttt{MexicanRestaurant} \sqsubseteq \texttt{Restaurant}$

2. Cities and countries are locations.

   - Option 1:
     $\texttt{City} \sqcup \texttt{Country} \sqsubseteq \texttt{Location}$
   - Option 2 (preferred):
     $\texttt{City} \sqsubseteq \texttt{Location}$
     $\texttt{Country} \sqsubseteq \texttt{Location}$

3. United Kingdom is a country.

   `Country(United_Kingdom)`

4. An instance cannot be a pizza and a location at the same time.

   $\texttt{Pizza} \sqcap \texttt{Location} \sqsubseteq \bot$

5. Restaurants are located in cities.

   $\texttt{Restaurant} \sqsubseteq \exists \texttt{located\_in}.\texttt{City}$
   `Restaurant` SubClassOf `located_in` some `City`

6. Ernesto works for City, University of London

   `works_for(ernesto, city_univ)`

7. If a person teaches a module and that module belongs to a university then that person works for the university.

   $\texttt{teaches} \circ \texttt{belongs\_to} \sqsubseteq \texttt{works\_for}$

8. A vegan pizza contains only vegan ingredients.

   $\texttt{VeganPizza} \sqsubseteq \forall \texttt{hasIngredient}.\texttt{VeganIngredient}$
   `VeganPizza` SubclassOf `hasIngredient` only `VeganIngredient`

9. A pizza with meat as ingredient is a meaty pizza.

   $\texttt{Pizza} \sqcap \exists \texttt{hasIngredient.Meat} \sqsubseteq \texttt{MeatyPizza}$
   `Pizza` and `hasIngredient` some `Meat` SubclassOf `MeatyPizza`

10. A super veggie pizza contains at least 5 vegetarian ingredients.

    $\texttt{SuperVeggiePizza} \sqsubseteq \geq_5 \texttt{hasIngredient.VegetarianIngredient}$
    `SuperVeggiePizza` SubclassOf `hasIngredient` min 5 `VegetarianIngredient`