Exercise Sheet 3

SPARQL and OWL

*Submit your solutions until **Friday, 7.7.2017, 23h00 vias an ILIAS email (.zip attachment)**. Later submissions won't be considered. Every solution should contain the **name(s)**, **email adress(es)** and **registration number(s)** of its (co-)editors(s).*

1 OWL Modeling (14pts)

Write the following OWL statements in Turtle syntax. Use the given URIs (alphabetical listing) and the provided "template".

1. The Khumbu is a Nepalese region, a Nepalese region is a region.
   (`ex:Khumbu`, `ex:NepaleseRegion`, `ex:Region`)
2. When A has climbed mountain M, M has been climbed by A.
   (`ex:hasClimbed`, `ex:hasBeenClimbedBy`)
3. Tenzing Norgay is a different person than Edmund Hillary.
   (`ex:EdmundHillary`, `ex:TenzingNorgay`)
4. One thing among many that makes something an interesting mountains is that it has been climbed by Tenzing Norgay.
   (`ex:hasBeenClimbedBy`, `ex:InterestingMountain`, `ex:TenzingNorgay`)
5. Mountains and cities are located in only in regions, regions are the only thing they can be located in. (`ex:City`, `ex:locatedInRegion`, `ex:Mountain`, `ex:Region`)
6. A Nepalese Mountain is defined as something that is a mountain and it is located in one of the regions of Nepal, nothing else is a Nepalese mountain.
   (`ex:locatedInRegion`, `ex:Mountain`, `ex:NepaleseMountain`, `ex:NepaleseRegion`)
7. Use any element of OWL to say something that makes sense in this domain. Give the OWL statemtent(s) and a short textual description (1-2 sentences).

2 Protégé (12 points)

This is a continuation of Exercise 1 from Assignment 2 (RDFS Serialization).

1. **OWL:** Enrich your Turtle RDFS model with a book and person taxonomy. Add next OWL class descriptions (combining existing classes with logical operators, restrictions). Use in particular negations and disjointness assertions. Add new instances as well.

2. **Reasoning:** Load your ontology in Protégé and start the reasoner.

Submit the extended ontology in Turtle format.

Describe what new information is added to the ontology. If there are surprising results, try to understand why this happened and if this is an error, correct it.

If there are inconsistencies, try to explain what happened and correct the errors.

If there are no inconsistencies, add more restrictions and complex class descriptions to your ontology. Explain why the restrictions have to be formulated exactly how they are and what inconsistencies could arise otherwise.

3 Equivalence

3.1 OWL DL Equivalence (6 points)

DLs and OWL allow to rewrite the same concept in several ways, provided each rewriting is (logically) equivalent to the original concept. Formally, two DL concepts A and A' are said to *equivalent*, in symbols $A \equiv A'$, if for all interpretations $\mathcal{I}$, $A^{\mathcal{I}} = A'^{\mathcal{I}}$. Either **(1)** reason set-theoretically, or **(2)** argue why the equivalence holds[1].

- $\exists_{\geq 1} r.A \equiv \exists r.A$
- $\neg(\neg A \sqcap \neg B) \equiv A \sqcup B$
- $A \sqcap A \equiv A$
- $A \sqcap \bot \equiv \neg(A \sqcup \neg A)$

3.2 SPARQL Equivalence (6 points)

Two SPARQL queries Q and Q' are said to be *equivalent* w.r.t. ontology $\mathcal{O}$, denoted Q $\equiv_{\mathcal{O}}$ Q', when their lists of answers over $\mathcal{O}$ **coincide**. Consider the following queries over the DBpedia ontology $\mathcal{O}_{DB}$:

Q1:
```
PREFIX dbo: <http://dbpedia.org/ontology/>
SELECT ?film ?director ?y WHERE {
```

[1] **Hint:** If you choose **(2)**, it may help to rely on the properties of the associated OWL concept constructors and triples.

```
 ?film rdf:type dbo:Film .
 ?film dbo:director ?director .
 ?director dbo:birthYear ?y .
} ORDER BY ?director
LIMIT 100
```

Q2:

```
PREFIX dbo: <http://dbpedia.org/ontology/>
SELECT DISTINCT ?film ?director ?y WHERE {
 ?film rdf:type dbo:Film .
 ?film dbo:director ?director .
 ?director dbo:birthYear ?y .
} ORDER BY DESC(?director)
LIMIT 100
```

Q3:

```
PREFIX dbo: <http://dbpedia.org/ontology/>
SELECT ?film ?director ?y WHERE {
 ?film rdf:type dbo:Film .
 ?film dbo:director ?director .
 ?director dbo:birthYear ?y .
 FILTER(?y = "1959"^^xsd:gYear)
} ORDER BY ?director
LIMIT 100
```

Q4:

```
PREFIX dbo: <http://dbpedia.org/ontology/>
SELECT ?film ?director ?y WHERE {
 ?film rdf:type dbo:Film .
 ?film dbo:director ?director .
 ?director dbo:birthYear "1959"^^<http://www.w3.org/2001/XMLSchema#gYear>.
 ?director dbo:birthYear ?y .
} ORDER BY ?director
LIMIT 100
```

Check if the following equivalences hold, and in each case, explain **(1)** why it does or does not hold and **(2)** what is the main difference between the two:

1. Q1 $\equiv_{\mathcal{O}_{DB}}$ Q2.
2. Q3 $\equiv_{\mathcal{O}_{DB}}$ Q4.

4 OWL DL (Bonus!)

Important remark: This section is optional, but can be used to gather extra points and/or replace other sections

4.1 Description Logic Ontologies (6 points)

You are given the following Description Logic ontology fragment:

$$\begin{array}{|l|}\hline \text{WildPig(Rooter)} \\ \text{pulledBy(HogfathersSleigh, Rooter)} \\ \text{belongsTo(HogfathersSleigh, Hogfather)} \\ \hline\end{array}$$

We want to derive new knowledge about Rooter.

1. Write the following statements in Description Logic syntax. Use the given class and property names:
   - The Hogfather and Death are anthropomorphic personifications (APs). (`AnthropomorphicPersonification`, `Death`, `Hogfather`)
   - Among other things, a wild pig sleigh is pulled only by wild pigs. (`WildPigSleigh`, `pulledBy`, `WildPig`)
   - Discworld godlike beings can either be Discworld gods or APs and nothing else. (`AnthropomorphicPersonification`, `DWGod`, `DWGodlikeBeing`)
   - No-one can be an AP and a human at the same time. (`AnthropomorphicPersonification`, `Human`)
2. What do we know for certain about Rooter now?

4.2 Description Logic Reasoning (6 points)

You are given the following Description Logic ontology $\mathcal{O}_a$:

• Bird $\sqsubseteq$ Flying	– birds fly.
• Penguin $\sqsubseteq$ Bird	– penguins are birds.
• Penguin $\sqcap$ Flying $\sqsubseteq \bot$	– penguins cannot fly.
• Penguin $\sqcap$ Giraffe $\sqsubseteq \bot$	– penguins are different from giraffes.
• Penguin(skipper)	– Skipper is a penguin.
• Giraffe(melman)	– Melman is a giraffe.

Reason **model-theoretically** to answer the following:

1. Show that the ontology $\mathcal{O}_a$ is **consistent**.

2. Show that $\mathcal{O}_a$ **does not entail** that:

   - neither melman flies, nor
   - giraffes fly.

4.3 Description Logic Semantics (2 points)

Description Logic semantics maps, broadly speaking, Description Logic concepts, properties and statements to sets, set-valued relations, and set-theoretical statements, resp.

1. Convert the expressions to set theory using Description Logic semantics and explain why $\exists r.\top \sqsubseteq A$ expresses that the domain of r is A?

2. Convert the expressions to set theory using Description Logic semantics and explain why $\top \sqsubseteq \forall r.A$ expresses that the range of r is A?