COMP321 (Ontology Languages): Test 2

Lecturer: F. Wolter
Time: 50 minutes

This test makes up 10 percent of the final mark for this module. You can achieve 100 marks.

1. Let the TBox \( \mathcal{T} \) be given by

\[
\begin{align*}
\text{City} & \sqsubseteq \forall \text{has\_location. Region} \\
\text{Region} & \sqsubseteq \text{GeographicalE} \\
\exists \text{has\_location.} \top & \sqsubseteq \text{GeographicalE} \\
\text{Region} \sqcap \text{City} & \sqsubseteq \bot
\end{align*}
\]

Let the ABox \( \mathcal{A} \) be given by

\[
\begin{align*}
\text{Liverpool} & : \text{City} \\
(\text{Liverpool, Merseyside}) & : \text{has\_location} \\
\text{York} & : \text{GeographicalE}
\end{align*}
\]

The answers given by the knowledge base \((\mathcal{T}, \mathcal{A})\) to Boolean queries are “Yes”, “No”, or “Don’t know”. Give the answers given by \((\mathcal{T}, \mathcal{A})\) to the following Boolean queries:

- City(Liverpool);
- Region(Liverpool);
- GeographicalE(Liverpool);
- City(York);
- Region(York);
- GeographicalE(York);
- City(Merseyside);
- Region(Merseyside);
- GeographicalE(Merseyside);

Give an informal explanation of your answers. (30 marks)
2. Explain why the answer to a query \( q \) returned by an ABox \( A \) is not always the same as the answer returned by the corresponding relational database instance. Use an example to illustrate your explanation and discuss the relevance of this difference. (20 marks)

3. Consider the following assertions:

- Every city has at least two shops;
- Only cities have shops and cinemas;
- Liverpool is a city that is located in the UK and has at most 5 cinemas;
- No city located in the UK is located in France.

(a) Translate them into description logic inclusions in \( SHOIQ \). State which concept names, role names, and nominals are used. Also name the description logic constructors used in your translation.

(b) Translate the first two assertions into FOPL (first-order predicate logic). (30 marks)

4. Let \( T = \{ A \sqsubseteq \exists r. B, A \sqsubseteq B, B \sqsubseteq E, \exists r. E \sqsubseteq F, \exists r. B \sqsubseteq F \} \). Determine two sets of axioms in \( T \) that are in the pinpointing set \( Pin(T, A \sqsubseteq F) \). (20 marks)

Answer for Question 1:

- City(Liverpool): “Yes”. Already in ABox.
- Region(Liverpool): “No”, since Liverpool is a City (ABox) and the TBox states that City and Region are disjoint.
- GeographicalE(Liverpool): “Yes”, since Liverpool is located in something (ABox) and everything that is located in something is a GeographicalA (TBox).
- City(York): “Don’t know” since there are interpretations satisfying \((T, A)\) in which the assertion holds and interpretations satisfying \((T, A)\) in which the assertion does not hold.
- Region(York): “Don’t know”, for the same reason.
- City(Merseyside): “No”. According to the answer to the next query, Merseyside is a Region. So, since Region and City are disjoint (TBox), it cannot be a city.
- Region(Merseyside): “Yes”. Liverpool is located in Merseyside (ABox) and therefore Merseyside is a Region by the TBox.
- GeographicalE(Merseyside): “Yes”. Because Merseyside is a Region (see above) and every Region is a GeographicalE according to the TBox.
Answer for Question 2: See Lecture Notes.

Answer for Question 3: We use has and located_in as role names, city, shop, cinema as concept names, and Liverpool, UK, France as nominals.

- Every city has at least two shops:
  \[\text{City} \sqsubseteq (\geq 2 \text{ has} \text{.Shop})\]
  Here we use a qualified number restriction.

- Only cities have shops and cinemas:
  \[\exists \text{has.Shop} \sqcap \exists \text{has.Cinema} \sqsubseteq \text{City}\]
  Here we use existential restrictions.

- Liverpool is a city that is located in the UK and has at most 5 cinemas:
  \[\{\text{Liverpool}\} \sqsubseteq \text{City} \sqcap \exists \text{located.in} \{\text{UK}\} \sqcap (\leq 5 \text{ has.Cinema})\]
  Here we use existential restrictions, qualified number restrictions, and nominals.

- No city located in the UK is located in France:
  \[\text{City} \sqcap \exists \text{located.in} \{\text{UK}\} \sqcap \exists \text{located.in} \{\text{France}\}\]
  Here we use existential restrictions and nominals.

Translations into FOPL:

\[
\forall x (\text{city}(x) \rightarrow \exists x_1 \exists x_2 (\text{has}(x, x_1) \land \text{has}(x, x_2) \land \text{shop}(x_1) \land \text{shop}(x_2) \land \neg (x_1 = x_2))).
\]

\[
\forall x ((\exists y_1 \exists y_2 (\text{has}(x, y_1) \land \text{has}(x, y_2) \land \text{shop}(y_1) \land \text{cinema}(y_2)) \rightarrow \text{city}(x))
\]

Answer for Question 4:

Two set are given by:

- \{A \sqsubseteq \exists r.B, B \sqsubseteq E, \exists r.E \sqsubseteq F\};
- \{A \sqsubseteq \exists r.B, \exists r.B \sqsubseteq F\}.  