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

$$\begin{aligned} \mathsf{City} &\sqsubseteq \forall \mathsf{has\_location}.\mathsf{Region} \\ \mathsf{Region} &\sqsubseteq \mathsf{GeographicalE} \\ \exists \mathsf{has\_location}.\top &\sqsubseteq \mathsf{GeographicalE} \\ \mathsf{Region} \sqcap \mathsf{City} &\sqsubseteq \bot \end{aligned}$$

Let the ABox $\mathcal{A}$ be given by

$$\begin{aligned} \mathsf{Liverpool} &: \mathsf{City} \\ (\mathsf{Liverpool}, \mathsf{Merseyside}) &: \mathsf{has\_location} \\ \mathsf{York} &: \mathsf{GeographicalE} \end{aligned}$$

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:

- $\mathsf{City}(\mathsf{Liverpool})$;
- $\mathsf{Region}(\mathsf{Liverpool})$;
- $\mathsf{GeographicalE}(\mathsf{Liverpool})$;
- $\mathsf{City}(\mathsf{York})$;
- $\mathsf{Region}(\mathsf{York})$;
- $\mathsf{GeographicalE}(\mathsf{York})$;
- $\mathsf{City}(\mathsf{Merseyside})$;
- $\mathsf{Region}(\mathsf{Merseyside})$;
- $\mathsf{GeographicalE}(\mathsf{Merseyside})$;

Give an informal explanation of your answers. (**30 marks**)

2. Explain why the answer to a query q returned by an ABox $\mathcal{A}$ 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 $\mathcal{SHOIQ}$. 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 $\mathcal{T} = \{A \sqsubseteq \exists r.B, A \sqsubseteq B, B \sqsubseteq E, \exists r.E \sqsubseteq F, \exists r.B \sqsubseteq F\}$. Determine two sets of axioms in $\mathcal{T}$ that are in the pinpointing set $\mathsf{Pin}(\mathcal{T}, A \sqsubseteq F)$. (**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 $(\mathcal{T}, \mathcal{A})$ in which the assertion holds and interpretations satisfying $(\mathcal{T}, \mathcal{A})$ in which the assertion does not hold.
- Region(York): "Don't know", for the same reason.
- GeographicalE(York): "Yes". Already in ABox.
- 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 $\mathsf{located\_in}$ as role names, city, shop, cinema as concept names, and $\mathsf{Liverpool}$, UK, france as nominals.

- Every city has at least two shops:

  $$\mathsf{City} \sqsubseteq (\geq 2\ \mathsf{has.Shop})$$

  Here we use a qualified number restriction.

- Only cities have shops and cinemas:

  $$\exists \mathsf{has.Shop} \sqcap \exists \mathsf{has.Cinema} \sqsubseteq \mathsf{City}$$

  Here we use existential restrictions.

- Liverpool is a city that is located in the UK and has at most 5 cinemas:

  $$\{\mathsf{Liverpool}\} \sqsubseteq \mathsf{City} \sqcap \exists \mathsf{located\_in}.\{\mathsf{UK}\} \sqcap (\leq 5\ \mathsf{has.Cinema})$$

  Here we use existential restrictions, qualified number restrictions, and nominals.

- No city located in the UK is located in France:

  $$\mathsf{City} \sqcap \exists \mathsf{located\_in}.\{\mathsf{UK}\} \sqcap \exists \mathsf{located\_in}.\{\mathsf{France}\}$$

  Here we use existential restrictions and nominals.

Translations into FOPL:

$$\forall x(\mathsf{city}(x) \rightarrow \exists x_1 \exists x_2(\mathsf{has}(x, x_1) \wedge \mathsf{has}(x, x_2) \wedge \mathsf{shop}(x_1) \wedge \mathsf{shop}(x_2) \wedge \neg(x_1 = x_2)).$$

$$\forall x((\exists y_1 \exists y_2(\mathsf{has}(x, y_1) \wedge \mathsf{has}(x, y_2) \wedge \mathsf{shop}(y_1) \wedge \mathsf{cinema}(y_2)) \rightarrow \mathsf{city}(x))$$

Answer for Question 4:
Two set are given by:

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