Knowledge Representation and Semantic Technologies – 16/6/2022

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Exercise 1 Given the following $\mathcal{ALC}$ TBox:

$$\begin{array}{rcl} A & \sqsubseteq & B \sqcup C \\ B & \sqsubseteq & \exists r.D \\ C & \sqsubseteq & \forall r.\neg D \\ B \sqcap E & \sqsubseteq & C \\ C \sqcap E & \sqsubseteq & \exists r.F \\ F & \sqsubseteq & D \end{array}$$

(a) tell whether the concept A is satisfiable with respect to $\mathcal{T}$, and if so, show a model for $\mathcal{T}$ where A is satisfiable, otherwise explain your answer;

(b) tell whether the concept $B \sqcap E$ is satisfiable with respect to $\mathcal{T}$, and if so, show a model for $\mathcal{T}$ where $B \sqcap E$ is satisfiable, otherwise explain your answer;

(c) tell whether the concept $A \sqcap E$ is satisfiable with respect to $\mathcal{T}$, and if so, show a model for $\mathcal{T}$ where $A \sqcap E$ is satisfiable, otherwise explain your answer;

(d) given the ABox $\mathcal{A} = \{C(a), r(a, b)\}$, tell whether the knowledge base $\langle \mathcal{T}, \mathcal{A} \rangle$ entails the assertion $\neg D(b)$, explaining your answer.

Exercise 2 Given the following ASP program P:

```
r(X,Y,Z,W) :- p(X,Y), q(Z,W).
s(X,Z) :- p(X,Y), r(Y,Z,W,V).
t(X,Y) :- s(X,Y), s(Z,W), not r(X,Y,Z,W).
t(X,Y) :- r(X,Y,Z,W), not s(X,Y).
u(X,Y) :- s(X,Y), not t(X,Y).
v(X,Y) :- t(X,Y), u(X,Y), not t(Y,X).
p(a,b). p(b,c).
q(a,b). q(c,a).
```

(a) tell whether P is stratified;

(b) compute the answer sets of P.

Exercise 3

We want to formalize knowledge about persons and kinship relationships. In particular, we want to formalize the following statements:

1. every employee is a person;
2. every manager is a person;
3. employee and manager are disjoint classes;
4. every project is either a research project or an industrial project;
5. the property "is manager of" has domain manager and range employee;
6. the property "is manager of" is a subproperty of the property "works with".

(a) Choose the most appropriate knowledge representation language for expressing the above knowledge among the following ones: $\mathcal{ALC}$, Datalog, Datalog with constraints, ASP, OWL, *DL-Lite*$_R$, $\mathcal{EL}$, *RL*, RDFS, motivating your choice;

(b) express the above knowledge in the formalism chosen at the previous point.

Exercise 4

(a) Write an RDF/RDFS model representing the following statements about URIs `Person`, `HasParent`, `HasMother`, `HasFather`, `Man`, `Woman`, `City`, `livesIn`, `Ann`, `Bob`, `Jane`, `Mary`, `Paul`, `Sandy`, `Rome`, `Milan`,

1. `Person`, `Man`, `Woman`, and `City` are classes;
2. `Man` and `Woman` are subclasses of `Person`;
3. `HasParent`, `HasMother`, `HasFather`, `livesIn`, are properties;
4. `IsMother` and `HasFather` are subproperties of `HasParent`;
5. `HasParent` has domain `Person` and range `Person`;

6. `HasMother` has domain `Person` and range `Woman`;
7. `HasFather` has domain `Person` and range `Man`;
8. `livesIn` has domain `Person` and range `City`;
9. Jane is a woman;
10. Jane has father Bob;
11. Paul is the son of Ann;
12. Mary and Bob are the children of Paul and Sandy;
13. Jane and Bob live in Milan.

(b) Write SPARQL queries corresponding to the following requests: (b1) return all the uncles of Bob (i.e., the men who have the same parents as one of Bob's parents); (b2) return all the aunts of Mary (i.e., the women who have the same parents as one of Mary's parents) and optionally the city where they live; (b3) return all the grandchildren of Paul.

Exercise 5

Given the *RL* knowledge base $\langle \mathcal{T}, \mathcal{A} \rangle$, where $\mathcal{T}$ is the following TBox:

$$
\begin{array}{l}
F \sqcap A \sqsubseteq D \\
C \sqcap A \sqsubseteq B \\
r \sqsubseteq u \\
s \sqsubseteq u \\
u^{-} \sqsubseteq t \\
\exists t.\top \sqsubseteq E \\
\exists t.E \sqsubseteq A \\
\exists s^{-}.\top \sqsubseteq F \\
\exists r^{-}.\top \sqsubseteq C
\end{array}
$$

and $\mathcal{A}$ is the following ABox:

$$s(a_7, a_5), \quad s(a_5, a_3), \quad s(a_1, a_4), \quad r(a_7, a_1), \quad r(a_5, a_8), \quad r(a_3, a_2), \quad r(a_4, a_6)$$

1. compute the materialization of the ABox $\mathcal{A}$ with respect to the TBox $\mathcal{T}$;
2. tell whether the concept assertion $D(a_4)$ is entailed by $\langle \mathcal{T}, \mathcal{A} \rangle$;
3. write a Datalog program corresponding to the above TBox.