Knowledge Representation and Semantic Technologies – 14/7/2015

LAST NAME: ____________________

FIRST NAME: ____________________

ID (MATRICOLA): __________

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

$$
\begin{array}{lcl}
A & \sqsubseteq & B \sqcup C \\
B & \sqsubseteq & D \sqcup E \\
D & \sqsubseteq & \exists R.E \\
E & \sqsubseteq & \forall R.\neg E
\end{array}
$$

(a) tell whether the TBox $\mathcal{T}$ is satisfiable, and if so, show a model for $\mathcal{T}$;

(b) tell whether the concept B is satisfiable with respect to $\mathcal{T}$, and if so, show a model for $\mathcal{T}$ where the interpretation of B is non-empty;

(c) given the ABox $\mathcal{A} = \{D \sqcap E(a)\}$, tell whether the knowledge base $\langle \mathcal{T}, \mathcal{A} \rangle$ is satisfiable (consistent), explaining your answer.

Exercise 2 Given the following ASP program P:

```
r(x,y) :- p1(x), p2(y).
s(x,y) :- p2(x), p1(y).
t(x,y) :- r(x,y), not s(x,y).
v(x,y) :- s(x,y), not r(x,y).
w(x,y) :- t(x,y), v(y,z).
w(x,y) :- v(x,y), not t(y,x).
p1(a). p1(b). p1(c). p2(b). p2(c). p2(d).
```

(a) tell whether P is stratified;

(b) compute the answer sets of P.

Exercise 3 We want to formalize knowledge about the domain of employees. In particular, we want to formalize the following statements:

1. every employee is a person;
2. the property 'is manager of" has domain employee and range employee;
3. the property "is manager of" is a subproperty of the property "works with";
4. a special-employee is an employee who is the manager of some employee;
5. a simple-employee is an employee who is not the manager of any employee.

(a) Choose the most appropriate knowledge representation language for expressing the above knowledge among the following: $\mathcal{ALC}$, Datalog, ASP, OWL, DL-Lite, 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`, `Director`, `Actor`, `Country`, `Movie`, `HorrorMovie`, `Male`, `Female`, `filmedIn`, `isDirectorOf`, `actsIn`, `bornIn`, `Joe`, `Mary`, `Ann`, `Paul`, `France`, `ABC`, `XYZ`.

1. `Person`, `Director`, `Actor`, `Country`, `Movie`, `HorrorMovie`, `Male`, and `Female` are classes;
2. `Male` and `Female` are subclasses of `Person`;
3. `actsIn`, `bornIn`, `filmedIn` and `isDirectorOf` are properties;
4. `isDirectorOf` has domain `Director` and range `Movie`;
5. `flmedIn` has domain `Movie` and range `Country`;
6. `bornIn` has domain `Person` and range `Country`;
7. `actsIn` has domain `Actor` and range `Movie`;
8. Ann is the director of movie XYZ;
9. Joe and Paul act in movie ABC;
10. ABC was filmed in France;
11. Ann is female.
12. Paul is male.

(b) Write SPARQL queries corresponding to the following requests: (b1) "return the male actors who acted with Joe in at least one movie"; (b2) "return every horror movie and, optionally, the director of the movie and the country where it was filmed."

Exercise 5

(a) Write an OWL ontology that formalizes the domain described at point (a) of Exercise 4.

(b) Add to the above ontology the axioms formalizing the following statements:

1. add a new property `directed` and state that it is the inverse of `isDirectorOf`;
2. add the new class `NonHorrorDirector` and state that `NonHorrorDirector` corresponds to the class of directors who directed no horror movies;
3. every actor is born in exactly one country;
4. every movie is filmed in at least one country;
5. `bornIn` and `actsIn` are disjoint properties.

Then, tell whether the resulting OWL ontology is redundant, i.e.: can some of the axioms constituting the ontology be deleted without changing the meaning (that is, the models) of the ontology? if so, identify and list such axioms.

Exercise 6

(a) Axiomatize the following scenario, appropriately with action precondition and effect axioms, and obtain successor state axioms.

Fluents:

- `doorOpen(s)` - The door is open in situation s.
- `closeToDoor(s)` - The robot is close to the door in situation s.
- `windowOpen(s)` - The window is open in situation s.
- `closeToWindow(s)` - The robot is close to the window in situation s.
- `airFlows(s)` - The air flows into the room in situation s.

Actions:

- `moveCloseToDoor` - The robot moves close to the door. This can be done if the robot is not close to the door, and has the effect that the robot will be close to the door.
- `openDoor` - The robot opens the door. This can be done if the robot is close to the door and the door is closed, and has the effect that the door will be open.
- `moveCloseToWindow` - The robot moves close to the window. This can be done if the robot is not close to the window, and has the effect that the robot will be close to the window.
- `openWindow` - The robot opens the window. This can be done if the robot is close to the window and the window is closed, and has the effect that the window will be open and the air will flow into the room.

Initial situation description: Initially the robot is close to the door and is not close to the window, the door is closed, the window is closed, and the air does not flow into the room.

(b) Show, by applying regression, that the air flows into the room after the sequence of actions `moveCloseToWindow, openWindow`, and that the sequence of actions is indeed executable.