Basics of Description Logic $\mathcal{ALC}$

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1 Getting familiar with $\mathcal{ALC}$

Consider the following $\mathcal{ALC}$ ontology :

$$\begin{aligned} Man &\sqsubseteq Person \\ Woman &\sqsubseteq Person \sqcap \neg Man \\ Father &\equiv Man \sqcap \exists hasChild \cdot Person \\ GrandFather &\equiv \exists hasChild \cdot \exists hasChild \cdot \top \\ Sister &\equiv Person \sqcap \neg Man \sqcap \exists hasSibling \cdot Person \end{aligned}$$

1. What is the meaning of these particular axioms ? Try to formulate them in natural language.
2. Rewrite last axiom into the semantically equivalent FOPL formula.
3. Consider the following structure:

$$\begin{aligned} \Delta^{\mathcal{I}} &= Person^{\mathcal{I}} = \{John, Mary\} \\ Man^{\mathcal{I}} &= \{John\} \\ Woman^{\mathcal{I}} &= \{Mary\} \\ Sister^{\mathcal{I}} &= \{\} \\ Father^{\mathcal{I}} &= GrandFather^{\mathcal{I}} = \{John\} \\ hasChild^{\mathcal{I}} &= \{\langle John, John\rangle\} \\ hasSibling^{\mathcal{I}} &= \{\} \end{aligned}$$

   a) Decide, whether this structure is a model of the ontology. If not, modify it, so that it is. If yes, decide, whether this model can reflect some real setup.

   b) We know that $\mathcal{ALC}$ has *tree model property* and *finite model property*. Is the interpretation $\mathcal{I}$ from this example tree-shaped ? If not, find a model that is tree-shaped.

   c) Is the interpretation $\mathcal{I}$ finite ? If not, find an interpretation of this ontology that is finite.

4. Using other axioms define concepts:
   - "A father having just sons."
   - "Someone who has at least one sister, but no brother."
5. Let's consider two roles *hasChild* and *hasSibling*. During knowledge modeling, it is often necessary to specify :

   global domain and range of given role, i.e. statement of the type "By *hasChild* we connect always a person (instance of the *Person* class – domain) with another person (instance of the *Person* class – range)".

   local domain and range of given role, e.g. "Every father having only sons can be connected by *hasChild* just with man (instances of the *Man* class – range)".

   Show, in which way it is possible to model global domain and range of these roles in $\mathcal{ALC}$.

2 Using Protégé

1. Go through the Protégé Crash Course on the tutorial web pages.
2. Create a new ontology in Protégé 4 and insert there all the definitions from Section 1. Verify correctness of your solution of the previous task (e.g. in the DL query tab).