3. Modeling and Reasoning Using Protégé

Exercise 3.1

1. Model in Protégé the following ontology $\mathcal{O} = \langle \mathcal{T}, \mathcal{A} \rangle$:

$$\mathcal{T} = \{\ \text{Father} \equiv \text{Human} \sqcap \text{Male} \sqcap \exists \text{hasChild},$$
$$\text{HappyFather} \sqsubseteq \text{Father} \sqcap \forall \text{hasChild}.(\text{Doctor} \sqcup \text{Lawyer})\ \}$$
$$\mathcal{A} = \{\ \text{HappyFather}(\texttt{john}), \quad \text{hasChild}(\texttt{john}, \texttt{mary})\ \}$$

2. Check, using the reasoner available in Protégé, if the following entailments hold:

$$\mathcal{T} \models \text{HappyFather} \sqsubseteq \exists \text{hasChild}.(\text{Doctor} \sqcup \text{Lawyer})$$
$$\mathcal{O} \models \text{Doctor}(\texttt{mary}) \qquad \mathcal{O} \models (\text{Doctor} \sqcup \text{Lawyer})(\texttt{mary})$$

Exercise 3.2

1. Modify in Protégé the ontology $\mathcal{O}$ so as to include in $\mathcal{T}$ the concept inclusions

$$\begin{aligned}
\text{Father} &\equiv \text{Human} \sqcap \text{Male} \sqcap \exists \text{hasChild} \\
\text{HappyFather} &\sqsubseteq \text{Father} \sqcap \forall \text{hasChild}.(\text{Doctor} \sqcup \text{Lawyer} \sqcup \text{HappyPerson}) \\
\text{HappyAnc} &\sqsubseteq \forall \text{descendant}.\text{HappyFather} \\
\text{Teacher} &\sqsubseteq \neg \text{Doctor} \sqcap \neg \text{Lawyer}
\end{aligned}$$

and the role assertions

$$\text{hasChild} \sqsubseteq \text{descendant} \qquad \text{hasFather} \sqsubseteq \text{hasChild}^-$$
(**transitive** descendant)   (**reflexive** descendant)   (**functional** hasFather)

and in $\mathcal{A}$ the membership assertions

$$\text{Teacher}(\texttt{kate}) \qquad \text{hasFather}(\texttt{kate}, \texttt{peter}) \qquad \text{HappyAnc}(\texttt{peter})$$

2. Check if the following entailments hold for the modified $\mathcal{T}$ and $\mathcal{O}$:

$$\mathcal{T} \models \text{HappyAnc} \sqsubseteq \exists \text{hasChild}.\text{HappyPerson}$$
$$\mathcal{T} \models \text{HappyAnc} \sqsubseteq \text{Father} \qquad \mathcal{T} \models \text{HappyAnc} \sqsubseteq \text{Male} \sqcup \text{Female}$$
$$\mathcal{O} \models \text{HappyPerson}(\texttt{kate}) \qquad \mathcal{O} \models \text{HappyFather}(\texttt{kate})$$
$$\mathcal{O} \models (\geq 1\,\text{hasChild})(\texttt{peter}) \qquad \mathcal{O} \models (\leq 2\,\text{hasChild})(\texttt{peter})$$

Do all entailments correspond to our intuition? If not, how can one fix $\mathcal{O}$ to avoid undesired ones?

Exercise 3.3

1. Model in Protégé the following concepts, assigning them suitable names:

    (a) $\text{Father} \sqcap \forall \text{hasChild}.(\text{Doctor} \sqcup \text{Manager})$
    (b) $\exists \text{manages}.(\text{Company} \sqcap (\geq 3\,\text{employs}.\text{Doctor}))$
    (c) $\exists \text{managedBy}^-.(\text{Company} \sqcap (\leq 3\,\text{employs}.\text{Doctor}))$
    (d) $\text{Father} \sqcap \forall \text{hasChild}.(\text{Doctor} \sqcup \exists \text{managedBy}^-.(\text{Company} \sqcap (\leq 3\,\text{employs}.\text{Doctor})))$

2. Model in Protégé the following axioms:

    (a) $\text{Person} \sqcap \forall \text{hasChild}.\text{HappyPerson} \sqsubseteq \exists \text{hasChild}.\forall \text{hasChild}.\text{HappyPerson}$
    (b) $\text{Father} \sqcap \forall \text{hasChild}.(\text{Doctor} \sqcup \text{Manager}) \sqsubseteq \exists \text{manages}.(\text{Company} \sqcap (\geq 3\,\text{employs}.\text{Doctor}))$
    (c) $\text{Person} \sqcap \exists \text{hasChild}.\text{HappyPerson} \sqsubseteq \text{Happy} \sqcap (\text{Father} \sqcup \text{Mother})$

Exercise 3.4 For the modeled domain, define some suitable data properties and assign domain and range as appropriate. For example, you could introduce the data property name with domain Person and range string.