

M2R Exam
Fundamentals of data processing and distributed knowledge
Semantics of Distributed Knowledge part

Duration : 3h
All documents allowed – *No* communication device allowed

January 2024

Note: Read all the questions carefully before answering. Justify your answers with respect to the semantics: this is the semantics that justifies their correctness.

Time and points are indicative.

Course questions

[Expectation: 30mn; 5pts]

Here I give only three examples, but it should be around 10 questions, the answers are in the course in general.

Answers to these questions are generally short (if the answer is more than three sentences, it is probably wrong, except for the last one). They are related to the course content.

1. For what is it useful to query different sources?
2. What does it mean for a structure (formula, theory, network, etc.) to be inconsistent?
3. In modal logic, is $S \models S'$ defined by $\forall M, M \models S \Rightarrow M \models S'$ or by $\forall M, \forall w \in W_M, M, w \models S \Rightarrow M, w \models S'$? Does one expression imply the other? Why?

Application

[Expectation: 2h; 15pts]

Data and ontology

We have three actors each one having their ontologies.

O_a : Cook

$oa:Meal \equiv \forall oa:madeOf. oa:Ingredient$
 $oa:VeggyMeal \equiv oa:Meal \sqcap \forall oa:madeOf. \neg oa:Meat$
 $oa:SpicyMeal \equiv oa:Meal \sqcap \exists oa:madeOf. oa:Chilly$
 $oa:Chily \sqsubseteq oa:Ingredient$
 $oa:Meat \sqsubseteq oa:Ingredient$

O_b : Producer

$\top \sqsubseteq ob:Product$
 $ob:Mushroom \equiv ob:Product \sqcap ob:species = fungus$
 $ob:Vegetable \equiv ob:Product \sqcap ob:species = plant$
 $ob:Meat \equiv ob:Product \sqcap ob:species = animal$
 $ob:Mushroom \perp ob:Meat$
 $ob:Vegetable \perp ob:Meat$
 $ob:RedMushroom \equiv ob:Mushroom \sqcap ob:color = red$
 $ob:WhiteMushroom \equiv ob:Mushroom \sqcap ob:color = white$
 $ob:BlackMushroom \equiv ob:Mushroom \sqcap ob:color = black$

O_d : Doctor / dietetician

$\top \sqsubseteq od:Substance$
 $od:Edible \sqsubseteq od:Substance$
 $od:Toxic \sqsubseteq od:Substance$
 $od:Lethal \sqsubseteq od:Toxic$
 $od:Edible \perp od:Toxic$

\perp is owl:disjointWith, \sqsubseteq is rdfs:subClassOf, \equiv is rdfs:subClassOfowl:equivalentClass, $=$ is owl:hasValue, \forall is owl:allValuesFrom, \exists is owl:minQualifiedCardinality with $n = 1$ and \sqcap is owl:intersectionOf.

The following table features instances and their attribute values which make the graph G :

Instance in G	ob:taste	ob:color	ob:texture	ob:species
d:AmanitaP		white		fungus
d:AmanitaM		red		fungus
d:AjiA	spicy	yellow		plant
d:Snail		black	crisp	animal
d:Wasabi	spicy	green	crisp	
d:Shitake			velvety	fungus

- Classify these instances, i.e. assign them to the classes in which they must belong in the ontologies above, i.e. for each $i \in G$, to all classes $c \in O$, such that $O \cup G \models_{OWL} i \text{ rdf:type } c$?
- Does $O_b \models_{OWL} ob:Vegetable \perp ob:Mushroom$? Justify.

Alignments and queries

Consider the following data making G_a :

d:meal1 rdf:type oa:Meal	d:meal2 rdf:type oa:VeggyMeal	d:meal3 rdf:type oa:SpicyMeal
d:meal1 oa:madeOf d:AjiA	d:meal2 oa:madeOf d:Wasabi	d:meal3 oa:madeOf d:Shitake
d:meal1 oa:madeOf d:Snail	d:meal2 oa:madeOf d:Shitake	d:meal3 oa:madeOf d:AjiA

- Does it allow you to reclassify some instances and which ones?
- Consider that a client wants a meal which is both spicy and vegeatation, how would you write such a query?
- Is this possible to find an answer to this query in one of the ontologies ($O_i \cup G_i$, $i \in \{a, b, d\}$ and G_i containing the statements using O_i vocabulary)?

Consider the following alignments between the ontologies:

$A_{a,b}$ $A_{b,d}$ $A_{d,a}$

$oa:Meat \leq ob:Meat$
 $oa:Ingredient \leq ob:Product$
 $oa:Chily \leq ob:Vegetable$

$ob:RedMushroom \leq od:Lethal$
 $ob:Meat \leq od:Proteins$

$oa:Ingredient \leq od:Edible$

We consider the network of ontologies $\langle \Omega, \Lambda \rangle = \langle \{O_a \cup G_b, O_b \cup G_b, O_d\} \{A_{a,b}, A_{b,d}, A_{d,a}\} \rangle$.

9. Does it allow you to reclassify some instances with respect to $\langle \Omega, \Lambda \rangle$, i.e. $\langle \Omega, \Lambda \rangle \models i \text{ rdf:type } c$, and which ones?
10. Is there a query semantics under which your query of question 7 receives an answer, tell which answer(s) and explain why?

Revision and evolution

Now everyone becomes aware that Fred has eaten a delicate red mushroom. This means that the following statement has to be added to ontology O_d : $d:AmanitaM \text{ rdf:type } od:Edible$.

11. Does this change the answer to the query of question 7? (please be precise: say in which interpretation, and how it would change the answer)
12. Is $O_d \cup \{d:AmanitaM \text{ rdf:type } od:Edible\}$ inconsistent? Explain why.
13. Is the network with the assertion $(\langle \Omega, \Lambda \rangle \boxplus d:AmanitaM \text{ rdf:type } od:Edible/O_d)$ inconsistent? Explain why.
14. Is there a local revision of ontology O_d that would restore consistency? If, yes provide a minimal one, if no, justify.
15. Are there global revisions of $\langle \Omega, \Lambda \rangle$ that would restore consistency? If, yes provide a minimal one, if no, justify.
16. How to compute a partial meet revision of the network of ontologies by the assertion $AmanitaM \text{ rdf:type } od:Edible$

Open question

[Expectation: 15mn; 3pts]

Multi-agent epistemic and doxastic logics express what agents know and believe. It should be possible to turn a network of ontology into a theory in such a logic. The logic comes with a semantics defining how the theory can entail (\models_{MAEL}) statements.

How would you use these considerations to define the semantics of query evaluation by using such techniques? What problem does it pose? (No need to be formal for this question)