M2R Exam – Semantic web: from XML to OWL
Semantics of Distributed Knowledge part

Duration : 2h
All documents allowed – *No* communication device allowed

January 2021

Note: Read all the questions carefully before answering. Do not hesitate to justify your answers.
Time and points are indicative.

Course questions [Expectation: 25mn; 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?

   For accessing/retrieving more information.

2. What does it means for a structure (formula, theory, network, etc.) to be inconsistent?

   It has no model.

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 implies the other? Why?

   The latter. It entails the former because it will also consider worlds in structures which do not universally satisfy S.

Application [Expectation: 1h10; 10pts]

After the pandemic had settle down, Alan and Bianca enjoy going to the aquarium to observe the marvellous fishes on display there. They represent these fishes with respect to what impress them most: Alan deeply enjoys their bright colors and patterns; Bianca is fascinated by their size and the variety of their diet.

They tend to classify them in this way ($\equiv$=owl:equivalentClass,$\oplus$=owl:disjointFrom, $\sqcap$=owl:intersectionOf, $\sqcup$=owl:unionOf, $\exists$=owl:someValuesFrom, etc.):

O_{Alan}

$$\begin{aligned}
\texttt{oa:PatternedFish} &\equiv \texttt{oa:Fish} \\
&\sqcap \exists \texttt{oa:skin}.\{\texttt{pyjama}, \texttt{striped}\} \\
\texttt{oa:MonocolorFish} &\equiv \texttt{oa:YellowFish} \\
&\sqcup \texttt{oa:BlueFish} \sqcup \texttt{oa:RedFish} \\
\texttt{oa:PatternedFish} &\oplus \texttt{oa:MonocolorFish} \\
\texttt{oa:BlueFish} &\equiv \texttt{oa:PaleBlueFish} \\
&\sqcup \texttt{oa:BrightBlueFish} \\
\texttt{oa:YellowFish} &\equiv \texttt{oa:Fish} \\
&\sqcap \exists \texttt{oa:skin}.\{\texttt{yellow}\} \\
\texttt{oa:RedFish} &\equiv \texttt{oa:Fish} \\
&\sqcap \exists \texttt{oa:skin}.\{\texttt{red}\} \\
\texttt{oa:PaleBlueFish} &\equiv \texttt{oa:Fish} \\
&\sqcap \exists \texttt{oa:skin}.\{\texttt{paleblue}\} \\
\texttt{oa:BrightBlueFish} &\equiv \texttt{oa:Fish} \\
&\sqcap \exists \texttt{oa:skin}.\{\texttt{brightblue}\}
\end{aligned}$$

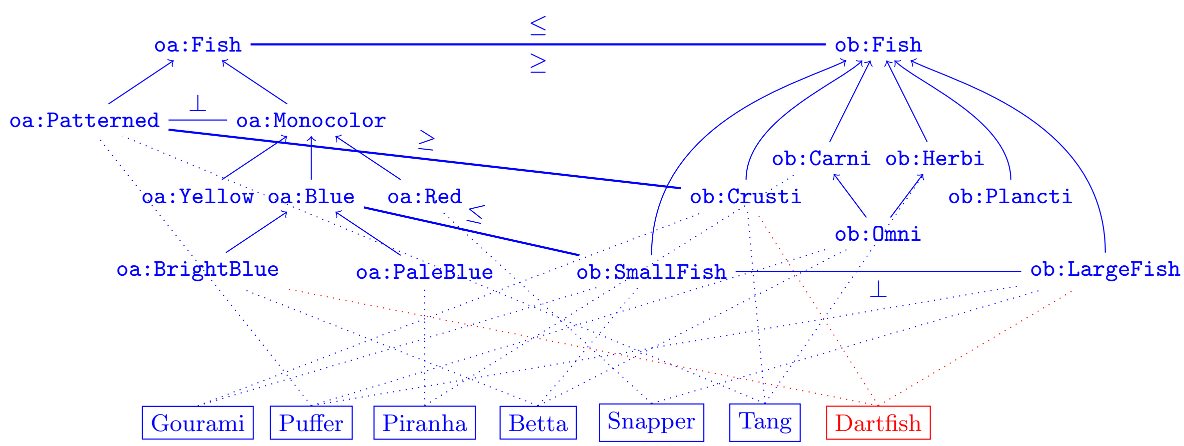
O_{Bianca}

$$\begin{aligned}
\texttt{ob:SmallFish} &\equiv \texttt{ob:Fish} \sqcap \exists \texttt{ob:size}.\{\texttt{small}\} \\
\texttt{ob:LargeFish} &\equiv \texttt{ob:Fish} \sqcap \exists \texttt{ob:size}.\{\texttt{large}\} \\
\texttt{ob:SmallFish} &\oplus \texttt{ob:LargeFish} \\
\texttt{ob:Carnivorous} &\equiv \texttt{ob:Fish} \\
&\sqcap \exists \texttt{ob:eats}.\{\texttt{meat}\} \\
\texttt{ob:Herbivorous} &\equiv \texttt{ob:Fish} \\
&\sqcap \exists \texttt{ob:eats}.\{\texttt{plant}, \texttt{algae}\} \\
\texttt{ob:Crustivorous} &\equiv \texttt{ob:Fish} \\
&\sqcap \exists \texttt{ob:eats}.\{\texttt{crustacea}, \texttt{worm}\} \\
\texttt{ob:Planctivorous} &\equiv \texttt{ob:Fish} \\
&\sqcap \exists \texttt{ob:eats}.\{\texttt{plancton}\} \\
\texttt{ob:Omnivorous} &\equiv \texttt{ob:Carnivorous} \sqcap \texttt{ob:Herbivorous}
\end{aligned}$$

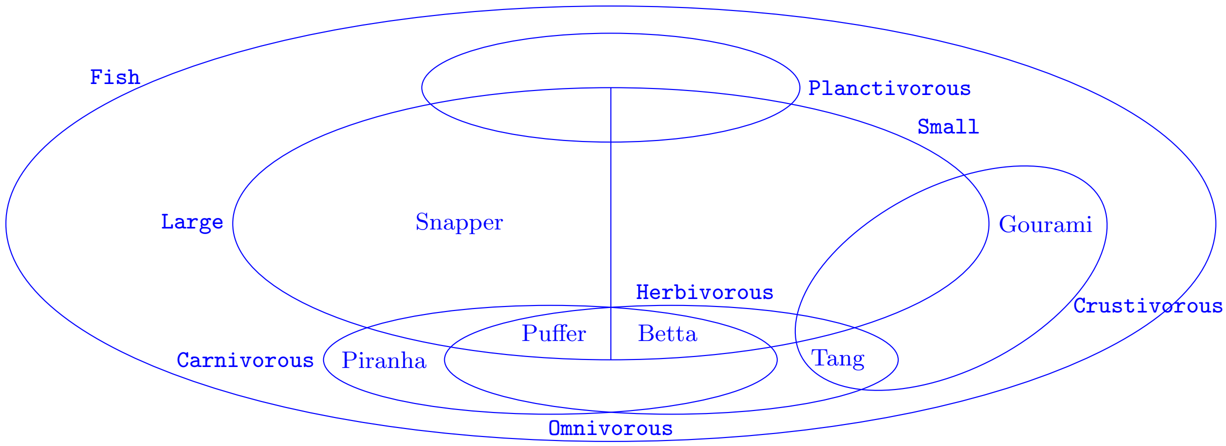
Here is a table of fishes that they saw in the aquarium (each line of the table corresponds to a fish in each of the ontologies):

Id	Name	size	eats	skin	area
A	Gourami	small	crustacea		southam
B	Puffer	large	meat,plant	pyjama	asia
C	Piranha		meat	paleblue	asia
D	Betta	small	algae,meat	brightblue	asia
E	Snapper	large		red	europe
F	Tang		algae,worm	stripped	europe

4. Attach each reported fish (species) to its class(es) in each of the classifications.



5. Describe a model of Bianca's ontology (and available fishes).



6. Show that this model entails that $\texttt{ob:Omnivorous} \sqsubseteq \texttt{ob:Fish}$

In order to communicate, Alan and Bianca have created the alignment made of the following correspondences:

$\texttt{oa:Fish} \leq \texttt{ob:Fish}$ $\quad$ $\texttt{oa:Fish} \geq \texttt{ob:Fish}$

$\texttt{oa:BlueFish} \leq \texttt{ob:SmallFish}$ $\quad$ $\texttt{oa:PatternedFish} \geq \texttt{ob:Crustivorous}$

7. Now Bianca has query $q[x] = \texttt{SELECT}\ x\ \texttt{WHERE}\ (\texttt{ob:Carnivorous} \sqcap \texttt{ob:SmallFish})(x)$ what is the answer to this query in Bianca's base?

   Betta

8. What are the results if she wants to take advantage of the alignment and Alan's base?

   Piranha, Betta

9. Can Alan also take advantage of this alignment to complete his knowledge? How?

   He can infer that Gourami is a **oa:PatternedFish**. But he cannot decide if it is **oa:Stripped** or **oa:Pyjama**. However, Gourami is already a **oa:MonocolorFish**, because yellow, which is disjoint from **oa:PatternedFish**. This means that the two ontology, data and alignments are inconsistent.

Their friend Clarisse has only been able to look into fishes in the encyclopedia. They are also fascinating. She reports a new fish to her friends.

Id	Name	size	eats	skin	area
G	Dartfish	large	crustacea	brightblue	asia

10. What is the consequence of adding this fish within Bianca's data? Within Alan's data? within both aligned ontologies?

    The new fish can belong to both ontologies (as indicated in red in the figures above). But with the alignment it makes them inconsistent.

11. How could Alan and Bianca react to this problem?

oa:PatternedFish $\leq$ ob:Crustivorous cannot be fixed and has to be suppressed. oa:BlueFish $\geq$ ob:SmallFish can be refined to oa:PaleBlue $\geq$ ob:SmallFish only.

12. Is there a way to check that the modifications are minimal? How would you measure it?

    Set-theoretically, it is possible to consider as minimal those fixes that are not larger than another valid fix. When they are not comparable, it is also possible to select the one which involves less modifications. In the example above, this would lead to suppress oa:BrightBlueFish $\geq$ ob:BlueFish. This is very syntactic and may not be the best solution.

    Semantically, it is better compare the differences in entailed statements and not only on the statements that are modified. It is more likely that a specific statement that does not apply to many individuals is incorrect, than a very general statement that applies to many. But this would not solve the problem here.

General ideas [Expectation: 25mn; 4pts]

What would be your thoughts about modelling (some part of) cultural evolution with dynamic epistemic logic?

Cultural evolution means that beliefs can be transmitted from agents to agents both in a vertical way (from parents to offspring) and in a horizontal way (from peer to peer). Cultural selection may take various forms, but the most basic one is that agents try to preserve only consistent sets of beliefs.

Dynamic epistemic logics offer ways to express agent beliefs ($B_a\phi$) and announce formulas ($!\phi$ or $\uparrow \phi$). It can also constrain consistency: ($\neg(B_a\phi \wedge B_a\neg\phi)$).

What elements do you think should be added to dynamic epistemic logics to model cultural evolution? How the model presented during the course could be extended? Can you criticise it?

So far, announcements are not private and relations between agents not expressed. This is a missing capability. The former can be considered with private announcements. It may thus be possible to model one-to-one communication, as well as broadcast to a group. However, the reification of the group (or relation between agents, i.e. acquaintances) may be necessary as well for a proper model.

In the example provided, selection is triggered externally when an inconsistency is discovered. Agents then receive an announcement of the inconsistency and 'are applied' a conservative upgrade of their beliefs corresponding to an adaptation operator. A different approach would leave the agent take a decision about what to do with its beliefs given the inconsistency. This is the topic of belief revision, that may be incorporated into dynamic epistemic logic. One problem for logical agents is that if they fall into an inconsistent state, they cannot recover (announcement and upgrades cannot create a model when there is none). More reactive agents, may be able escape such inconsistent states.

Note that the information about fishes is not accurate...