# M2R Exam – Semantic web: from XML to OWL
# Semantic web part

Duration : 1h
Documents allowed – no communication device allowed

November 2015

**Note:** Read all the questions carefully before answering.

## RDF Entailment

We have two graphs coming from two different sources. Consider the graph $G_1$ coming from the municipality made of the following triples:

```
a:Pierre o1:father a:Carole .
a:Pierre o1:father a:Kevin .
a:Jacques o1:father a:Jean .
_:b1 o1:father a:Sylvie .
_:b1 o1:father a:William .
a:Jacques o1:father a:Julie .
a:Sven o1:father a:Laurent .
```

```
a:Marie o1:mother a:Carole .
a:Marie o1:mother a:Kevin .
a:Marie o1:mother a:Jean .
a:Stephanie o1:mother a:Sylvie .
a:Stephanie o1:mother a:William .
a:Nabila o1:mother a:Julie.
a:Lucie o1:mother a:Laurent .
```

and $G_2$ coming from the school made of the following information:

```
a:Carole o2:attendsClass b:4e3.
a:Kevin o2:attendsClass b:6e1 .
a:Sylvie o2:attendsClass b:5e2 .
a:William o2:attendsClass b:5e2 .
a:Julie o2:attendsClass b:5e2 .
a:Laurent o2:attendsClass b:4e3  .
a:Jasmine o2:attendsClass b:5e1 .
```

```
a:Carole rdf:type o2:Female .
a:Kevin rdf:type o2:Male .
a:Sylvie rdf:type o2:Female .
a:William rdf:type o2:Male .
a:Julie rdf:type o2:Female .
a:Laurent rdf:type o2:Male .
a:Jasmine rdf:type o2:Female .
```

1. Draw these two graphs (together);

   They are like the graph of Figure 1.

2. In order, to work with these two graphs, we want to answer queries that span through both of them. Consider the following graph $Q_1$:

   ```
   _:x o2:attendsClass _:w .
   _:y o2:attendsClass _:w .
   _:x rdf:type o2:Male .
   _:y rdf:type o2:Female .
   _:z o:parent _:x .
   _:z o:parent _:y .
   ```

   Express in English the meaning of $Q_1$.

   $Q_1$ could be rephrased as "there exist a male and a female sharing at least one parent attending the same class".

   Is $Q_1$ entailed by any of $G_1$ or $G_2$? (explain why)

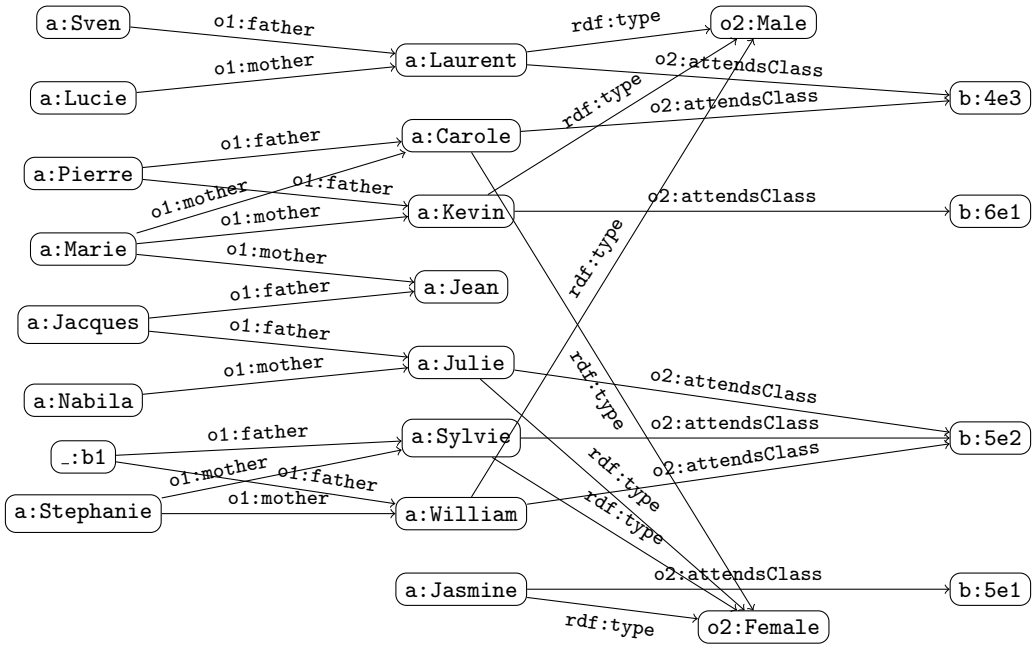


Figure 1: RDF graph $G_1$ and $G_2$.

$Q_1$ is not entailed by any of these graphs, this would require these graphs to contain at least one triple with `o:parent` as predicate and none contains this.

3. Express the graph $Q_2$ corresponding to the English: "there exist two people sharing at least one parent attending the same class"?

   $Q_2$ can be expressed by the following graph:

   ```
   _:x o2:attendsClass _:w .
   _:y o2:attendsClass _:w .
   _:z o:parent _:x .
   _:z o:parent _:y .
   ```

   Does $Q_2 \models_{RDF} Q_1$ or $Q_1 \models_{RDF} Q_2$?

   $Q_2 \not\models_{RDF} Q_1$ because there is no subgraph of $Q_2$ that is an instance of $Q_1$. In particular, any instance of $Q_1$ should contain references to `o2:Male` and `o2:Female` which are not present in $Q_2$ (so neither in any subgraph of $Q_2$).

   $Q_1 \models_{RDF} Q_2$ because $Q_2$ is (and instance of itself and) a subgraph of $Q_1$, namely the subgraph in which the `rdf:type` information is missing.

## RDFS and OWL interpretation

4. One convenient way to interpret together two heterogeneous sources is to interpret them through a common ontology. Consider the ontology $O$ made of the following statements:

   ```
   o:parent rdfs:domain foaf:Person .
   o:parent rdfs:range foaf:Person .
   o1:mother rdfs:subPropertyOf o:parent .
   o1:father rdfs:subPropertyOf o:parent .
   ```

```
o1:mother rdfs:domain o2:Female .
o1:father rdfs:domain o2:Male .
```

Does $O \cup G_1 \cup G_2 \models_{RDF} Q_1$?

No, because it would still need to contain `o:parent` statements which are not in any of $O$, $G_1$ or $G_2$ (in $O$, `o:parent` is used as subject and object but not as predicate).

5. Does $O \cup G_1 \cup G_2 \models_{RDFS} Q_1$? (explain your answer)

   Yes, because through the ter Horst closure it is possible to saturate the graph $O \cup G_1 \cup G_2$ and, in particular, each time `o1:father` and `o1:mother` are used, the same triple can be added with `o:parent` as predicate, due to rule [RDFS 9]. So the graph made of:

   ```
   a:Stephanie o1:mother a:Sylvie .
   a:Sylvie o2:attendsClass b:5e2 .
   a:Sylvie rdf:type o2:Female .
   a:Stephanie o1:mother a:William .
   a:William o2:attendsClass b:5e2 .
   a:William rdf:type o2:Male .
   ```

   is a subgraph of the closure of $O \cup G_1 \cup G_2$. It is also an instance of the graph $Q_1$ through the assignment: $\{$`?x` $\leftarrow$ `a:William`, `?y` $\leftarrow$ `a:Sylvie`, `?w` $\leftarrow$ `b:5e2`, `?z` $\leftarrow$ `a:Stephanie`$\}$

   Give all mappings (variable/blank assignments) which support this entailment.

| ?x | ?y | ?w | ?z |
|---|---|---|---|
| a:William | a:Sylvie | b:5e2 | a:Stephanie |
| a:William | a:Sylvie | b:5e2 | _:b1 |

   What additional facts does $O \cup G_1 \cup G_2$ RDFS-entail? (provide an example).

   It allows to deduce the gender of parents (through the `owl:domain` constraints on the `o1:father` and `o1:mother` properties). So, for instance, `a:Pierre rdf:type o2:Male` and `a:Marie rdf:type o2:Female`.

6. Can you express in OWL the class `o:ParentOfNumerousChildren`, as the class of those parents with more than three children, using the concepts and properties of ontology $O$?

   $$\texttt{o:ParentOfNumerousChildren} \sqsubseteq \geq_3 \texttt{o:parent}$$

   or

```
<owl:Class rdf:about="o:ParentOfNumerousChildren">
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="o:parent" />
      <owl:minCardinality>3</owl:minCardinality>
    </owl:Restriction>
  </rdfs:subClassOf>
</owl:Class>
```

   Give the interpretation of this (compound) class.

$$\begin{aligned} I(\texttt{o:ParentOfNumerousChildren}) \subseteq & I(\geq_3 \texttt{o:parent}) \\ = & \{o \in O \mid ||\{\langle o, y\rangle \in I(\texttt{o:parent})\}|| \geq 3\} \end{aligned}$$