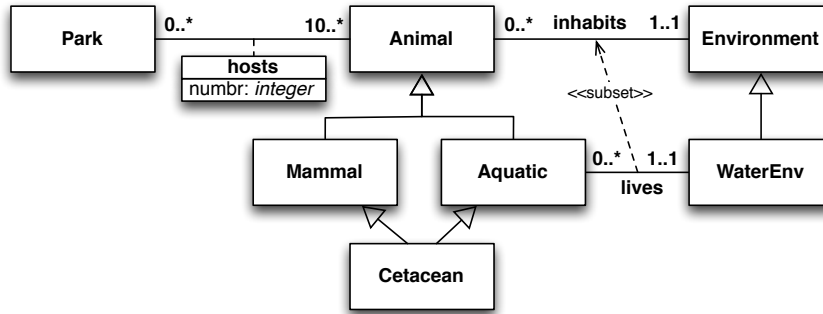
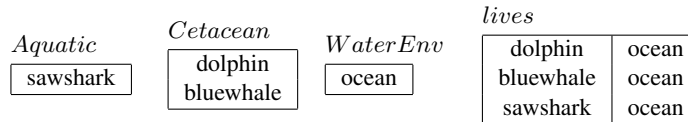


Exercise 1. Express the following UML class diagram in *FOL*.

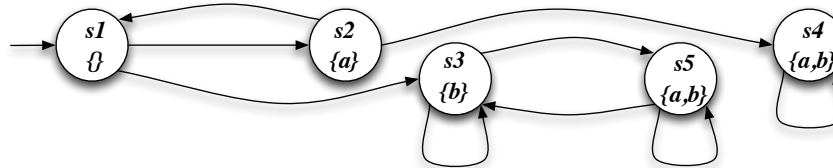


Exercise 2. Consider the above UML class diagram and the following (partial) instantiation.



1. Check whether the instantiation (once completed) is correct (and explain why it is or it is not).
2. Express in FOL and evaluate the following queries:
 - (a) Return the all animals and the environment they inhabit.
 - (b) Return the mammals that inhabit all environments.

Exercise 3. Model check the Mu-Calculus formula $\nu X. \mu Y. ((a \wedge [next]X) \vee [next]Y)$ and the CTL formula $EFAGa \wedge EFAGb$ (showing its translation in Mu-Calculus) against the following transition system:



Exercise 4. Consider the following program:

```
while (x<10) do x := x + 5
```

Compute its *execution* and *final state*, starting from an *initial state* where $x = 1$, using:

1. *evaluation semantics*;
2. *transition semantics*.

Exercise 5. Given the following conjunctive queries:

```
q1(x) :- r(x,y), r(y,y), r(y,z), r(z,x).
q2(x) :- r(x,y), r(x,z), r(x,v), r(y,w), r(w,x), r(z,w), r(v,z).
```

check whether $q1$ is contained into $q2$, explaining the technique used and, in case of containment, showing the homomorphism between the canonical databases.