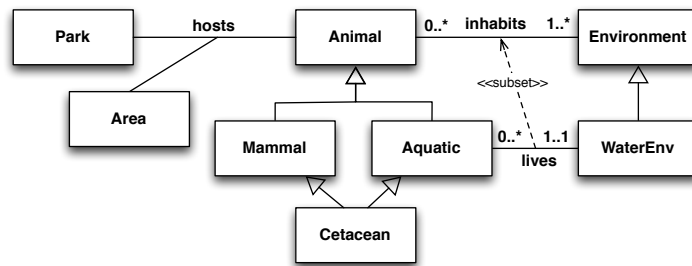
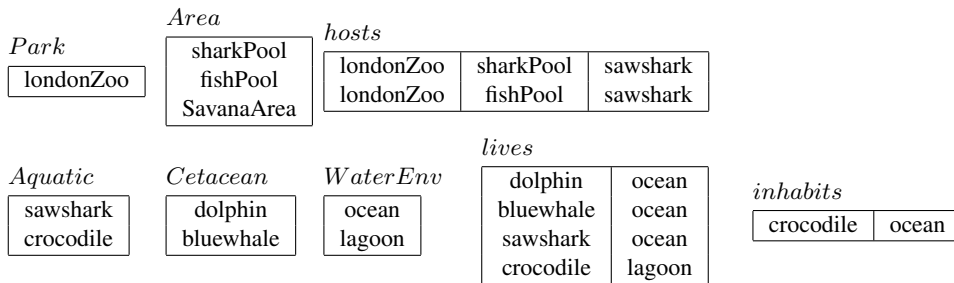


**Exercise 1.** Express the following UML class diagram in *FOL*.

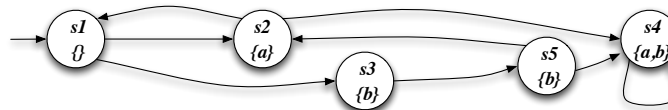


**Exercise 2.** Consider the above UML class diagram and the following (partial) instantiation.

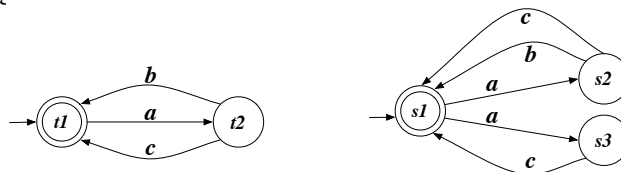


1. Check whether the above instantiation, once completed, is correct, and explain why it is or it is not.
2. Express in FOL and evaluate the following queries:
  - (a) Return animals that inhabit at least two environments.
  - (b) Return parks that they host only aquatic animals.
  - (c) Check if there are parks that host all Cetacean.

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



**Exercise 4.** Consider the following two transition systems:



Write the definition of bisimilarity and compute the bisimilarity relation for the two transition systems.

**Exercise 5.** Compute the certain answers to the CQ  $q(x) \leftarrow Employee(x), Manages(x, y)$  over the incomplete database (naive tables), by explaining and exploiting the connection with conjunctive query containment:

<i>Employee</i>		<i>Manages</i>	
<i>name</i>		<i>mgr</i>	<i>mgd</i>
Smith		Green	Smith
$null_1$		Smith	$null_1$
Brown		$null_1$	Brown
		Brown	$null_2$