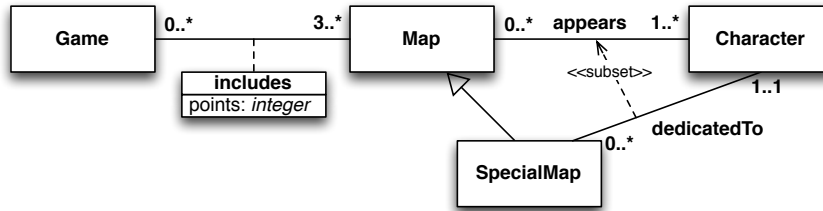
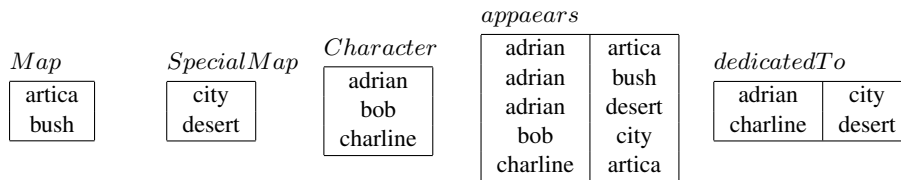


**Exercise 1.** Express the following UML class diagram in FOL.

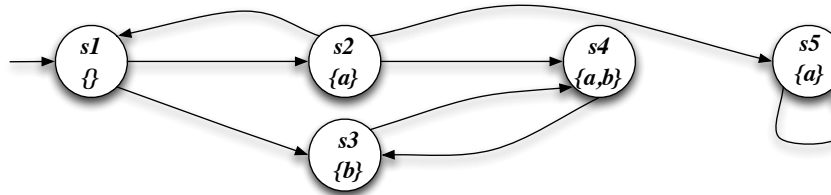


**Exercise 2.** Consider the above UML class diagram and the following (partial) instantiation.



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 characters that appear at least in one map.
  - (b) Return the characters that appear in all maps.

**Exercise 3.** Model check the Mu-Calculus formula  $\nu X. \mu Y. ((b \wedge \langle next \rangle X) \vee \langle next \rangle Y)$  and the CTL formula  $EG(AX(\neg a \vee AFb))$  (showing its translation in Mu-Calculus) against the following transition system:



**Exercise 4.** Compute the weakest precondition for getting  $\{x = 0\}$  by executing the following program:

```

x := 50 + y;
if (x > 50) then {
  if (y > 0) then
    x := x - y;
  else y := -y;
}
else x := x + y;
y := y + 50

```

**Exercise 5.** Given the following conjunctive queries:

```

q1(x) :- edge(x,y), edge(y,y), edge(y,z), edge(z,y).
q2(x) :- edge(x,y), edge(y,z), edge(x,z), edge(x,v), edge(v,z), edge(v,y).

```

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