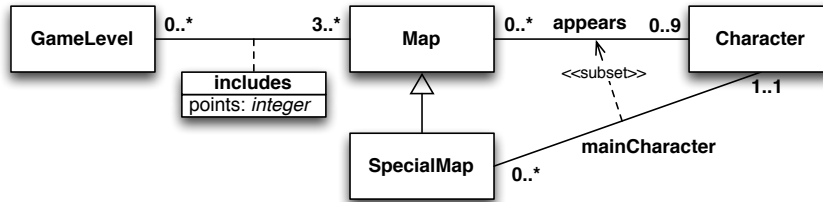
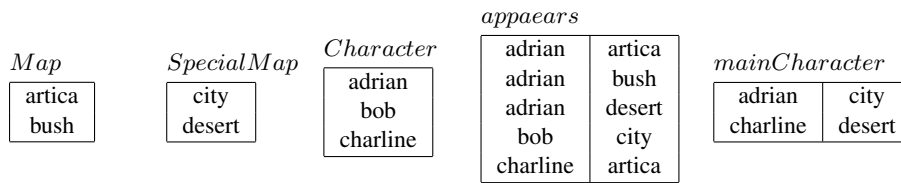


Exercise 1. Express the following UML class diagram in *FOL*.

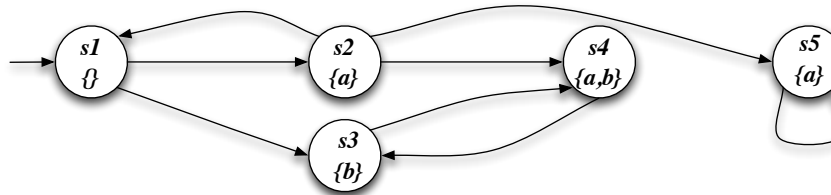


Exercise 2. Consider the above UML class diagram and the following (partial) instantiation.



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 maps with at least 3 distinct characters.
 - (b) Return the characters that appear in maps only as main characters.
 - (c) Check if there exists a map where all characters appears.

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



Exercise 4. Check whether the following Hoare triple is correct, using as *invariant* $(i + j = 9)$.

$\{i=0 \text{ AND } j=9\} \text{ while}(i<10) \text{ do } (i:= i+1; j=j-1) \{j<0\}$

Exercise 5. Given the following conjunctive queries:

$q_1(x) :- \text{edge}(x, y), \text{edge}(y, y), \text{edge}(x, z), \text{edge}(y, z), \text{edge}(z, y).$
 $q_2(x) :- \text{edge}(x, y), \text{edge}(y, z), \text{edge}(x, v), \text{edge}(v, z), \text{edge}(v, y).$

check whether q_1 is contained into q_2 , explaining the technique used and, in case of containment, showing the homomorphism between the canonical databases.