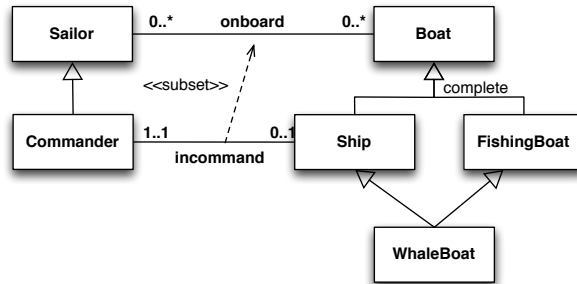
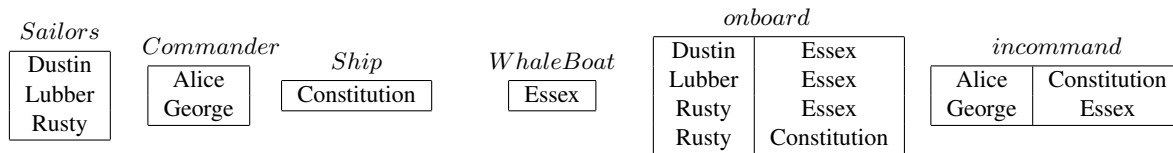


Exercise 1. Express the following UML class diagram in FOL.

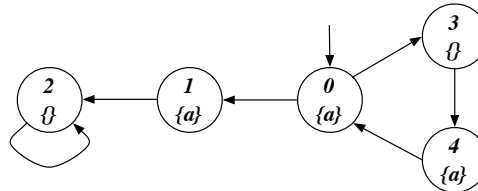


Exercise 2. Consider the above UML class diagram and the following (partial) instantiation.

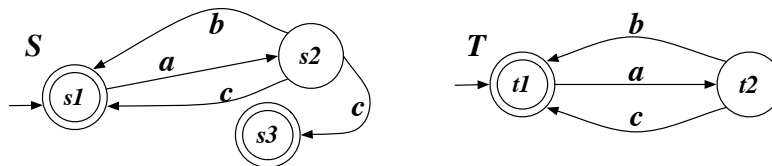


1. Check whether the above instantiation, once completed, is correct, and explain why it is or it is not.
2. Express in FOL the following queries and evaluate them over the completed instantiation:
 - (a) Return the sailors that have been onboard of a fishing boat.
 - (b) Check whether there exists a boat that has on board at least three sailors.
 - (c) Return the boats that had on board all sailors that are not commanders.

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



Exercise 4. Consider the following transition systems:



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

Exercise 5. Given the following conjunctive queries:

$$q_1(a, b) :- e(a, y), e(x, y), e(x, b)$$

$$q_2(a, b) :- e(a, y), e(x, y), e(x, z), e(w, z), e(w, b)$$

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.