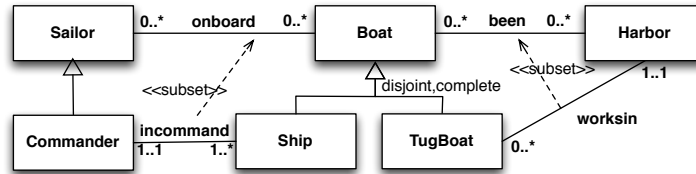
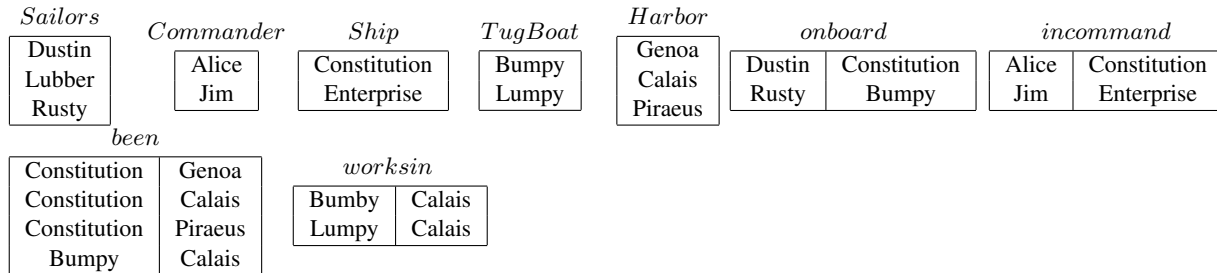


Exercise 1. Express the following UML class diagram in *FOL*.

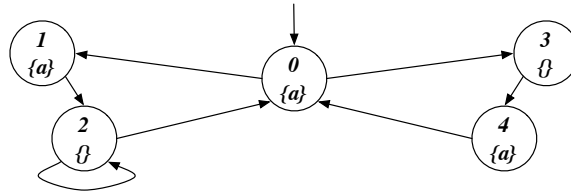


Exercise 2. Consider the above UML class diagram and the following (partial) instantiation.



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 on board of a boat which has been in a harbor where a tag boat works in.
 - (b) Check whether there exists a harbor in which there have been at least two tag boats.
 - (c) Return the sailors that have been in all harbors.

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



Exercise 4. Check whether the following Hoare triple is correct, using as *invariant* $(0 \leq i \wedge 0 \leq j \wedge i + j \leq 5)$.

$\{i=0 \text{ AND } j=5\} \quad \text{while}(i<5) \text{ do } (j=j-1; i:= i+1) \quad \{j=0\}$

Exercise 5. Given the following boolean conjunctive queries (with *a* constant):

$q1() :- e(a, y), e(y, y), e(y, a)$
 $q2() :- e(a, y), e(y, z), e(z, w), e(w, w), e(w, z), e(z, y), e(y, a)$

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