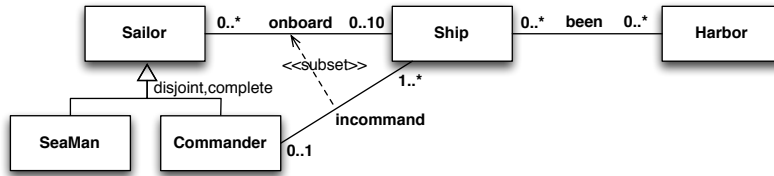
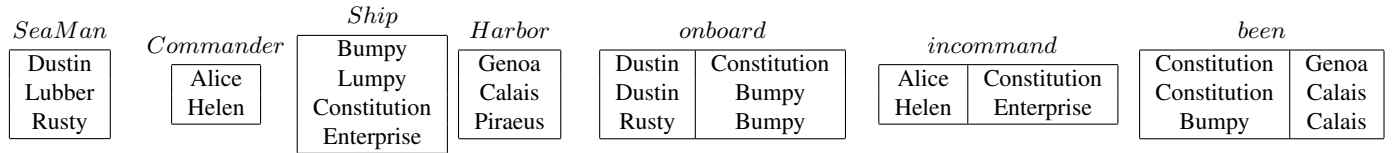


**Exercise 1.** Express the following UML class diagram in *FOL*.

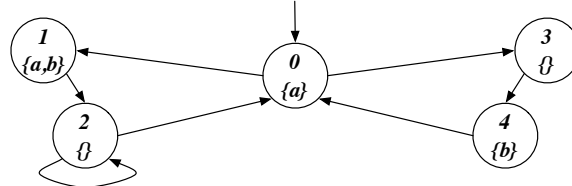


**Exercise 2.** Consider the above UML class diagram and the following (partial) instantiation.

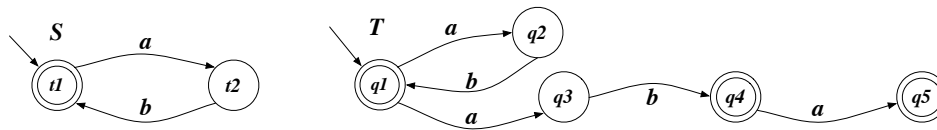


1. Check whether the above instantiation, once completed, is correct, and explain why it is or it is not.
2. Express in FOL the following queries and evaluate them over the completed instantiation:
  - (a) Return the ships that have on board at least two sailors.
  - (b) Return the sailor that are not on board of any ship.
  - (c) Check if there is a ship with all sailors that are not commanders on board.

**Exercise 3.** Model check the Mu-Calculus formula  $\nu X. \mu Y. (((a \vee b) \wedge [next]X) \vee ([next]Y))$  and the CTL formula  $AF(EG(a \supset AXEX(\neg a \wedge \neg b)))$  (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 following CQs over the following incomplete database (naive tables), and discuss how you obtained the result:

$$q(x) \leftarrow \text{contains}(x, y), \text{genre}(y, z) \qquad q(x, z) \leftarrow \text{contains}(x, y), \text{genre}(y, z)$$

<i>contains</i>	
<i>cd</i>	<i>song</i>
cd1	<i>null</i> <sub>1</sub>
<i>null</i> <sub>2</sub>	sg1
cd2	sg2
cd3	sg1
cd4	<i>null</i> <sub>3</sub>
<i>null</i> <sub>4</sub>	<i>null</i> <sub>3</sub>

<i>genre</i>	
<i>object</i>	<i>color</i>
<i>null</i> <sub>1</sub>	rock
sg1	rock
sg2	blues
<i>null</i> <sub>3</sub>	<i>null</i> <sub>5</sub>