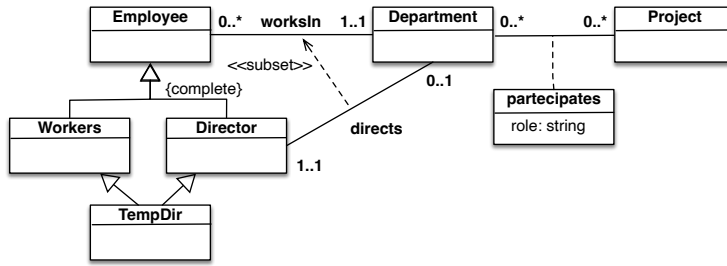
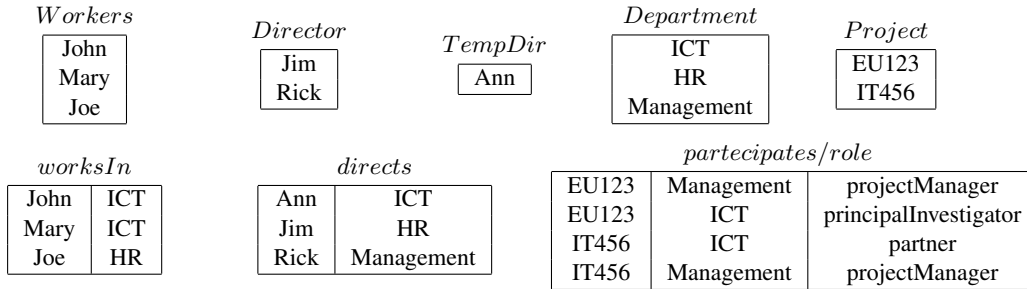


Exercise 1. Express the following UML class diagram in FOL:

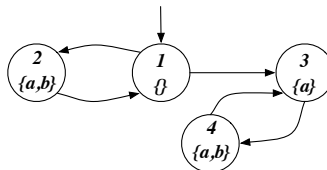


Exercise 2. Consider the above UML class diagram and the following (partial) instantiation:



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) Check if there is a department where both workers and directors work in.
 - (b) Returns those departments that are directed by a director who is not a temporary director.
 - (c) Return those departments that participate to all projects.
 - (d) Check if there is a department that participate to projects only with the role of “projectManager”.

Exercise 3. Consider the following transition system:



1. Model check the Mu-Calculus formula: $\nu X. \mu Y. (((a \wedge \neg b) \wedge \langle next \rangle X) \vee \langle next \rangle Y)$
2. Model check (by translating it in Mu-Calculus) the CTL formula $AG(a \supset AXEFb)$

Exercise 4. Check whether the following FOL formula is valid, by using tableaux, and in case it is not return a counter example:

$$(\forall x. ((\exists y. P(y)) \supset Q(x))) \equiv ((\exists y. P(y)) \supset (\forall x. Q(x)))$$

Exercise 5. Consider the transition system of Exercise 3. Model check the LTL formula $\Box(\neg a \supset \Diamond \neg b)$, by considering that the Büchi automaton *BA* for $\neg(\Box(\neg a \supset \Diamond \neg b))$ is the one below:

