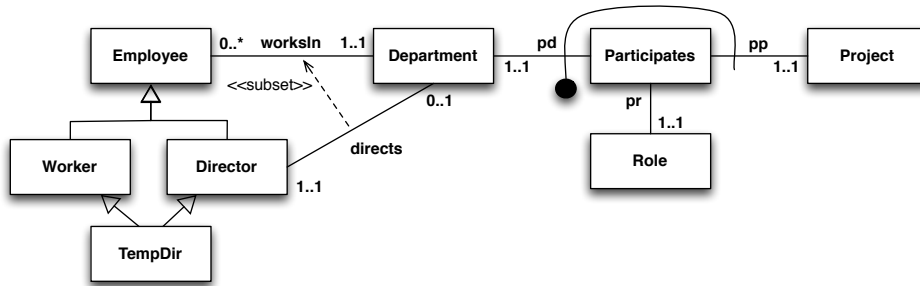


Exercise 1. Express the following UML class diagram in FOL.

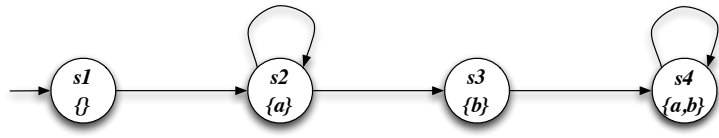


Exercise 2. Consider the above UML class diagram and the following (partial) instantiation.



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 directors that direct a department with at least one worker.
 - (b) Return the departments whose employees are all directors.

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



Exercise 4. Check whether the following Hoare triple is correct, using as invariant $i \leq 10$.

```
{i=0} while(i<10) do i:= i+1 {i=10}
```

Exercise 5. Given the following boolean conjunctive queries:

```
q1() :- edge(r,b), edge(b,g), edge(g,r).
q2() :- edge(x,y), edge(y,z), edge(z,x), edge(z,v), edge(v,w), edge(w,z).
```

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