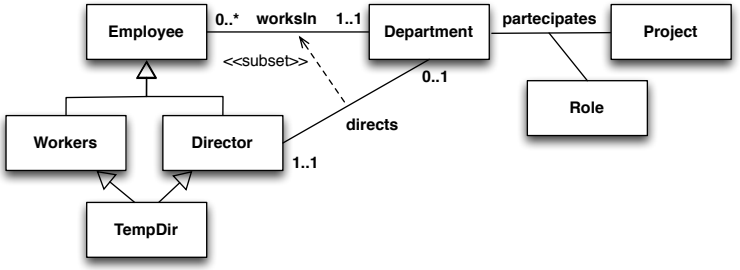
SAPIENZA Università di Roma – MSc. in Engineering in Computer Science

Formal Methods – June 11, 2015

(Time to complete the test: 2 hours)

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



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

$Workers$

John
Mary
Joe

$Director$

Jim
Rick

$TempDir$

Ann

$Department$

ICT
HR
Management

$Project$

EU123
IT456

$Role$

projectManager
principalInvestigator
partner

$worksIn$

John	ICT
Mary	ICT
Joe	HR

$directs$

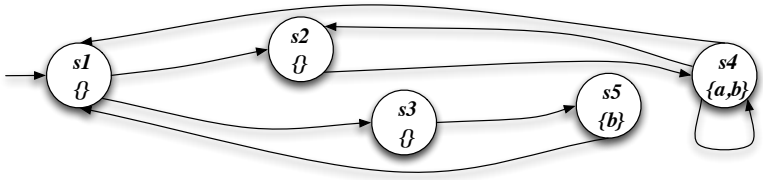
Ann	ICT
Jim	HR
Rick	Management

$partecipates$

EU123	ICT	projectManager
EU123	ICT	principalInvestigator
IT456	ICT	partner
IT456	Management	projectManager

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 projects where the same department participates in different roles.
   (b) Return the projects in which each participating department participates with exactly one role.

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 $EGAFa \vee EFAGb$ (showing its translation in Mu-Calculus) against the following transition system:



Exercise 4. Compute the weakest precondition for getting $\{x = 100\}$ by executing the following program:

```
x := y + 2;
if (x < 50) then {
  if (y < 0) then
    x := 2*x;
  else y := y*y
}
else  x := x + y;
y := y*y
```

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,y).
```

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