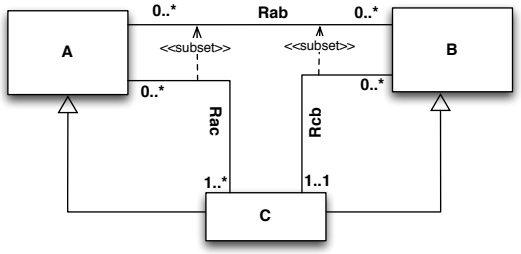
SAPIENZA Università di Roma – MSc. in Engineering in Computer Science

Formal Methods – June 9, 2014

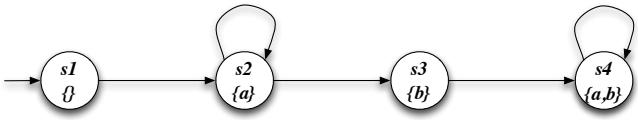
(Time to complete the test: 2 hours)

Exercise 1. Consider the following UML class diagram.



1. Express it in FOL.
2. Express it in *DL-Lite*$_\mathcal{A}$, highlighting parts that are not expressible.
3. Given the ABox $A = \{C(a)\}$ and the conjunctive query $q(x) \leftarrow Rab(x, y), Rab(y, z), Rab(w, z)$, return the certain answer by exploiting the *DL-Lite*$_\mathcal{A}$ rewriting algorithm.

Exercise 2. Model check the Mu-Calculus formula $\nu X.\mu Y.((a \wedge \langle next \rangle X) \vee \langle next \rangle Y)$ and the CTL formula $AG(EXa \supset AXAXEGa)$ (showing its translation in Mu-Calculus) against the following transition system:



Exercise 3. Consider the following predicates: $Student(x)$, saying that x is an student, $Exam(x)$, saying that x is an exam, and $passed(x, y)$, saying that x passed y. Express in FOL the following boolean queries, stating which ones are CQs (do not use abbreviations for cardinalities):

1. *There exists a student that passed an exam.*
2. *There exists a student that passed exactly one exam.*
3. *There exists a student that passed at least two exams.*
4. *There exists a student that passed no exam.*
5. *There exists a student that passed all exams.*
6. *There exists two students such that the first passed all exams of the second one, but not viceversa.*

Exercise 4. Given the following conjunctive queries:

```
q1(x) :- edge(x,y), edge(y,y).
q2(x) :- edge(x,y), edge(y,z), edge(x,z).
```

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

Exercise 5. Compute the weakest precondition for getting $\{x = y\}$ by executing the following program:

```
x := y + 1;
if (x > 0 & y >= 0) then {
  x := y - x;
  y := x - y
}
else if (x > 0) then
  x := x - y
```