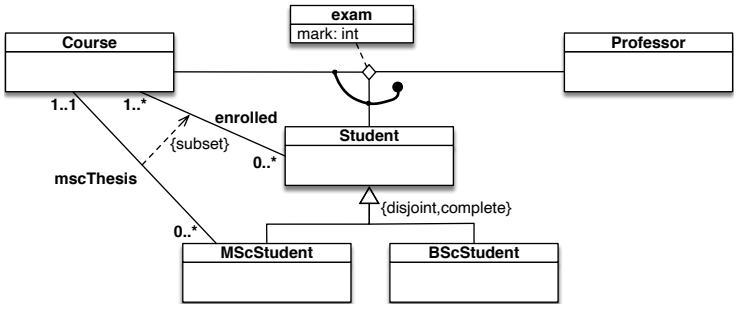
SAPIENZA Università di Roma – MSc. in Engineering in Computer Science

Formal Methods – June 25, 2021

(Time to complete the test online: 2:00 hours)

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



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

$BScStudent$

Barry
Bea

$MScStudent$

Mary
Murray
Mark

$Professor$

Paul
Peter
Phoebe

$Course$

AI
SE
FM

$enrolled$

Barry	SE
Bea	SE
Mary	AI
Mary	FM
Mary	SE

$mscThesis$

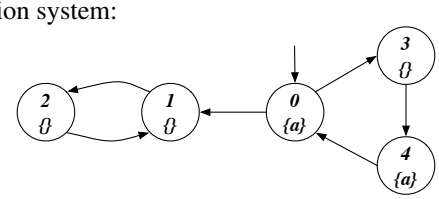
Mary	FM
Murray	AI
Mark	FM

$exam/mark$

Barry	SE	Paul	28
Bea	SE	Paul	30
Mary	AI	Peter	30
Mary	FM	Phoebe	30
Mary	SE	Paul	27

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 students who are enrolled in more then one course.
   (b) Check is there are students who have 30 in all exams they have taken.
   (c) Return the MSc students who are enrolled in other courses apart those for which do their MSc thesis.
   (d) Return the MSc students who are enrolled only in the course for which they do their MSc thesis.

Exercise 3. Consider the following transition system:



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

Exercise 4. Check whether the following FOL formula is valid, by using tableaux:

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

Exercise 5. Consider the transition system TS below. Model check the LTL formula $\Box\Diamond a$, by considering that the Büchi automaton BA for $\neg\Box\Diamond a$ (i.e., $\Diamond\Box\neg a$) is the one below: