SAPIENZA Università di Roma – MSc. in Engineering in Computer Science
Formal Methods - Final Test B – December 16, 2016
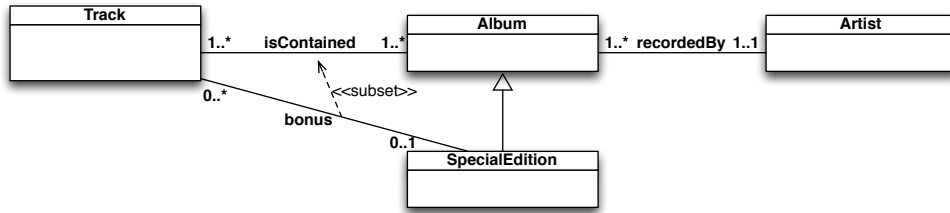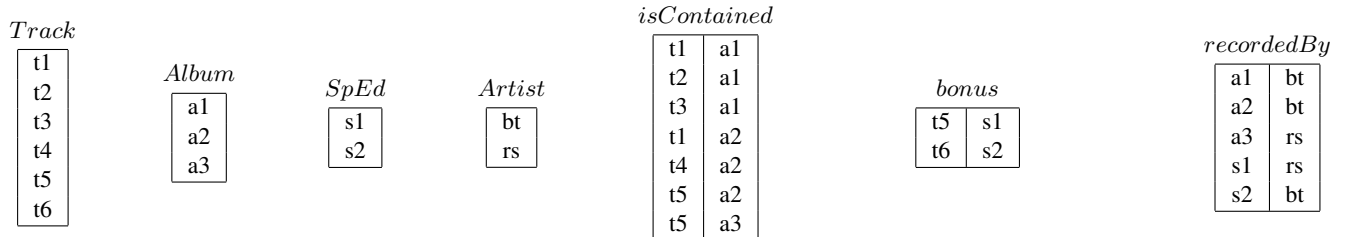*(Time to complete the test: 2 hours)*

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

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

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 tracks that are contained in an album and a special edition of the same artist.

   (b) Return those artist that have recorded only albums that are not special editions.

   (c) Check if there is a track appearing in all special editions.

Exercise 3. Model check the Mu-Calculus formula $\nu X.\mu Y.((\neg a \wedge \langle next \rangle X) \vee ([next]Y))$ and the CTL formula $EF(AG(a \supset EXAX\neg a))$(showing its translation in Mu-Calculus) against the following transition system:
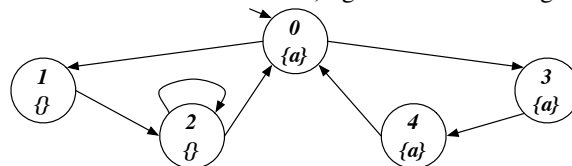
Exercise 4. Consider the following two transition systems:

Write the definition of bisimilarity and compute the bisimilarity relation for the two transition systems.

Exercise 5. Compute the certain answers to the following CQs over the following incomplete database (naive tables), and discuss how you obtained the result:

$$q() \leftarrow lives(x,y), incountry(y,z) \qquad q(x,z) \leftarrow lives(x,y), incountry(y,z)$$

lives

person	city
$null_0$	$null_1$
$null_2$	$null_3$
$null_4$	$null_5$
mary	$null_5$

incountry

city	country
$null_1$	IT
$null_3$	$null_6$
$null_5$	JP