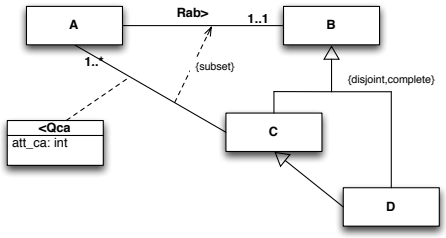
SAPIENZA Università di Roma – MSc. in Engineering in Computer Science

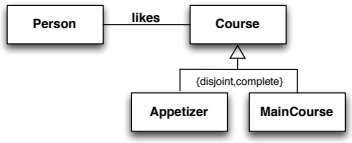
Formal Methods – February 16, 2022

(Time to complete the test: 2 hours)

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

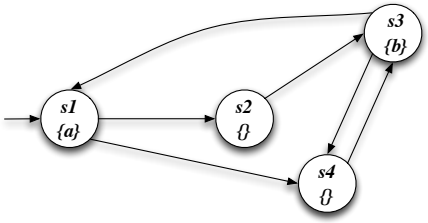


Exercise 2. Consider the following simple UML class diagram, and express in FOL the following boolean queries stating which ones are CQs (do not use abbreviations for cardinalities):



1. *Return persons who like an appetizer and a main course.*
2. *Check if there exists a person who likes two appetizers and a main course.*
3. *Check if there exists a person who likes exactly one appetizer.*
4. *Return persons who like all appetizers.*
5. *Return persons who likes only appetizers.*
6. *Check if there is a pair of persons such that the first likes all appetizers that the second likes.*

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



Exercise 4. Compute the certain answers to the CQ $q(x) \leftarrow Person(x), Person(y), Likes(x, z), Likes(z, y)$ over the following incomplete database (naive tables), and explain formally how you obtained the result:

$Person$

$name$
Smith
$null_1$
Brown
$null_2$
Green

$Likes$

ls	ld
Smith	$null_1$
$null_1$	Brown
Brown	$null_2$
Green	White
White	$null_2$
$null_2$	White

Exercise 5. Compute the weakest precondition for getting $\{x = 100\}$ by executing the following program:

```
x := 90 - y;
if (x = 0) then {
  if (y > 10) then
    x := y - x;
  else x := 10 - x
}
x := x + y;
y := 10 + y
```