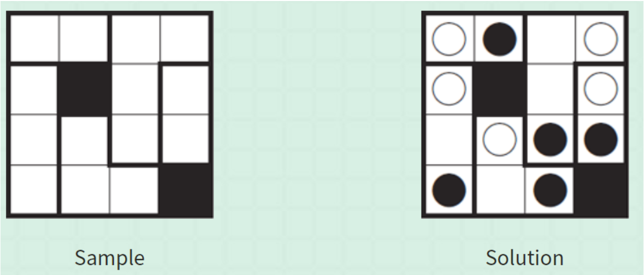
Formal Methods - lab exam ____
Facsimile di prova

Exercise 1

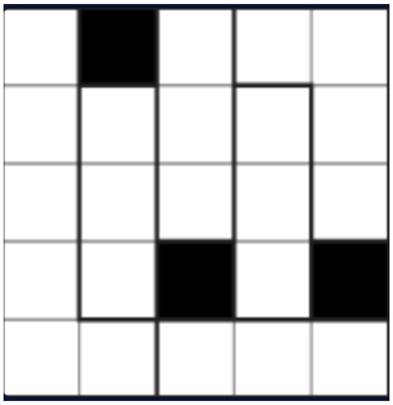
Recently, your teaching assistant started playing Dosun-Fuwari, an old Japanese game. Given a grid, fill it with balloons (white circles) and iron balls (black circles) according to the following rules:

- Place one balloon and one iron ball in each of the areas surrounded by bold lines.
- Balloons are light and float, so they must be placed in one of the cells at the top, or in a cell right under a black cell (filled-in cell) or under other balloons.
- Iron balls are heavy and sink, so they must be placed in one of the cells at the bottom, or in a cell right over a black cell or over other iron balls.
- Of course you cannot add additional black cells into the grid!

This is a solution for a simple 4*4 grid, so you can get an idea.



Given the following 5*5 grid, use MathSAT/OptiMathSAT as an SMT solver to find a solution.



Check also if the solution is unique:

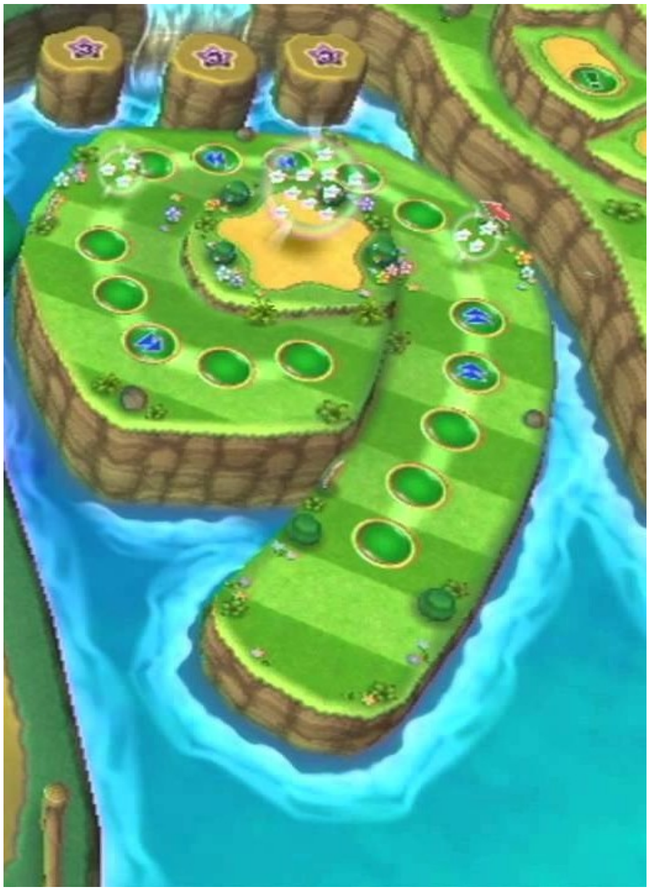
- If it is not unique, report a second solution in the comments.
- If it is unique, explain in a comment why you are sure about it.

Some hints:

- Be sure to give a unique representation for each kind of cells into your encoding; one data type will drastically help you in obtaining the solution.

Exercise 2

You are playing Mario Party with your friends Giuseppe, Roberto and Jingwen. You are now competing in the infamous 9-board! Here's a representation of the board, so that you have an idea.



Starting from the first player, they throw a dice whose values range in the interval 1-4. Places with 3 stars on it are not considered cells of the map. If they reach a speed cell (the one with blue arrows), they can throw the dice again and continue their turn. If they reach a simple green cell, the player changes and it's turn for the remaining ones. If one of the players reaches the stars in the center of the map (which counts as the last cell, numbered 16), everyone win. If all four players reach a green cell without reaching the stars, they all lose. In addition, the game makes sure that the number obtained from the dice between two consecutive turns is never the same.

Model the problem as a nuXmv model and check the following properties:

- Is there an execution such that the players win?
- Is there an execution such that the players lose?
- Is there an execution such that the players win without reaching a single simple green cell?

In addition, write a comment into the solution file to answer the following short question:

- Considering timed automata, what is the meaning and the main difference between these two LTL operators: X and X∼?