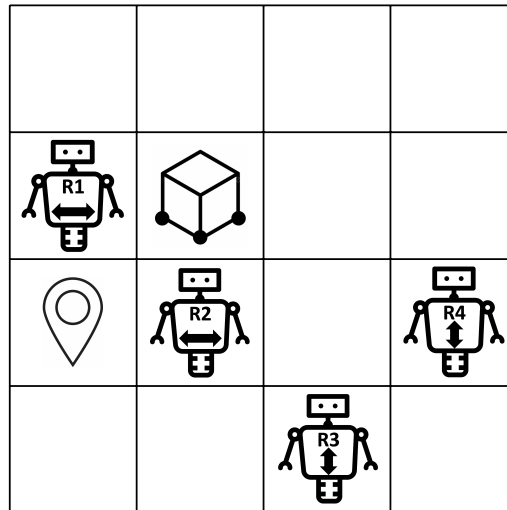


COS 741

Practical Assignment 4

EXERCISE 1 (9 Marks):

Consider the following 4x4 grid warehouse with four robots, one trolley and one delivery point. The positions of the robots, the trolley and the delivery point are depicted below. The robots $R1$ and $R2$ can only move *horizontally*, whereas the robots $R3$ and $R4$ can only move *vertically*. Each robot also has the ability to *idle*. If a robot is on the field right to the trolley, makes a move to the left, and the field to the left of the trolley is empty, then the trolley will be pushed onto that empty field and the robot moves onto the field where the trolley was previously placed. In a similar manner the trolley can be pushed right, up and down. A robot cannot move outside the grid or onto a field that is already occupied by another robot. Moreover, a robot cannot push the trolley outside the grid or onto a field that is already occupied by a robot.



a) [5 Marks]:

Model the warehouse system in *Promela* where each robot is represented by a process and each robot repeatedly makes a move. The directions of the moves shall be non-deterministically chosen and conform with the constraints given above. The termination criterion of the system shall be the arrival of the trolley at the delivery point.

b) [4 Marks]:

- Does there exist a run of the system where the trolley eventually arrives at the delivery point? How would you go about verifying this property with Spin's LTL model checking?
- It turns out that $R4$'s battery is flat and the robot can only idle. Under this condition, does there exist a run of the system where the trolley eventually arrives at the delivery point? How would you go about verifying this property with Spin's LTL model checking? (You shall not modify the model for verifying this property.)