Industrial Processes Automation

MSc in Electrical and Computer Engineering

Scientific Area of Systems, Decision, and Control

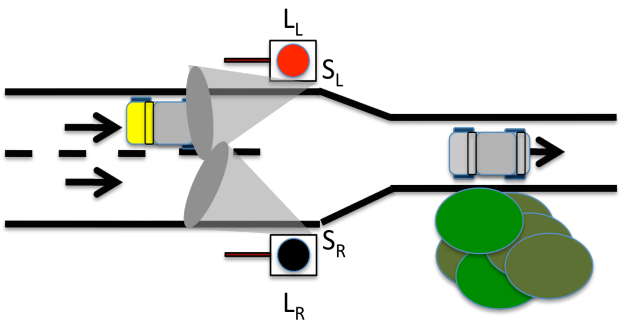
Winter Semester 2010/2011

1st Exam, 11th January 2011

Read all questions of the exam carefully before starting to answer.

- Provide detailed justifications to all answers.
- The use of bibliographic material, either in paper or in digital format is allowed.
- Exchange of information is forbidden (talk, WiFi, Bluetooth, GPRS, WAP,…).
- Exam duration: 3 hours.

Problem I



This problem will focus on the modeling and synthesis of a discrete event system: an automatic traffic light system must be installed on the confluence of two roads that give access to a narrow way, as depicted in the above figure. There are two sensors $S=\{ S_L, S_R \}$, with binary outputs to detect the presence/absence of vehicles in the left and right way, respectively. There exists also installed two red lights $A=\{ L_L, L_R \}$, one at each side, both with a digital ON/OFF command.

a) [1 point] Assume that a PLC must to be installed, to implement the automatic traffic light system. Discuss its characteristics.

b) [1 point] Design an electrical diagram that details the proposed solution.

c) [1 point] Design a Petri net for the discrete event system described above, considering the information from the two sensors and the two ON/OFF traffic lights commands.

d) [2 points] Design a supervisor, based on the place invariant method studied in the course, such that independently for each side of the access, when the presence of a car is detected the light on the opposite side is commanded to become RED.

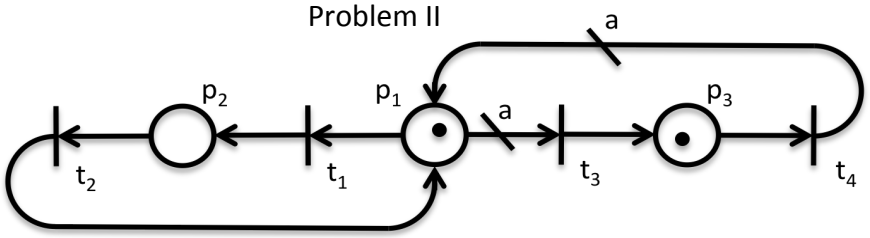
e) [1 point] Represent in the global Petri net obtained, the situation depicted in the figure above.

f) [2 points] There is a functional deadlock in the previous solution. Design a supervisor that implements a solution such that only one RED light can be commanded to ON.

g) [1 point] Discuss on how to generalize this problem, of 2 ways changing to 1, for the case where n ways are reduced to 1.

h) [1 point] Propose a simple Ladder, Structure Text or Instruction List segment of code that implements the supervisors synthesized.

Problem II



This second problem will focus on Discrete Event Systems analysis tools studied on the course, for the Petri Net graph depicted in the figure above. Note that there are two arcs with generic non-negative weights 'a'.

Consider a=0.

a) [1 point] Discuss the conservativeness and the boundness of the aforementioned Petri net, resorting to a reachability (sub)tree.

b) [2 points] Discuss the liveness of each transition and the overall level of liveness for the Petri net.

Consider a=1.

c) [1 points] Discuss the conservativeness of the Petri net, for this case, and provide the weight vector.

d) [1 point] Resorting to the Method of the Matrix Equations, study if and how the marking u=[1 1 1]' can be reached.

e) [1 point] Build the reachability tree. Is the marking u=[0 2 0]' reachable?

f) [2 points] Find the cycles of operation or place invariants, for this Petri Net.

Consider a=2.

g) [1 point] Discuss the following statement "This Petri net is of level 3".

h) [1 point] Discuss the liveness levels for a=0 and a greater or equal to 2.

Boa sorte!
Paulo Oliveira