Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Distributed Computing

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# Discrete Event Systems

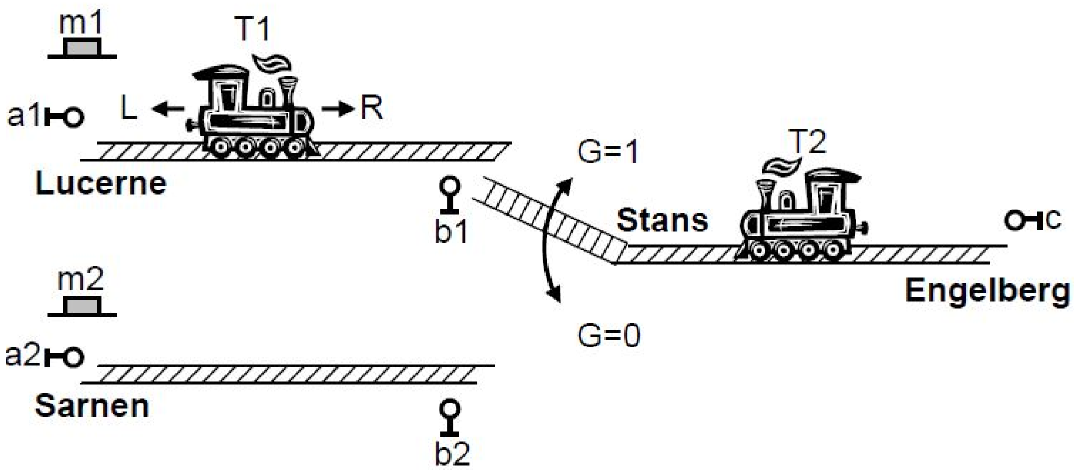
### Exercise Sheet 6

## 1 The Winter Train Problem

We consider two trains T1 and T2 transporting skiers from Sarnen and Lucerne to Engelberg. Because there is only one ground rail track from Stans to Engelberg, at most one train might be between these two villages at any time. There is a switch in Stans, which either connects the track between Sarnen and Engelberg xor the track between Lucerne and Engelberg. After the train conductor has pressed a button m in (Sarnen j Lucerne), its train moves to Engelberg, but might have to wait in Stans until the other train has left the critical section. Once arrived in Engelberg, the train waits for 100s and then returns.

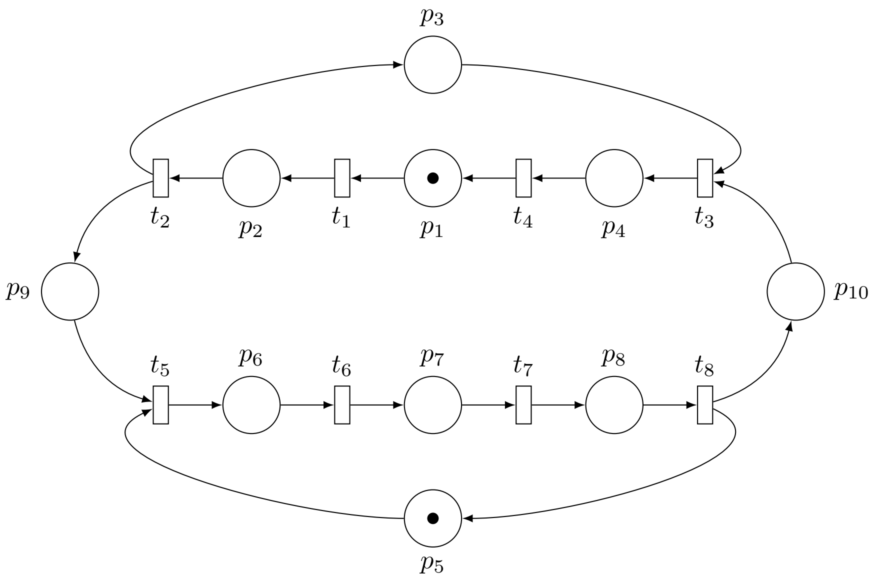
The sensors a1, a2, b1, b2 and c indicate the presence of a train with the value 1, otherwise, the value is 0. The switch in Stans is accessed through a variable G, as indicated in the picture. Finally, the motion of the trains is regulated by assigning 'R', 'L' or 'S' to the train, to move right, left, or stop, respectively.

The situation is shown below. Draw the corresponding State Chart using the notation introduced in the Figure!



## 2 Structural Properties of Petri Nets and Token Game

Given is the following petri net $N_1$:




**a)** What are the pre and post sets of transitions $t_5$ and $t_8$ and of place $p_3$?

**b)** Which transitions are enabled after $t_1$ and $t_2$ fired?

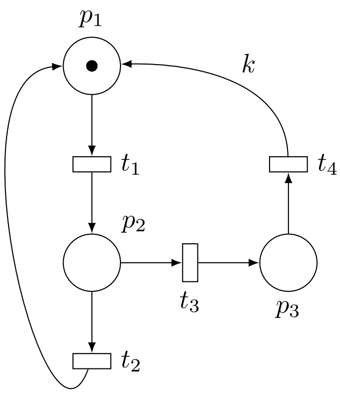
**c)** Determine the number of tokens in $N_1$ before and after $t_2$ fired.

**d)** Play the token game for $N_1$ and construct the reachability graph.

*Hint:* You may denote the states in such a way that the index indicates the places that hold a token in this state, for example $\vec{s}_0 = (1, 0, 0, 0, 1, 0, 0, 0, 0, 0) =: s_{1,5}$.

## 3 Basic Properties of Petri Nets

Given is the following petri net $N_2$:




Explain the terms *boundedness* and *deadlock-freeness* using this example, i.e. for which values of $k \in \mathbb{N}$ is the petri net $N_2$ bounded/unbounded and not deadlock-free?

## 4 Mutual Exclusion

Your task is to model a system as a petri net in which two processes want to access a common exclusive resource. This means that the two processes have to exclude each other mutually from the concurrent access to the resource (e.g. a critical program section). More concrete, this means:

1. A process executes its program.
2. In order to enter the critical section, a given mutex variable must be 0.
3. If this is the case, the process sets the mutex to 1 and executes its critical section.
4. When done, it resets the mutex to 0 and enters an uncritical section.
5. Then the procedure starts all over again.