Take-home Examination Part II: Modeling and analysis of concurrent systems (MACS), 2018/2019.

To be handed in before Monday 19 November, 18.00h.

- This examination should be made individually. Any form of collaboration with others is considered fraud.
- The work should be handed in in the mailbox of Rom Langerak, in Zi 3047. In addition, you have to send the UPPAAL files by e-mail to r.langerak@utwente.nl.
- Indicate your student number and study.
- Each item is worth 10 points. Total mark is sum divided by 4.

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1. A measurement unit consists of two sensors and a data device. The sensors produce a data element with a rate of μ resp. λ, and then start again (so the only action of a sensor is *data*). The data device may be inactive, after which it becomes active with rate ν, reads a data element, and becomes inactive again (initially the data device is inactive). So when performing the *data* action the data device interacts with one of the two sensors.
   (a) Specify the sensors, the data device, and the composition of the three processes; do not yet hide any actions.
   (b) Give a formal derivation of a sequence of actions where the data device reads a data element from one of the two sensors.
   (c) Now hide all actions, and give the resulting transition system.
   (d) Give a minimal CTMC that is bisimulation equivalent to the transition system in (c). If the transition system still contains non-determinism, i.e. several outgoing tau transitions from a single state, you may assume that these tau transitions all have equal probability.

2. Consider the timed automaton in figure 1 of the paper "Timed Automata" by Rajeev Alur.
   (a) Suppose initially we have a zone $[(s0, [0 \leq x \leq 4, 0 \leq y \leq 3])$. Give the zone after a sequence $a.b$ and show the intermediate steps in the derivation.
   (b) Give the zone automaton of the timed automaton, with initial state $(s0, [x = 0, y = 0])$.

3. In the missionaries and cannibals problem, three missionaries and three cannibals must cross a river using a boat which can carry at most two people, under the constraint that, for both banks, if there are missionaries present on the bank, they cannot be outnumbered by cannibals (if they were, the cannibals would eat the missionaries). The boat cannot cross the river by itself with no people on board.

   Make an UPPAAL model and find the most efficient schedule for getting everyone across the river.

4. A vessel where some chemical reaction takes place can be cooled by inserting two different rods, each with different cooling capacities. Only one rod can be inserted at a certain time. The vessel can be in three different states:

   no rods: then the temperature T evolves according to the differential equation $T' = 0.1T - 10.0$

   with rod1: equation is $T' = 0.1T - 11.2$

with rod2: equation is $T' = 0.1T - 12.0$ (so rod2 cools better than rod1).

A rod will be inserted if the temperature reaches 110 degrees. A rod that is in the vessel will be removed from the vessel if the temperature is between 102 and 105 degrees. When a rod is removed, it cannot be used for 20 time units.

Initial temperature is 102 degrees. The objective is to keep the temperature between 102 and 110 degrees. If the temperature is going up to 110 degrees but no rod is yet available, the system goes into a state `Overheating`.

Specify the system in UPPAAL. Show that unfortunately it may reach state `Overheating`. What is the chance this happens within 100 time units?