Formal Methods in Software Engineering
Exercise 8 (January 12)

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December 10, 2008

The result is to be submitted by the deadline stated above via the Moodle interface as a .zip or .tgz file which contains

- A PDF file with
  - a cover page with the title of the course, your name, Matrikelnummer, and email-address,
  - for each exercise, a section with the number and name of the exercise and the content of the exercise.

1 Modeling a Traffic Light (50)

Given a natural number N, an N-way car traffic light has three light bulbs R(ed), Y(ellow), G(reen). When the light is switched on, only R is on. When R is on, after some time also Y is switched on. Again after some time both R and Y are switched off, and G is switched on. After some further time G is switched off and the traffic light runs through N cycles of switching on and off G. After that, Y is switched on, then Y is switched off and R is switched on again. From now on, the system behaves as in the beginning.

At any time outside the cycling phase at least one light bulb is switched on (when G is finally switched off, immediately Y is switched on).

Model this system formally by defining its state space, initial state condition, and transition relation (although the system is clearly deterministic, please use a relation rather than a function). Use three state variables to model the states of the light bulbs (and any additional state variables you might need).

Show a run of the system (from initial state to initial state) for $N = 2$.

2 Modeling a Traffic System (50)

Take a traffic system with three traffic lights:

1. the first one is an N-way car traffic light as defined above,
2. the other two are simple traffic lights for pedestrians each with two bulbs R(ed) and G(reen) which perpetually are switched from R to G and from G to R (without blinking phase).

The three lights operate asynchronously but under the constraint that the pedestrian lights may be only green if the car traffic light is red. Furthermore, if the N-traffic light has become red, at least one of the pedestrian lights must become green before the car traffic light may become green again.

Model this system by defining its state space, initial state condition, and transition relation using the interleaving model of concurrency. Reuse in this model the transition relation defined in the previous assignment and define a separate transition relation for a pedestrian light. Do not forget to make sure that above constraints are obeyed.

Answer the questions (with convincing justifications):

1. Is it guaranteed that infinitely often some pedestrian light becomes green?
2. Is it guaranteed that infinitely often every pedestrian light becomes green?
3. Is it guaranteed that infinitely often the car light becomes green?

3 Bonus (15)

Choose some question from the previous assignment for which the answer is "no" and change the system model such that the answer becomes "yes".