Exercise 1: Regions (3/20 Points)

Recall that we started to indicate the equivalence classes on clock valuations of \( X = \{x, y\} \) in the graph shown in Figure 1. A point \((p, q)\) in the graph represents the unique clock valuation \(\{x \mapsto \rightarrow p, y \mapsto \rightarrow q\}\). The equivalence classes shown in Figure 1 are actually not correct.

- What is wrong? Why is it wrong? (The correct equivalence classes are in the book [2]). (3)
- Outline which equivalence classes we get if we have \(c_x = 2\). (2)

As usual, convince the tutors of the correctness of your proposal.


Consider the timed automaton \(A\) in Figure 2. In the tutorial, we had the impression that location \(\ell_2\) is not reachable. Prove this statement by constructing the region automaton.

*Hint:* you need not present all configurations of \(R(A)\) if you explain why the ones, that you do present, are sufficient for the exercise.

Compute

\[ \text{Post}_e(\ell_0, z) \]

for the zone \( \varphi_0 \) given by Figure 3 and for both edges originating at \( \ell_0 \); give the intermediate steps up to \( \varphi_5 \).

What can you conclude about the reachability of \( \ell_1 \) and \( \ell_2 \)?

You may represent zones graphically or symbolically.

Exercise 4: Deadlock (5+5/20 Points)

(i) Please give (possibly from (correctly cited) literature) an exact formal definition of deadlock in Uppaal [1], i.e. please explain (formally) using the notions and definitions from the lecture when exactly a network of timed automata satisfies

\[ E \leftrightarrow \text{deadlock}. \]

Consider the following examples:

a) 

b) 

\( x < 10 \)

\( x < 5 \)

\( x = 2 \)

\( x < 2 \)

\( x < 10 \)

d) 

e) 

Do they have a deadlock according to your definition?

And according to Uppaal (i.e., what does Uppaal’s deadlock check yield)? (3/5)

(ii) How does deadlock relate to timelock? (1/5)

(iii) What is checking for deadlocks good for? (1/5)

(iv) Can Uppaal check for timelock? What would checking for timelock be good for? (5 Bonus)
Exercise 5: Model-Checking with Uppaal \hspace{1cm} (4/20 Points)

Consider the Off/Light/Bright model from Exercise Sheet 4.

(i) Use the model checker to verify whether the original user can reach the Bright location. \hspace{1cm} (1/4)

(ii) Use the model checker to verify that your modified user from Sheet 4, Exercise 2, part (iii) cannot reach the Bright location as requested. \hspace{1cm} (1/4)

(iii) Check whether the original user is able to keep the lamp at location Bright for more than 5 time units. \hspace{1cm} (1/4)

(iv) Check whether the original user is able to switch the lamp to Bright twice. \hspace{1cm} (1/4)

Explain your approach.

References
