

Real-Time Systems

<http://swt.informatik.uni-freiburg.de/teaching/SS2014/rtsys>

Exercise Sheet 5

Early submission: Tuesday, 2013-07-21, 10:00 Regular submission: Wednesday, 2013-07-22, 10:00

**Exercise 1: Region Construction [2] (10/20 Points)**

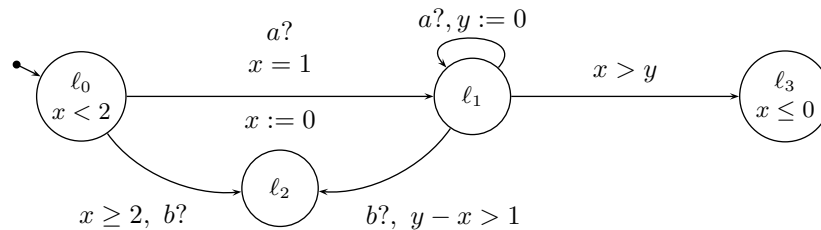


Figure 1: Timed Automaton for Exercise 1.

Consider the timed automaton  $\mathcal{A}$  in Figure 1. In the tutorial, we had the impression that locations  $l_2$  and  $l_3$  are not reachable.

Prove this statement by constructing the region automaton.

*Hint: you need not present all configurations of  $\mathcal{R}(\mathcal{A})$  if you explain appropriately why those, which you do present, are sufficient.*

**Exercise 2: Zone Construction [2] (5/20 Points)**

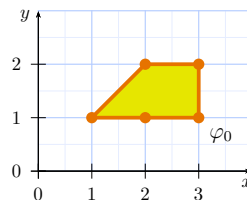


Figure 2: Zone  $\varphi_0$  for Exercise 3.

Compute

$$\text{Post}_e(l_0, z)$$

for the zone  $\varphi_0$  given by Figure 2 and for both edges originating at  $l_0$ ; give the intermediate steps up to  $\varphi_5$ .

What can you conclude about the reachability of  $l_1$  and  $l_2$ ?

*You may represent zones graphically or symbolically.*

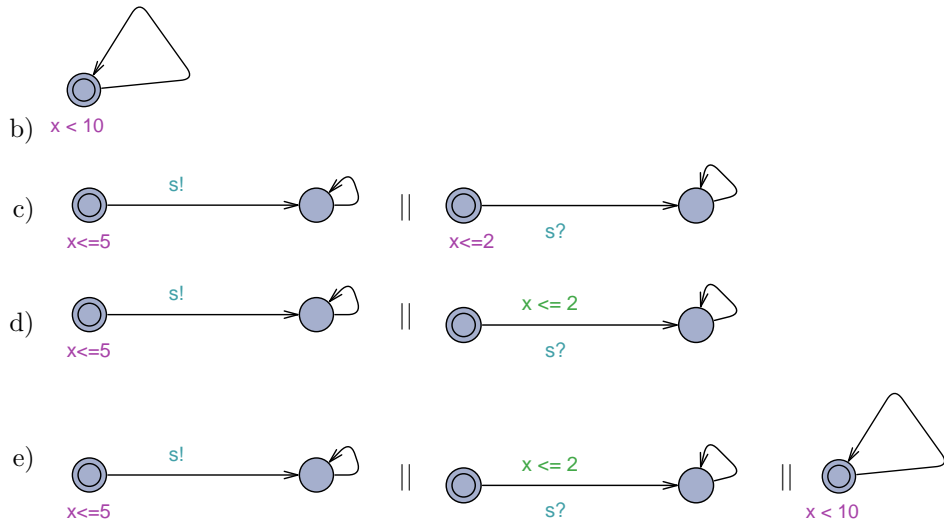
**Exercise 4: Deadlock (5/20 Points)**

- (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

$$E \langle\langle \text{deadlock} \rangle\rangle.$$

Consider the following examples:

- a)



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)

## References

[1] Gerd Behrmann, Alexandre David, and Kim G. Larsen. A tutorial on uppaal 2004-11-17. Technical report, Aalborg University, Denmark, November 2004.

[2] Ernst-Rüdiger Olderog and Henning Dierks. *Real-Time Systems - Formal Specification and Automatic Verification*. Cambridge University Press, 2008.