

## „Real-Timed Automata“ Exercise 1

The following exercises must be submitted 05.05.2014 *before* the lecture.

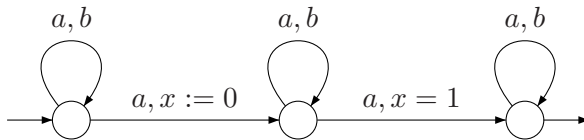
1. For each of the following timed languages  $L_i$  over the alphabet  $\Sigma = \{a, b, c, d\}$ , give a timed automaton  $\mathcal{A}_i$  such that  $L(\mathcal{A}_i) = L_i$ :

- (a)  $L_1 = \{((abcd)^*, \bar{t}) \mid \forall i. t_{4i+3} < t_{4i+1} + 1\}$ ,
- (b)  $L_2 = \{((abcd)^*, \bar{t}) \mid \forall i. t_{4i+4} < t_{4i+2} + 2\}$ ,
- (c)  $L_3 = L_1 \cap L_2$ .

2. Are the following timed languages over the alphabet  $\Sigma = \{a, b\}$  recognizable by a timed automaton? Justify your answer!

- (a)  $L_4 = \{((a^m b^n), t_1 \dots t_{m+n}) \mid \forall i. 1 \leq i \leq m+n-1 : t_{i+1} = t_i + 1, 1 \leq m \leq n\}$
- (b)  $L_5 = \{(a^n, t_1 \dots t_n) \mid \forall i. 1 \leq i \leq n-1 : t_{i+1} = t_i + \frac{1}{2}, n \geq 1\}$
- (c)  $L_6 = \{(a^n, t_1 \dots t_n) \mid \forall i. 1 \leq i \leq n-1 : t_i = t_{i+1} + 1, n \geq 1\}$

3. Which timed language does the following timed automaton recognize?



4. Is the complement of the timed language recognized by the automaton in 3. recognizable by a timed automaton? Justify your answer!
5. For the following two clock valuations  $\nu_1$  and  $\nu_2$ , give the corresponding clock region as well as the direct time successor of the clock region. We assume  $c_{\max}$  to be 2.

- (a)  $\nu_1(x_1) = 0.5, \nu_1(x_2) = 1.7, \nu_1(x_3) = 0.7$
- (b)  $\nu_2(x_1) = 2.0, \nu_2(x_2) = 1.9, \nu_2(x_3) = 0.1$