RWTH AACHEN
Theory of Hybrid Systems
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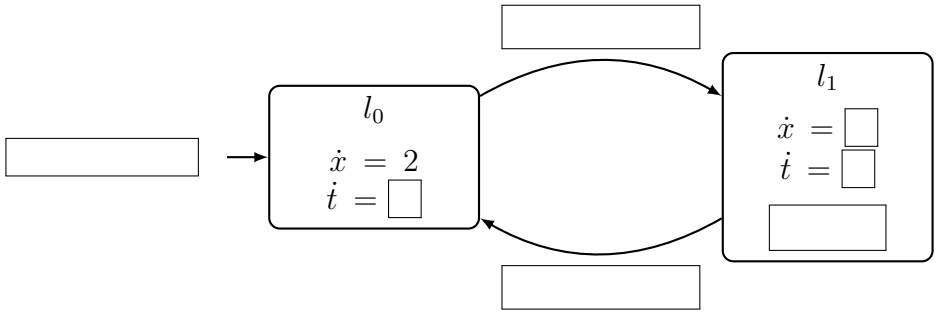
Modeling and Analysis of Hybrid Systems - SS 2015

Series 10

Exercise 1

Below we have given an incomplete graphical representation of a hybrid automaton $\mathcal{H}$:



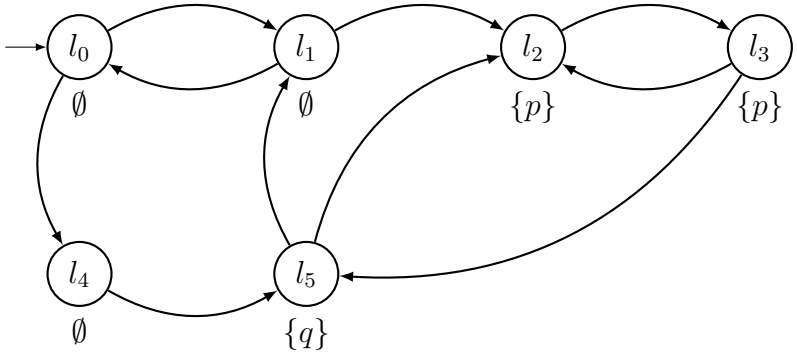
a) Please complete $\mathcal{H}$ by filling in the missing information according to the following specification:

- Both variables x, t are initialized with 0.
- t is used as a clock to measure the time spent in each location.
- In location l_1 x evolves twice as fast as in location l_0.
- Due to inertia the system rests in location l_1 for exactly 1 time unit.
- Whenever x has reached at least value $c, c > 0$, the system may switch from l_0 to l_1.
- Upon each switch, x is set to $d, d \geq 0$.

b) Please give a formal specification of $\mathcal{H}$.

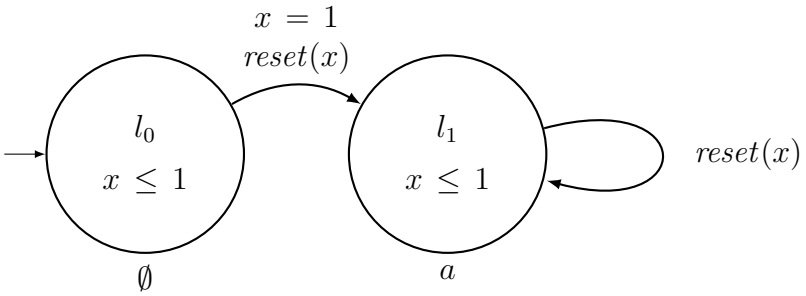
Exercise 2

A transition system TS is given below. Decide whether $TS \models \Phi$ where $\Phi = EFAG(p \vee q)$. Please sketch the main steps of the CTL model-checking algorithm.



Exercise 3

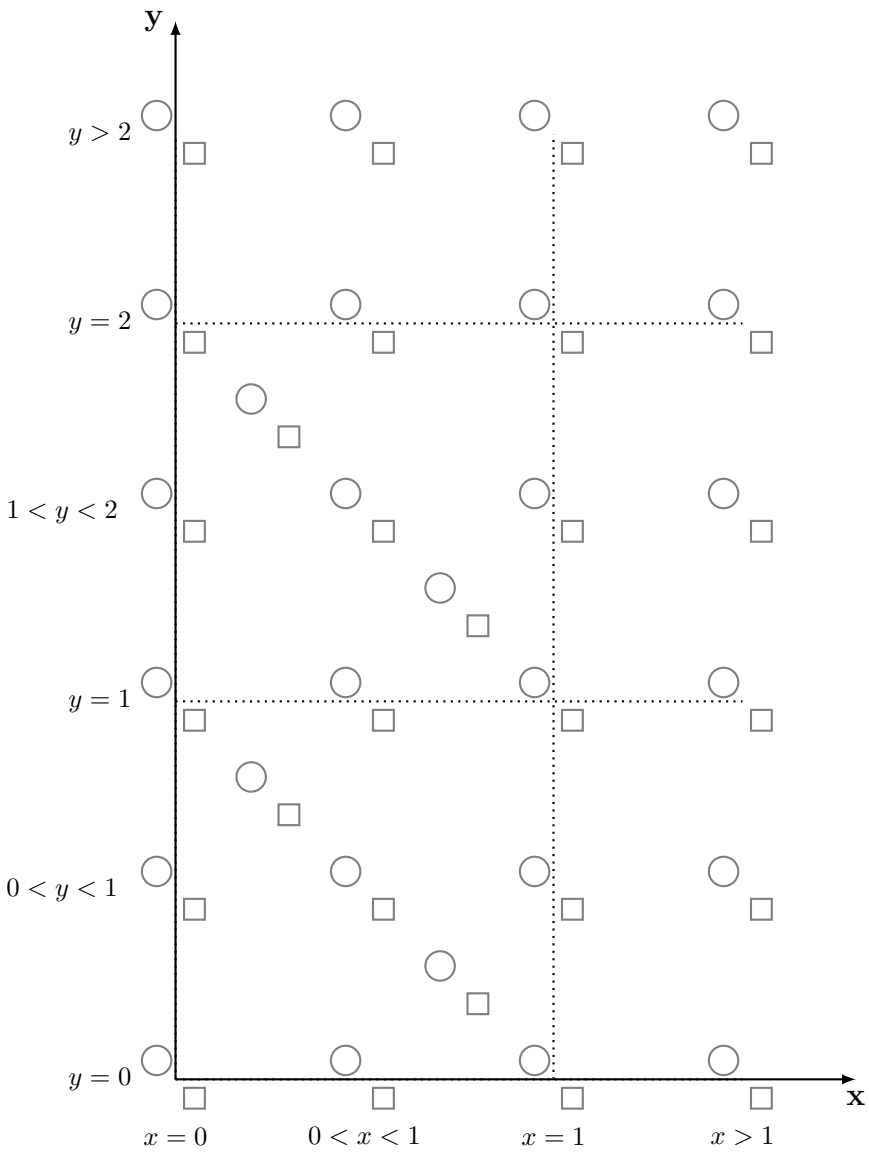
Consider the following timed automaton $\mathcal{T}$ and the TCTL formula $\varphi = AF^{\geq 2}a$:



a) Construct $\hat{\varphi}$ by eliminating timing parameters from φ. Use the name y for the auxiliary clock.

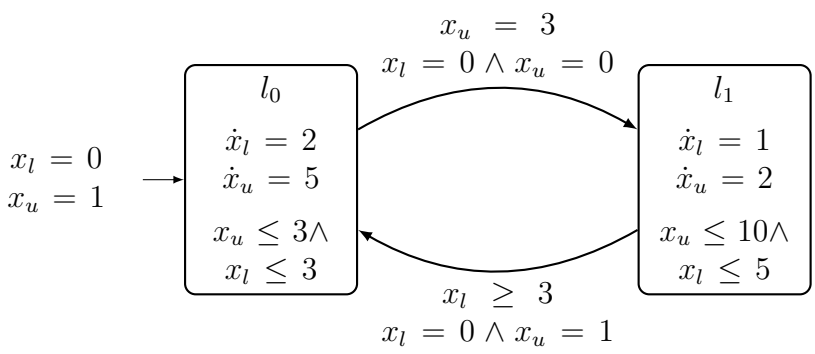
b) Construct a *RTS* $\mathcal{R}$, such that $\mathcal{T} \models_{TCTL} \varphi$ iff $\mathcal{R} \models_{CTL} \hat{\varphi}$. As $\mathcal{R}$ will become big, use the prepared grid below to sketch the *RTS* (by adding the required transitions) as follows:

- ◯ represents a state, where the location is l_0.
- □ represents a state, where the location is l_1.
- The position of a state in the grid remarks, which clock region the state represents.
- Please draw only the reachable fragment of $\mathcal{R}$.



Exercise 4

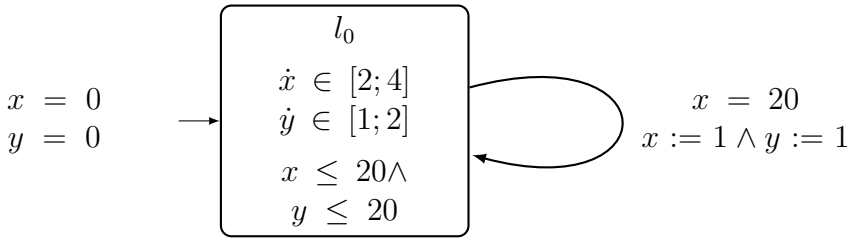
Consider the following initialized stopwatch automaton $\mathcal{S}$:



Please reduce $\mathcal{S}$ to a timed automaton $\mathcal{T}$.

Exercise 5

Consider the following linear hybrid automaton $\mathcal{H}$:



Please use the forward reachability algorithm presented in the lecture to compute the set of reachable states **after taking one transition** in the model.