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Embedded Systems 2010/2011 – Assignment Sheet 1

Due: Tuesday, 2$^{\text{nd}}$ November 2010, *before* the lecture (i.e., 10:10)
Please indicate your **name**, **matr. number**, **email address**, and which **tutorial** you are planning to attend on your submission. We encourage you to collaborate in **groups** of up to **three** students. Only one submission per group is necessary. However, in the tutorials every group member must be capable to present each solution.

Exercise 1: Mealy Automata (15 pts.)

Provide a mealy automaton that reads a sequence of symbols from the set $\{0, 1\}$. It outputs '1', if the last 3 symbols match the pattern "101". Otherwise, it outputs '0'.
Example:

Input	0	1	1	0	1	0	0	1	0	1	0	1	0	1	...
Output	0	0	0	0	1	0	0	0	0	1	0	1	0	1	...

Exercise 2: Modeling with StateCharts (30 pts.)

Figure 1 shows the control of a simple vending machine (in the StateCharts formalism). Figure 2 lists all occurring events together with their meaning.

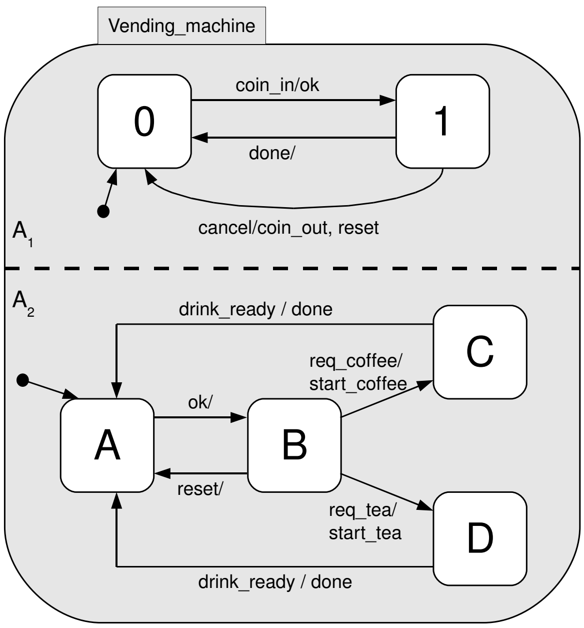

Figure 1: A vending machine.

Event	Generated by	Consumed by	Meaning
COIN_IN	environment	A_1	user inserts coin
CANCEL	environment	A_1	user presses cancel-button
REQ_COFFEE	environment	A_2	user presses coffee-button
REQ_TEA	environment	A_2	user presses tea-button
DRINK_READY	environment	A_2	drink is ready
COIN_OUT	A_1	environment	coin returned to user
START_COFFEE	A_2	environment	start preparation of coffee
START_TEA	A_2	environment	start preparation of tea
OK	A_1	A_2	enough coins inserted
RESET	A_1	A_2	coins back to user
DONE	A_2	A_1	drink delivered

Figure 2: Events for the vending machine in Figure 1.

A typical interaction of the vending machine with the environment is:

- Initially the system is in the states [0] and [A].
- The user inserts a coin, the environment generates the event COIN_IN, A_1 moves to state [1], and the event OK is generated.
- A_2 consumes the event OK and moves to state [B].
- The user presses the cancel-button, A_1 moves back to state [0], the events RESET and COIN_OUT are generated.
- A_2 consumes the RESET event and moves back to state [A].

(a) Describe the trace of transitions occurring when the user inserts a coin and orders coffee. (5 pts.)

(b) The control of the vending machine has a bug that allows the user to cheat. Find it. (5 pts.)

(c) Fix the bug. (10 pts.)

(d) Now, construct an equivalent automaton Q where no parallelism is involved. The initial state should be [0A]. When the event COIN_IN occurs, Q moves to state [1A] and the event OK is generated. This causes Q to move from state [1A] to state [1B]. Now continue yourself. (10 pts.)

Exercise 3: Timed StateCharts (25 pts.)

Consider the AND-state in Figure 3 that models a system with two concurrent processes `P1` and `P2` accessing a shared resource. The StateChart comprises the global variable `id` that is initially set to 0, and the external events `try1`, `try2`, `set1`, `set2`, `retry1`, `retry2`, `enter1`, `enter2`, `exit1`, and `exit2`. Furthermore, the timing behavior is parameterized by the integer constants `D` and `T`. The system is considered as *safe* if it is never the case that `P1` is in `crit1` and `P2` is in `crit2` at the same time.

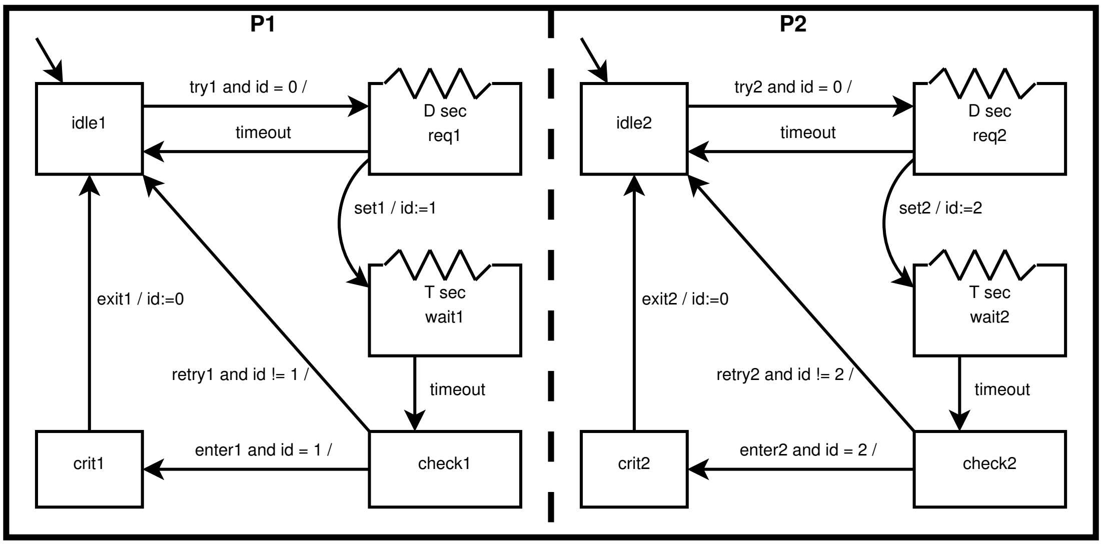

Figure 3: A timed mutual exclusion protocol.

(a) Assume `D` $= 10$ and `T` $= 5$. Is the system safe? Justify your answer either by giving a *formal* argument why it is safe, or by providing a (short) trace (i.e., a scenario of delays and events) leading to an unsafe state, where `P1` is in `crit1` and `P2` is in `crit2` at the same time. (10 pts.)

(b) Give the most general characterization how `D` and `T` must be chosen such that for *any* occurring of events, the system will always remain safe. (15 pts.)

Exercise 4: MATLAB / Simulink (30 pts.)

Download the Simulink model of the damped harmonic oscillator from the course web page.

`http://react.cs.uni-saarland.de/teaching/embedded-systems-10-11/assignments.html`

(a) Let

$$y_s = \lim_{t\to\infty} y(t);$$
$$t_s(d) = \inf\{t \in \mathbb{R}_0^+ :\ \forall t' \geq t.\ |y(t') - y_s| \leq d\}.$$

Approximate y_s and $t_s(0.2)$ with a precision of 1 (by simulation) for the parameters $k = 10$, $m = 1.2$, $y_0 = 15$, and $R = 0.1$. (15 pts.)

Hint: You can increase the precision of your simulation when you select under *Simulation* $\to$ *Configuration Parameters* a *fixed-step* solver and decrease the *Fixed-step size.*

(b) Extend the model such that the suspension $u(t)$ varies with a 0.5Hz cosine with an amplitude of 1. Use the following differential equation:

$$\ddot{y}(t) = -\frac{1}{m}\left(k\left(y(t) - \frac{1}{k}u\left(\frac{t}{4}\right)\right) + R\dot{y}(t)\right)$$

In your submission, please provide a print out or a drawing of your Simulink model. State the parameters of all changed or newly added function blocks. (15 pts.)