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Winter term 2008/2009
Problem Set 1
Due: Monday, 3rd November 2008

Embedded Systems

Problem 1: A vending machine (40 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.

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.

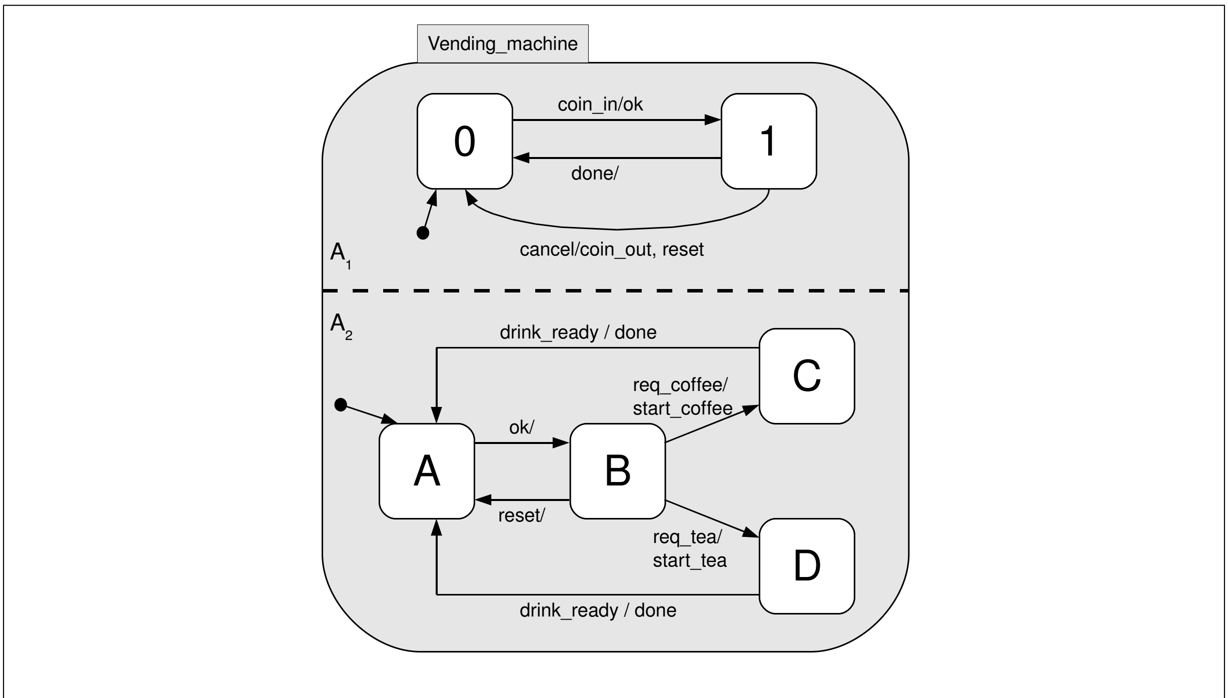

Figure 1: A vending machine.

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 2.

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

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

(c) 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.)

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

(e) Allow the vending machine to accept coins for €0,05, €0,10, €0,20, and €0,50. Coffee costs €0,75. Tea costs €0,50. (10 pts.)

Problem 2: Time models (10 pts.)

Discuss the differences between the synchronous and the super-step time model (Slide set 2, slides 41-44). Why does it make sense to assume instantaneous state transitions although in practice all computing devices need some time for transitions between states?

Problem 3: StateCharts (20 pts.)

What is the advantage of having hierarchical structures (as present in StateCharts) over flat structures (as used for Mealy and Moore automata) for the description of systems?

Furthermore, assume that you were using a StateCharts modelling tool that does not support OR-super-states. Are you (theoretically) still able to model the same set of systems with it? What about AND-super-states?

Problem 4: Simulink (30 pts.)

The purpose of this excercise is to get started with MATLAB/Simulink. Download the Simulink model of the damped harmonic oscillator from the course web page.

`http://react.cs.uni-sb.de/index.php?id=503`

4.1 Simulation (10 pts.)

Let

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

Approximate y_s and $t_s(0.1)$ with a precision of 0.1 (by simulation) for the parameters $k = 1$, $m = 1$, $l_0 = 10$, and $R = 0.1$.

4.2 Modeling (20 pts.)

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

$$\ddot{y}(t) = \frac{1}{m}\Big(k\big(u(t) - y(t)\big) - R\dot{y}(t)\Big)$$