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T-79.4302 Parallel and Distributed Systems
Examination, 14 December 2011

Write down on every answer sheet: the name of the course, the course code, the date, your name, your student id, and your signature.

To pass the course, you also need at least 50 % of the home assignment points for Autumn 2011.

Assignment 1. Consider the following Promela model, where $\mathtt{Z} \geq 1$ is a constant.

```
chan bus = [Z] of { byte };
byte x = 0;
active proctype produce0() { do :: bus ! 0; od }
active proctype produce1() { do :: bus ! 1; od }
active proctype consume() {
  do
  :: bus ? x;
  :: (x == 1) -> break;
  od
}
```

(a) What pieces of data are needed to identify a single state of this model? Design a way to represent an arbitrary state. (2p)

(b) Identify the sources of nondeterminism in the model. (2p)

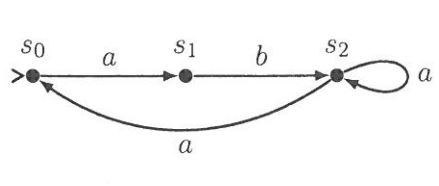
(c) Construct the reachability graph of the model for $\mathtt{Z} = 1$. (4p)

(d) List all reachable deadlock states for $\mathtt{Z} = 2$. (2p)

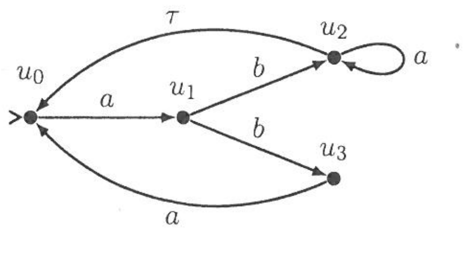
(e) How many reachable states does the model have for $\mathtt{Z} = 4$? (2p)

Assignment 2. Given the LTSs L_1 and L_2 below, construct a deterministic finite state automaton A' that accepts the language $\Sigma_2 \setminus \mathit{traces}(L_2)$. See A' as an LTS L' and compute the parallel composition $P = L_1 \,||\, L'$. Use P to conclude that $L_1 \leq_{tr} L_2$. (12p)

$L_1: \quad \Sigma_1 = \{a, b\}$



$L_2: \quad \Sigma_2 = \{a, b\}$



More assignments on the second page

Assignment 3. Consider the Kripke structure $M = (S, s^0, R, L)$ with $S = \{s_0, s_1, s_2, s_3, s_4, s_5\}$, $s^0 = s_0$, $R = \{(s_0, s_1), (s_1, s_2), (s_2, s_3), (s_3, s_4), (s_4, s_2), (s_0, s_4), (s_3, s_5)\}$, and the function L is defined by $L(s_0) = L(s_1) = \{crash\}$, $L(s_2) = \{alarm\}$, $L(s_3) = \{alarm, reset\}$, and $L(s_4) = L(s_5) = \emptyset$. For each of the formulas below, check whether the formula holds in M or not. If the formula holds, give a brief explanation (max 5 lines of text) why the formula holds. If the formula does not hold, give a finite counterexample execution of M and explain why it violates the formula.

(a) $\mathbf{G}\,(reset \Rightarrow alarm)$ (4p)

(b) $\mathbf{G}\,(alarm \Rightarrow \mathbf{O}\,crash)$ (4p)

(c) $\mathbf{G}\,(alarm \Rightarrow \mathbf{Y}\,((\neg reset)\,\mathbf{S}\,crash))$ (4p)

Assignment 4. Are the following statements true or false? For each statement that is true, give a brief justification. For each statement that is false, provide a counterexample that disproves the statement.

(a) There is no state s in any LTS such that there exists both a deadlock and a livelock in s. (4p)

(b) If $L_1 \leq_{tr} L_2$ and $L_2 \leq_{tr} L_1$ hold for LTSs L_1 and L_2, then L_1 and L_2 are bisimilar. (4p)

(c) The property $\mathbf{G}\,\mathbf{F}\,(p \Rightarrow q)$ is stuttering invariant for all atomic propositions p and q. (4p)

Please remember to give course feedback — find a link to the online form in Noppa.