Aalto University, Department of Information and Computer Science

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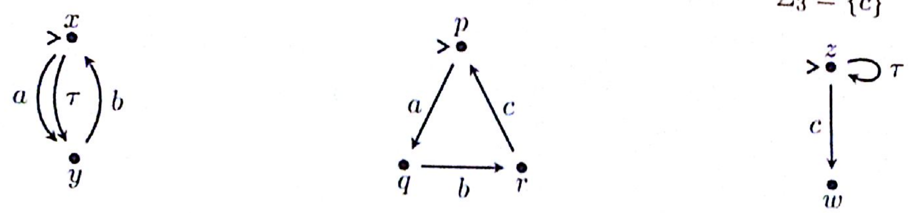
T-79.4302 Parallel and Distributed Systems
Examination, 19 December 2012

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 to have passed the quizzes and home assignments in Autumn 2012.

Assignment 1. Consider the parallel composition of the following LTSs $L_i = (\Sigma_i, S_i, s_i^0, \Delta_i)$.

L_1: $\Sigma_1 = \{a, b\}$ L_2: $\Sigma_2 = \{a, b, c\}$ L_3: $\Sigma_3 = \{c\}$



(a) List all pairs of independent actions of the parallel composition $L_1 \parallel L_2 \parallel L_3$. Represent actions as tuples (t_1, t_2, t_3), where each $t_i \in \Delta_i \cup \{-\}$. (2p)

(b) Construct the reachable part of the asynchronous product LTS $L = L_1 \parallel L_2 \parallel L_3$. (2p)

(c) List all reachable states of L that are deadlocks. (2p)

(d) List all reachable states of L in which a livelock exists. (2p)

(e) List all reachable states of L in which a conflict occurs. (2p)

(f) For each reachable state s of L with no conflict, justify why there is no conflict in s. (2p)

Assignment 2. Consider the Kripke structure $M = (S, s^0, R, L)$ with $S = \{s_0, s_1, s_2, s_3, s_4\}$, $s^0 = s_0$, $R = \{(s_0, s_1), (s_1, s_2), (s_2, s_3), (s_3, s_4), (s_4, s_0), (s_0, s_4), (s_1, s_3), (s_2, s_0), (s_2, s_2), (s_3, s_3)\}$, and the function L is defined by $L(s_0) = \emptyset$, $L(s_1) = \{start\}$, $L(s_2) = \{heat\}$, $L(s_3) = \{heat, error\}$, and $L(s_4) = \{open\}$. For each of the past safety 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) $\mathbf{G}\,(heat \Rightarrow \neg open)$ (4p)

(b) $\mathbf{G}\,(open \Rightarrow \mathbf{Y}\,\mathbf{H}\,\neg open)$ (4p)

(c) $\mathbf{G}\,(error \Rightarrow ((\neg open)\;\mathbf{S}\;start))$ (4p)

More assignments on the second page

Assignment 3.

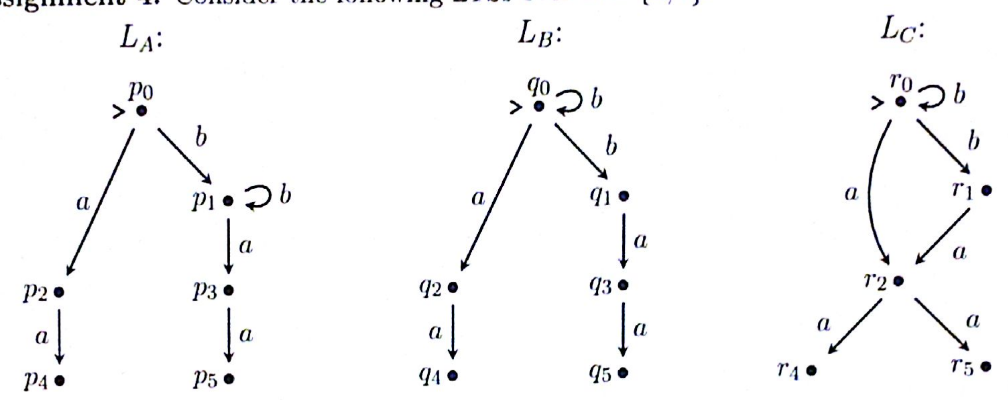
(a) Give an example of an LTL formula φ_{fair} that represents a weak fairness property. Give an infinite word of the form $\pi = x_0x_1x_2x_0x_1x_2x_0x_1x_2\ldots$, where each x_i is a subset of atomic propositions, such that $\pi \not\models \varphi_{fair}$. (3p)

(b) Give an example of an LTL formula φ_{safe} that represents a safety property. Give a finite word π of subsets of atomic propositions such that $\pi\rho \not\models \varphi_{safe}$ for every infinite word ρ. Explain briefly why φ_{safe} fulfills the definition of safety property. (3p)

(c) Give an example of an LTL formula φ_{live} that represents a liveness property. Explain why φ_{live} fulfills the definition of liveness property. (3p)

(d) Name one technique, within the scope of the course, that can be implemented in a model checker to reduce memory usage. Explain in a few sentences how this technique can result in lower memory usage than plain reachability analysis. (3p)

Assignment 4. Consider the following LTSs over $\Sigma = \{a, b\}$.



(a) From the theory of LTSs, define "bisimulation relation". (2p)

(b) Are L_A and L_B bisimilar? Justify your answer. (2p)

(c) Are L_B and L_C bisimilar? Justify your answer. (2p)

(d) Are L_A and L_C bisimilar? Justify your answer. (2p)

(e) Are L_B and L_C trace equivalent? Justify your answer. (2p)

(f) Construct a deterministic FSA A that recognizes the language $\Sigma^* \setminus traces(L_C)$. (2p)

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