Aalto University
Department of Information and Computer Science

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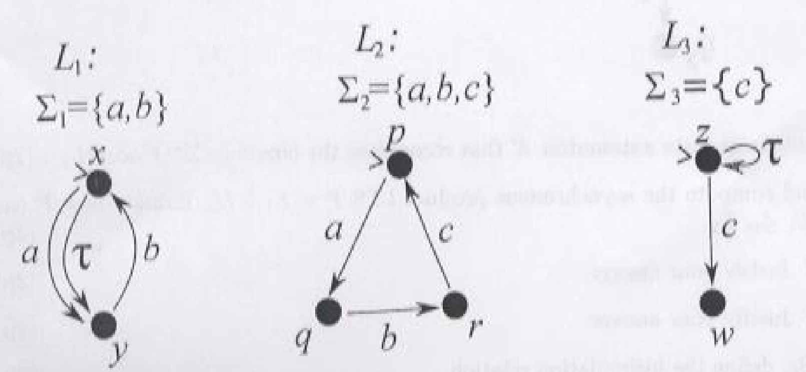
T-79.4302 Parallel and Distributed Systems

Examination 17 December 2014

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

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



(a) List all pairs of independent actions of the parallel composition $L_1 \parallel L_2 \parallel L_3$. Write the actions as tuples (t_1, t_2, t_3), where each $t_i \in \Delta \cup \{-\}$. (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 $S = \{s_0, s_1, s_2, s_3, s_4\}$, $s^0 = s_0$, $R = \{(s_0, s_1), (s_1, s_2), (s_2, s_3), (s_3, s_4), (s_4, s_1), (s_4, s_2)\}$, and the function L defined by $L(s_0) = \emptyset$, $L(s_1) = L(s_4) = \{power\}$, $L(s_2) = L(s_3) = \{ready,\ power\}$. For each of the LTL 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 counterexample execution of M and explain why it violates the formula.

(a) $\mathbf{G}\,(ready \Rightarrow power)$ (3p)

(b) $\mathbf{G}\,\mathbf{F}\,ready$ (3p)

(c) $\mathbf{F}\,\mathbf{G}\,power$ (3p)

(d) $\mathbf{G}\,(ready \Rightarrow \mathbf{X}\,\mathbf{X}\,\mathbf{X}\,\mathbf{X}\,ready)$ (3p)

(e) Identify which of these are safety formulas and which are liveness formulas. Justify your answer. (3p)

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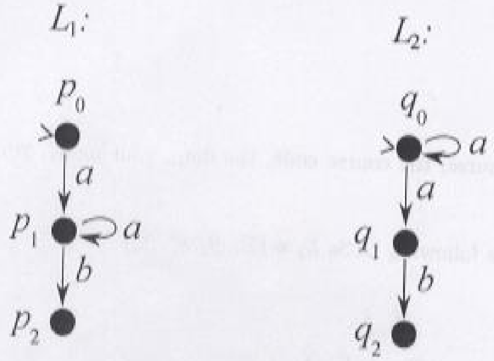
Assignment 3 Consider the following LTSs over $\Sigma = \{a, b\}$



(a) Construct a deterministic finite state automaton A' that recognizes the language $\Sigma^* \setminus traces(L_2)$. (2p)

(b) See A' as an LTS L' and compute the asynchronous product LTS $P = L_1 \parallel L'$. Explain how P can be used to argue that $L_1 \leq_{tr} L_2$. (2p)

(c) Does $L_1 \leq_{sim} L_2$ hold? Justify your answer. (2p)

(d) Does $L_2 \leq_{sim} L_1$ hold? Justify your answer. (2p)

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

(f) Does $L_1 \sim L_2$ hold? Justify your answer. (2p)

Assignment 4 Consider two philosophers who sit around a table. They spend their time in thinking, eating and sleeping. In order to eat, a philosopher needs a fork and a knife. However, there is only one fork and one knife on the table, so the philosophers cannot eat at the same time.

(a) Model the behavior of the philosophers, the knife and the fork as LTSs $Phil_1$, $Phil_2$, $Knife$, and $Fork$, respectively, (8p)

(b) such that the parallel composition $Phil_1 \parallel Phil_2 \parallel Knife \parallel Fork$ is deadlock-free and in every infinite trace, both philosophers eat infinitely often. (4p)

Explain the meaning of the states and actions of the LTSs or give self-explanatory names to the states and actions.