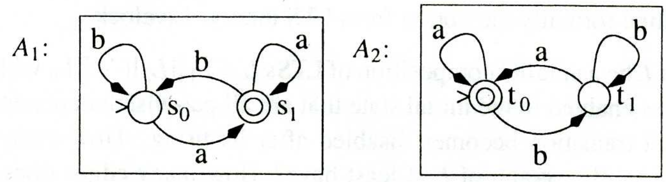
Helsinki University of Technology, Department of Information and Computer Science KH

T-79.4301 Parallel and Distributed Systems

Examination, December 16, 2009

Please note the following: To pass the course you need at least 50% of the home assignment points. Please contact the Lecturer after the exam if you've not completed the home assignments successfully.

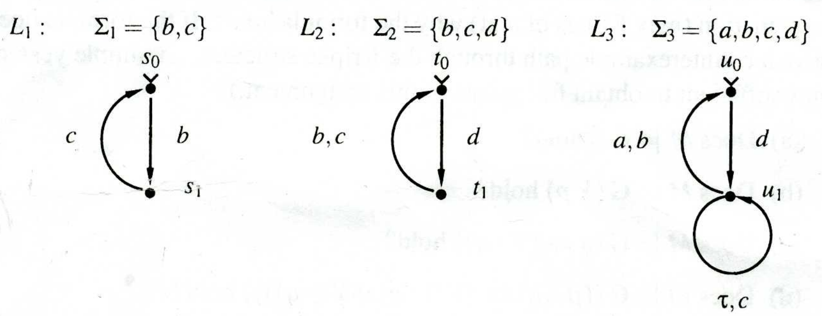
Assignment 1 Consider the following finite state automata A_1 and A_2, where $\Sigma_1 = \Sigma_2 = \{a, b\}$.



(a) Construct the finite state automaton $A_a = A_1 \cap A_2$. (3p)

(b) Construct the finite state automaton A_b that accepts the complement of the language accepted by the automaton A_a. (1p)

Assignment 2 Consider the following three labelled transition systems (LTSs) L_1, L_2, and L_3:



(a) Compute the parallel composition $L = L_1 || L_2 || L_3$. (3p)

(b) Does L contain any conflicts? If it does, please give a list consisting of all the triples (v, t, t'), where: v is a global state of L where a conflict occurs and t, t' are a pair of global transitions of L which are in conflict in v. (1p)

(c) Does L contain any deadlocks? If it does, please give a list of global states of L which are deadlocks. (1p)

(d) Does L contain any livelocks? If it does, please give a list of global states of L in which a livelock exists. (1p)

(e) Does L contain a pair of independent transitions? If it does, give one example of two global transitions which are independent. (1p)

(f) Give a deterministic finite automaton A_f accepting the language $\Sigma^* \setminus traces(L)$, where Σ is the alphabet of L. (1p)

(g) Answer the question: Is $traces(L_3) \subseteq traces(L)$? Please use the automaton A_f constructed in the previous step. If the answer is no, give a word in $traces(L_3) \setminus traces(L)$. (1p)

Note! More assignments on the other side of the paper.

The name of the course, the course code, the date, your name, your student id, and your signature must appear on every sheet of your answers.

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Assignment 3 (a) Give two LTSs L_a and L'_a such that $L'_a \leq_{sim} L_a$ holds but $traces(L_a) = traces(L'_a)$ does not hold. (1p)

(b) Is the following claim true: If L_b and L'_b are bisimilar, then $L_b \leq tr\ L'_b$ and $L'_b \leq tr\ L_b$. (1p)

(c) Define formally the notion from LTS theory: Livelock. (1p)

(d) Let L be a parallel composition of LTSs $L = L_1 || L_2 || \cdots || L_n$ with n global transitions enabled in the initial state that are all pairwise independent, and in which each transition becomes disabled after its firing. How many states does the reachability graph of L at least have? How many edges does the reachability graph of L at least have? (In both cases give as tight a lower bound as possible as a function of the parameter n.) (1p)

(e) Define formally the notion from LTS theory: Simulation preorder. (1p)

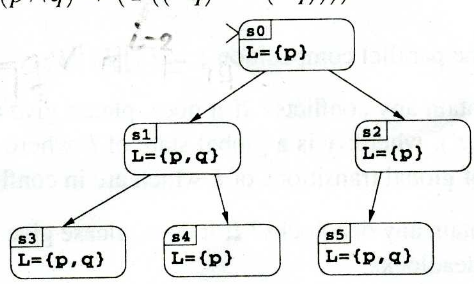
Assignment 4 Consider the Kripke structure M below. For each of the formulas below check whether the formula holds in M or not. If the formula holds, give a short explanation (max 5 lines of text) why the formula holds. If the formula does not hold, give a counterexample path through the Kripke structure. (A simple yes/no answer is **not** sufficient to obtain full points in this assignment.)

(a) Does $M \models \mathbf{G}\, p$ hold? (1p)

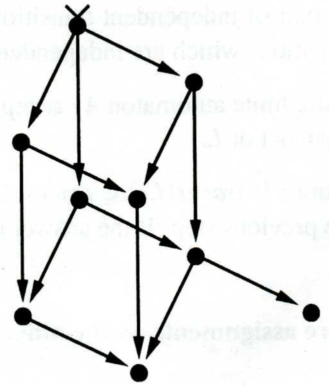
(b) Does $M \models \mathbf{G}\,(\mathbf{Y}\, p)$ hold? (1p)

(c) Does $M \models \mathbf{G}\,(q \Rightarrow (\mathbf{Y}\, \neg q))$ hold? (1p)

(d) Does $M \models \mathbf{G}\,((p \wedge q) \Rightarrow (\mathbf{Y}\,((\neg q) \vee \mathbf{Y}\,(\neg q))))$ hold? (1p)



Assignment 5 Create a P/T-net N with at most 4 transitions, whose reachability graph matches the reachability graph G below (all labellings removed). (2p)



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