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T-79.4302 Parallel and Distributed Systems
Examination, 4 September 2013

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 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 formulas below, check whether it holds in M. If the formula holds, give a brief explanation (max 5 lines of text) why it is true. If the formula does not hold, give a counterexample execution of M and explain why it violates the formula.

(a) $\mathbf{G}\,(heat \Rightarrow \neg open)$ (2p)

(b) $\mathbf{G}\,(open \Rightarrow \mathbf{Y}\,\mathbf{H}\,\neg open)$ (2p)

(c) $\mathbf{G}\,(error \Rightarrow ((\neg open)\,\mathbf{S}\,start))$ (2p)

(d) $\mathbf{G}\,(start \Rightarrow \mathbf{X}\,(heat\,\mathbf{U}\,open))$ (2p)

(e) $(\mathbf{G}\,\mathbf{F}\,start) \Rightarrow (\mathbf{G}\,\mathbf{F}\,heat)$ (2p)

(f) $\mathbf{F}\,\mathbf{G}\,(heat \vee open \vee start)$ (2p)

Assignment 2. Give the formalisation of the following properties as temporal formulae. Use the atomic propositions cs_0 (“process 0 is in the critical section”), cs_1 (“process 1 is in the critical section”), ts_0 (“process 0 is in the trying section”), ts_1 (“process 1 is in the trying section”).

(a) Processes 0 and 1 are never in the critical section at the same time. (1.5p)

(b) If process $i \in \{0, 1\}$ is in the trying section, then it will eventually enter the critical section. (2p)

(c) If process $i \in \{0, 1\}$ is in the trying section infinitely often, then it is in the critical section infinitely often, too. (2p)

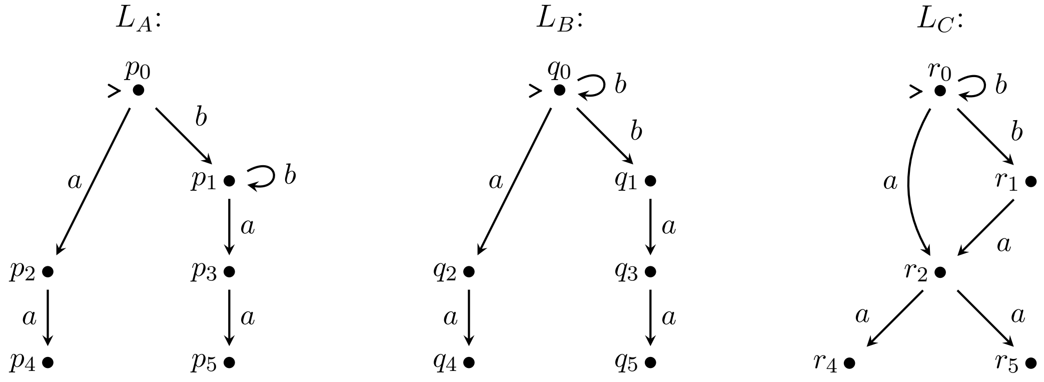
(d) Both processes 0 and 1 finally enter the critical section. (2p)

(e) Process $i \in \{0, 1\}$ can stay in the trying section infinitely long time only if it is in the critical section infinitely often. (2p)

(f) Classify the properties (a)–(e) into safety, liveness and fairness properties. (2.5p)

More assignments on the second page

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



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

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

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

(d) Are L_A and L_C trace equivalent? 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 $\Sigma^* \setminus \mathit{traces}(L_C)$. (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 behaviour 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 $\mathit{Phil}_1 \parallel \mathit{Phil}_2 \parallel \mathit{Knife} \parallel \mathit{Fork}$ is deadlock-free and in every infinite trace, both the 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.