Universität Stuttgart | Winter term 2008/09

Networks and Processes

– Written Exam –

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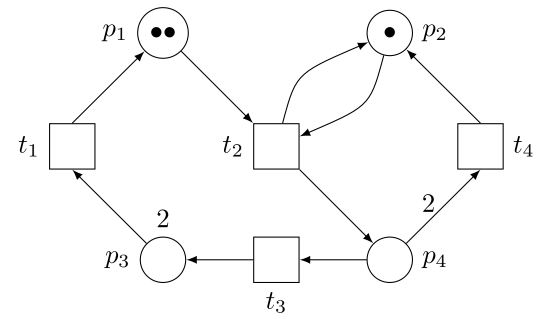
1. Consider the following P/T net N with capacities:



(a) Construct a P/T net N' without capacities that is equivalent to N. Use the construction given in the lectures. (2p)

(b) Give the largest set of concurrently enabled transitions of N' in the marking M, where M is obtained by firing t_2 in the initial marking. (2p)

(c) Draw the reachability graph of N'. (3p)

(d) Is N' deadlock-free? If not, indicate the marking(s) in which a deadlock occurs. (1p)

(e) Identify two independent transitions in N'. (1p)

(f) Give the incidence matrix C of N'. (1p)

(g) Find all proper minimal P-invariants by applying Farkas' algorithm to the incidence matrix C. (3p)

(h) Identify a nonempty trap in N' not including p_3. (1p)

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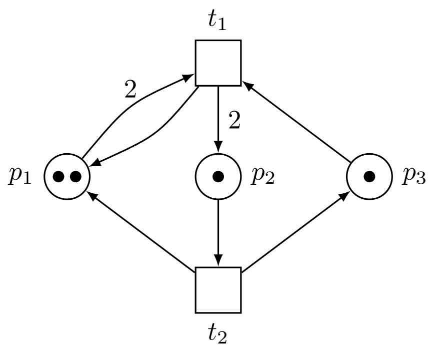
2. Consider the following P/T net:



(a) Construct a coverability graph of the net using the method discussed in the lectures. (3p)

(b) Can one conclude from a coverability graph in general that a given network is deadlock-free? Justify your answer. (2p)

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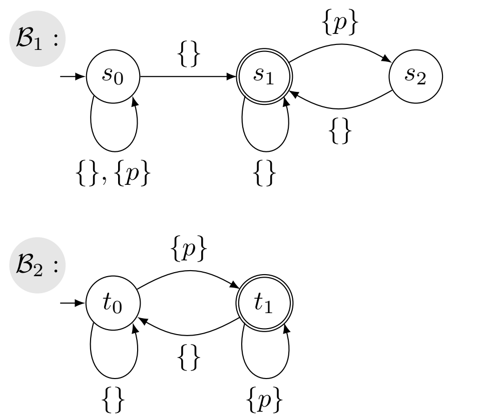
3. Büchi automata



(a) Consider the Büchi automata $\mathcal{B}_1$ and $\mathcal{B}_2$ over the alphabet $\Sigma = \{\{\}, \{p\}\}$ as shown on the left. Construct an automaton $\mathcal{B}$ that accepts the intersection of $\mathcal{L}(\mathcal{B}_1)$ and $\mathcal{L}(\mathcal{B}_2)$. Use the method shown in the lectures.
(Hint: Consider the reachable states of $\mathcal{B}$, only.) (3p)

(b) Construct in an ad hoc manner a Büchi automaton that is equivalent to $\mathcal{B}$ but has a smaller number of states. (3p)

(c) Give two LTL formulas ϕ and ψ over $AP = \{p\}$ such that we have $\mathcal{L}(\phi) = \mathcal{L}(\mathcal{B}_1)$ and $\mathcal{L}(\psi) = \mathcal{L}(\mathcal{B}_2)$. (4p)

Please turn ↻

4. LTL

Consider $\phi = \mathbf{F}\,(p \to q)$.

(a) Give $Sub(\phi)$. List all elements. (2p)

(b) Give $CS(\phi)$. You may leave out negated formulas. (2p)

(c) Construct a Büchi automaton $\mathcal{B}$ over the alphabet $\Sigma = 2^{\{p,q\}}$ such that $\mathcal{L}(\mathcal{B}) = \mathcal{L}(\phi)$. You may use the construction presented in the lectures or give $\mathcal{B}$ in an ad hoc manner. (2p)

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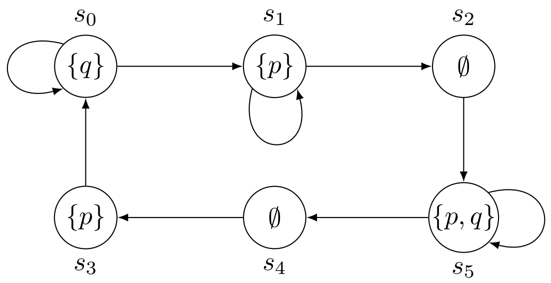
5. CTL



(a) Consider the Kripke structure on the left, determine the set of states in which the following CTL formulas hold: (3p)

i. $\phi_1 = \mathbf{AF}\,(p \to \mathbf{EX}\,q)$

ii. $\phi_2 = p\ \mathbf{EU}\ (\mathbf{AX}\,q)$

iii. $\phi_3 = \mathbf{EX}\,\mathbf{AG}\,p \to (\mathbf{EX}\,q)$

(b) Give a Kripke structure that satisfies $\mathbf{AG}\,\mathbf{EX}\,p \land \neg\mathbf{AF}\,p$. (2p)
