Concurrency Theory (WS 2011/12) Out: Thu, Feb 2 Due: N/A

Review Exercise Sheet

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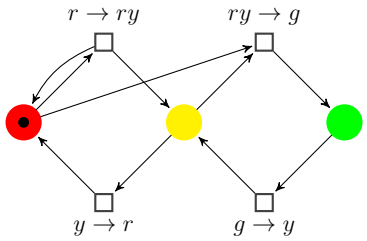
1. Consider the following Petri net modelling a traffic light:



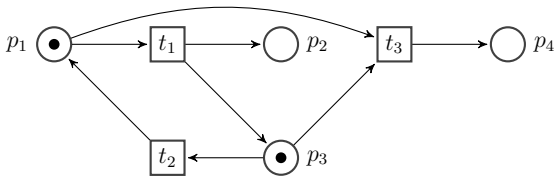
(a) Fix the net in order to avoid unwanted behavior (e.g. $r \to ry \to rr$). Make it 1-safe.

(b) Model two traffic lights handling a road crossing by using two such 1-safe Petri nets.

2. Petri nets are WSTS.

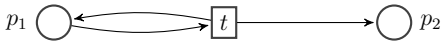
(a) Define a domain of limits L for Petri nets. Prove L's adequacy and its effectiveness.

(b) Compute $Over(N, \Gamma_1, L)$ and $Over(N, \Gamma_2, L)$ for the following Petri net N when $\Gamma_1 = \{M \in \mathbb{N}^S \mid M(s) \leq 1\}$ and $\Gamma_2 = \{M \in \mathbb{N}^S \mid M(s) \leq 2\}$.



3. Let $u, v \in T$ such that $v^\bullet \cap {}^\bullet u = \emptyset$. Prove that $M[v.u\rangle M'$ implies $M[u.v\rangle M'$.

4. Prove (**without computation**) that there is no covering structural invariant for the net



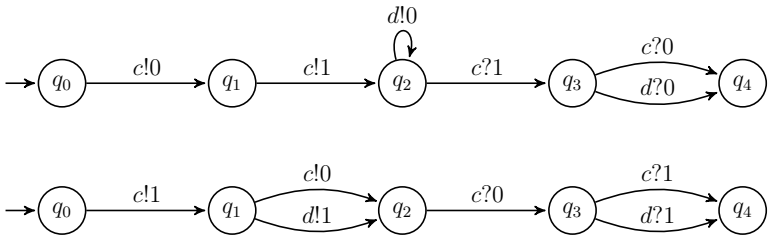
5. Give a recursive procedure that takes an SRE product p and returns a product p' that has the same language but no redundant atomic expressions.

6. Petri nets with transfer arcs (PNTs) have for each transition t at most one pair of places $p \in {}^\bullet t$, $p' \in t^\bullet$ with the property that when t is fired, all (including 0) tokens from p are moved to p'.

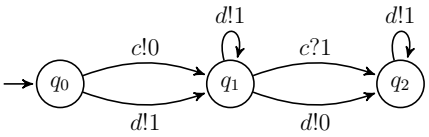
Prove PNT reachability undecidable. *Hint: Use the trick from the last lecture.*

7. Let $P \in \mathcal{P}_{fg<\infty}$ be an arbitrary structurally stationary process. It is known that the size of its structural semantics $N(P)$ cannot be bounded by a primitive recursive function in the size of the process P. Give and explain a construction that shows this.

8. Use Abdulla's backward search to determine if (q_4, ϵ) is coverable in either lcs below:



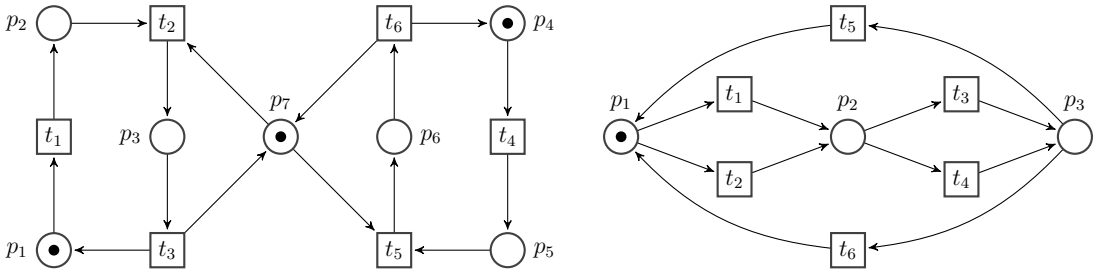
9. Consider the lossy channel system LCS:



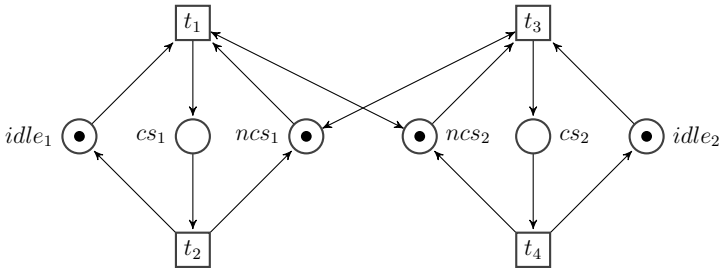
with $\Gamma = \{(q_0, \varepsilon), (q_1, \varepsilon), (q_2, \varepsilon)\}$ and $L = \{\top, (q_1, \begin{pmatrix}(0+1)^* \\ 1^*\end{pmatrix}), (q_2, \begin{pmatrix}(0+1)^* \\ 1^*.(0+\varepsilon)\end{pmatrix})\}$.

Compute $Over(LCS, \Gamma, L)$ and define Γ' so that $(q_2, \begin{pmatrix}\varepsilon \\ 1\end{pmatrix})$ is coverable in $Under(LCS, \Gamma')$.

10. Unfold the nets below using ERV and McMillan's adequate order. Give the possible extensions and cut-offs (and argument why each of them is a cut-off) at each iteration.



11. Compute the S-invariants for the following Petri net. Prove mutual exclusion for cs_1, cs_2.



12. Consider ($\preceq^*$) upward-closed languages $\mathcal{L}_1, \mathcal{L}_2 \subseteq \Sigma^*$. Prove that $\mathcal{L}_1.\mathcal{L}_2$ is upward-closed and that $\overline{\mathcal{L}_1}$ is downward-closed.

13. Prove decidability of termination and reachability for restriction-free π-calculus.

14. Use the Karp and Miller algorithm to compute the coverability graph of the Petri nets: