Homework for lecture
Automata and Formal Languages II

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SS 2015 | Homework Sheet 12 | 1.7.2014

Submission: July 8

Aufgabe 12.1. [**Independent Steps**] (10 points)
Prove the indep-steps lemma from the lecture (Slide 126)

$$\langle pw\rangle([c]) \xrightarrow{s}{}^{*} \langle p'w'\rangle(l') \iff$$
$$\exists c'\ l''\ s_1\ s_2.\ l' = c'l'' \wedge s \in s_1 \otimes s_2 \wedge \langle pw\rangle(\varepsilon) \xrightarrow{s_1}{}^{*} \langle p'w'\rangle(l'') \wedge c \xrightarrow{s_2}{}^{*} c'$$

Aufgabe 12.2. [**Execution Trees for Data Races**] (10 points)
Let P be a set of states, Γ be a stack alphabet. Moreover let Act $:= \{R, W, \tau\}$ be a set of actions. Construct a tree automaton that describes all execution trees that have a data-race, i.e., that may simultaneously execute an R and W, or two W actions.

Aufgabe 12.3. [Join] (20 bonus points)
Submission of this question on July 15

Bonus points count on your side, but not on the maximum reachable points.

Lets extend the DPN-model by joins. We add an additional state $p_\perp$, which indicates that a thread has terminated. We assume that there are no transitions from $p_\perp$. Moreover, we add an action $join \in \text{Act}$. A transition $p\gamma \overset{join}{\hookrightarrow} p'\gamma'$ can only be executed if all (direct) children of the thread have terminated.

1. Translate the following program to a DPN

```
p():
  spawn main;
  spawn main;
  join;
  write R;
  if (...) p();
  return;

main():
  p()
  terminate;
```

2. Does the program have a data-race on `write R`? Why (not)?
3. Extend the semantics of DPNs to include joins, i.e., specify the step-relation.
4. Can we decide reachability of a configuration in DPNs with joins? (Hint: Try to find a regular constraint that characterizes execution trees that actually have a join-sensitive execution)
5. Now let's include nested locks. Show that deciding reachability (already of a single program point) is PSPACE-hard. (Hint: Try to extend the NP-hardness result for DPNs from 3SAT to QBF)