Concurrency Theory (WS 2011/12) Out: Wed, Oct 19 Due: Wed, Oct 26

Exercise Sheet 1

Jun.-Prof. Roland Meyer, Georgel Călin Technische Universität Kaiserslautern

Problem 1: Shared Memory Concurrency

(a) Let **load**, **store** and **inc** be atomic operations for loading a variable's value into cache, storing a variable's cache value into memory and incrementing a variable's cache value.
If x is initially 0, argument why there are executions ending with $x = 2011$ of the program

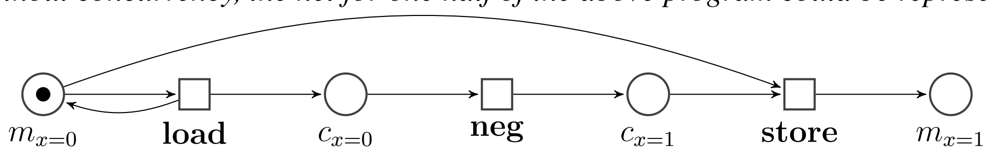
for $i = 1 \ldots 2011$ **do**	‖	**for** $i = 1 \ldots 2011$ **do**
load x	‖	**load** x
inc x	‖	**inc** x
store x	‖	**store** x
end for	‖	**end for**

Misleading Hint: Each of the two above programs is basically incrementing x 2011 times.

(b) Let **neg** be another atomic operation for negating a **Boolean** variable's cache value.
If x is initially 0, give a Petri net representation of the following program and specify transition sequences which describe why the program may terminate with $x = 0$ or $x = 1$ in memory.

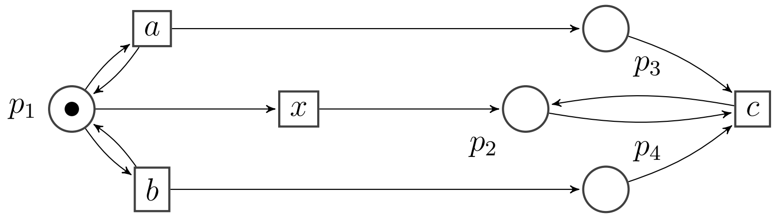
load x	‖	**load** x
neg x	‖	**neg** x
store x	‖	**store** x

Hint: Without concurrency, the net for one half of the above program could be represented by



Problem 2: A Petri Net Language

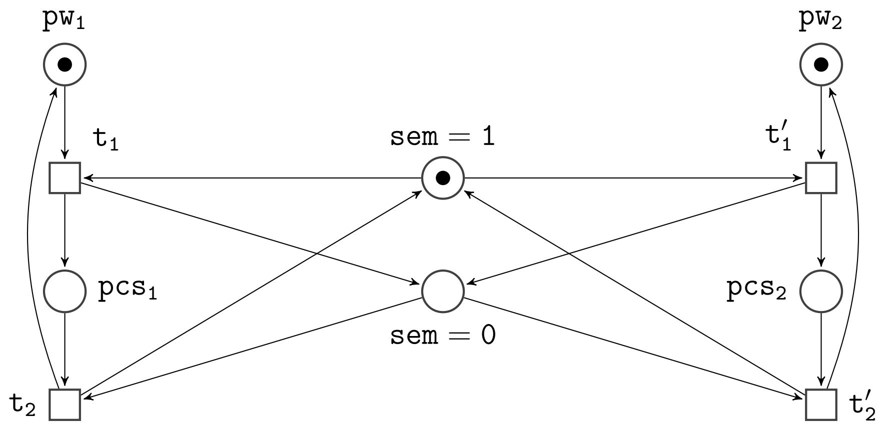
For the Petri net below, give the set of all transition sequences that end in deadlock.



Which are the deadlock markings for each of the sequences you found?

Problem 3: Invariants for Mutual Exclusion

Recall the mutual exclusion protocol given in class:



As seen in class $(0\ 1\ 0\ 1\ 2\ 1)^T$ is an invariant used to prove no marking M with

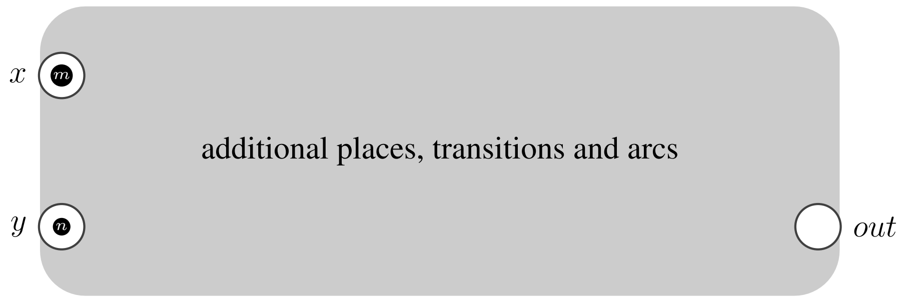
$$M(\texttt{pcs}_1) = M(\texttt{pcs}_2) = M(\texttt{sem} = 0) = 1$$

is reachable.

Which invariants can be used to prove no marking M with just $M(\texttt{pcs}_1) = M(\texttt{pcs}_2) = 1$ is reachable? Give a general description and prove mutual exclusion for such a concrete invariant.

Problem 4: "Multiplication" as a Petri Net

Consider the Petri net which contains places x, y and out as in the picture below.



Add places (and corresponding tokens), transitions and arcs to the net such that for arbitrary $m, n \in \mathbb{N}$, if $M_0(x) = m$, $M_0(y) = n$ and $M_0(out) = 0$ the net always reaches a deadlock and, if M_{ter} is the deadlock marking, $M_{ter}(out)$ is **any** of $\{0, \ldots, m \cdot n\}$.

Argument the corectness of your construction.