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| **Concurrency Theory** (WS 2010/11) | Out: Wed, Feb 2 Due: Mon, Feb 7 |

# Exercise Sheet 13

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## Problem 1: Structural Congruence of Restricted Form

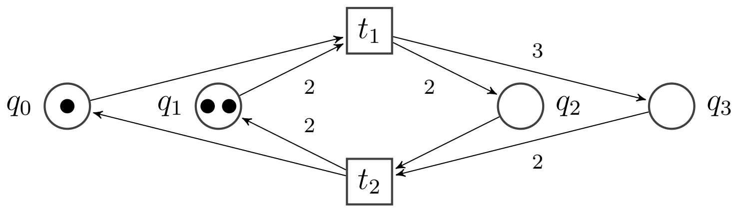
Affirm the following results on the restricted form of $\pi$-calculus processes:

(a) Let $P \in \mathcal{P}$ be a process and $\mathtt{rf}(P) \in \mathcal{P}_{\mathtt{rf}}$ its restricted form. Prove that $P \equiv \mathtt{rf}(P)$.

(b) Let $P, Q \in \mathcal{P}$. Prove that $\mathtt{rf}(P) \equiv_{\mathtt{rf}} \mathtt{rf}(Q)$ if and only if $dec(\mathtt{rf}(P)) = dec(\mathtt{rf}(Q))$.

## Problem 2: Petri Nets as $\pi$-Calculus Processes

Translate the following Petri net into $\pi$-Calculus:




## Problem 3: Structural Semantics of $\pi$-Calculus Processes

(a) Consider the following $\pi$-calculus process:

$$
\begin{aligned}
P = {} & a(x).x(y) + a(x).\overline{x}\langle a\rangle + \overline{a}\langle b\rangle \\
& \mid a(x).x(y) + a(x).\overline{x}\langle a\rangle + \overline{a}\langle b\rangle \\
& \mid a(x).x(y) + a(x).\overline{x}\langle a\rangle + \overline{a}\langle b\rangle \\
& \mid b(x).\overline{a}\langle x\rangle + \overline{a}\langle a\rangle.\nu n.a(n).(\overline{a}\langle n\rangle|\overline{n}\langle a\rangle) \\
& \mid b(x).\overline{a}\langle x\rangle + \overline{a}\langle a\rangle.\nu n.a(n).(\overline{a}\langle n\rangle|\overline{n}\langle a\rangle)
\end{aligned}
$$

Apply the method presented in class to determine the net $\mathcal{N}[\![P]\!]$ for the given process.

(b) A $\pi$-calculus process is said to be *closed* if it has only bound names. Such processes yield a special class of Petri nets under the given structural semantics. What is special about these nets?

## Problem 4: Interpretation of Polyadic $\pi$-Calculus

*Polyadic* $\pi$-calculus is a generalization of $\pi$-calculus which allows using tuples as inputs/outputs:

- ◦ $c(x_1, \ldots, x_n)$ denotes binding the input $n$-tuple on $c$ pointwise to $(x_1, \ldots, x_n)$
- • $\overline{c}\langle a_1, \ldots, a_n\rangle$ denotes sending the tuple $(a_1, \ldots, a_n)$ on channel $c$.

A naive way of understanding the above is by:

$$c(x_1, \ldots, x_n) := c(x_1).c(x_2)\ldots c(x_n) \text{ and } \overline{c}\langle a_1, \ldots, a_n\rangle := \overline{c}\langle a_1\rangle.\overline{c}\langle a_2\rangle \ldots \overline{c}\langle a_n\rangle.$$

Why is this interpretation not satisfying ∘ and •? Enhance the naive encoding to make it correct. This shows that polyadic $\pi$-calculus can be encoded into standard (called *monadic*) $\pi$-calculus.

*Hint: think of* $\overline{c}\langle a, b\rangle | c(x, y) | c(x', y')$. *Restricted names are helpful.*