# MPRI Concurrency (course number 2-3) 2004-2005: $\pi$-calculus Exercises

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http://pauillac.inria.fr/~leifer/teaching/mpri-concurrency-2004/

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1. Consider the term $!(x(w).\overline{z}w) \mid \overline{x}x \mid x(y).\boldsymbol{\nu}v.\overline{y}v$. You may assume that all bound names are distinct from each other and from all free names.

   (a) Show all possible labelled transitions of this process.

   (b) Show the derivation trees for these.

2. Demonstrate the necessity of the side condition $\mathsf{bn}(()\alpha) \cap \mathsf{fn}(()Q) = \varnothing$ in the rule (lab-par-l). To do so, suppose this side condition were deleted. Now find a process $P$ such that $P \xrightarrow{\tau}\xrightarrow{\tau}$ and for which after alpha converting it to $P'$, it is not the case that $P' \xrightarrow{\tau}\xrightarrow{\tau}$.

3. The coding I gave in the slides of synchronous $\pi$-calculus in terms of asynchronous $\pi$-calculus is unsatisfactory (despite my claim otherwise). The problem is that the translation uses asynchronous *polyadic* $\pi$-calculus (e.g. $\overline{x}\langle y, z\rangle$), not asynchonous monadic $\pi$-calculus, which was the original goal.

   (a) Show that the original goal can be achieved by defining a translation $[\![-]\!]$ from synchronous monadic $\pi$-calculus directly to asynchronous monadic $\pi$-calculus.

   (b) Show the reduction steps of $[\![\overline{x}y.P \mid x(u).Q]\!]$.

4. Consider the definition of strong bisimilarity given in the slides:

   > A relation $\mathcal{R}$ is a strong bisimulation if for all $(P, Q) \in \mathcal{R}$ and $P \xrightarrow{\alpha} P'$, where $\mathsf{bn}(()\alpha) \cap \mathsf{fn}(()Q) = \varnothing$, there exists $Q'$ such that $Q \xrightarrow{\alpha} Q'$ and $(P', Q') \in \mathcal{R}$, and symmetrically.
   >
   > Strong bisimilarity $\sim_\ell$ is the largest strong bisimulation.

   Let $\sim_\ell{}'$ be exactly the same except we omit the side condition $\mathsf{bn}(()\alpha) \cap \mathsf{fn}(()Q) = \varnothing$.

   (a) Is one included in the other, i.e. $(\sim_\ell) \subseteq (\sim_\ell{}')$ or $(\sim_\ell{}') \subseteq (\sim_\ell)$?

   (b) Are they equal? If not, find a pair of processes $(P, Q)$ that distinguish the relations, i.e. $P \sim_\ell Q$ but not $P \sim_\ell{}' Q$ or vice versa.