Cyber-Physical Programming
TPC-1

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Exercise 1. Consider the CCS process $c.(a.\mathtt{0} \parallel b.\mathtt{0})$.

Part 1.1. Informally describe what it does.

Part 1.2. Write its transition system using the semantics provided in the lectures.

Exercise 2. Consider the CCS processes $\mathtt{rec}\ X.\ (a.X + a.a.X)$ and $\mathtt{rec}\ X.\ a.X$.

Part 2.1. Informally describe what they do.

Part 2.2. Prove that $\mathtt{rec}\ X.\ (a.X + a.a.X) \sim \mathtt{rec}\ X.\ a.X$.

Exercise 3 (Hard)**.** Prove that for all CCS processes P and Q we have $P \parallel Q \sim Q \parallel P$.

Exercise 4. Consider the following scenario. There exist four processes $P_1, \ldots, P_4$, each of them responsible for performing a certain task repetitively. For example P_1 might read the current velocity, P_2 the current altitude, P_3 current radiation levels, etc ... These processes (re)start their tasks in increasing order (P_1 then P_2 etc ...) but can finish in any order. Additionally process P_1 can only restart its task when all processes $P_1, \ldots, P_4$ finish their current tasks. Let us then consider process $P = (I \parallel S \parallel P_1 \parallel \cdots \parallel P_4) \backslash \{st_1, \ldots, st_4, end\}$ where:

$$
\begin{aligned}
I &= \overline{st_1} \ldots \overline{st_4}.\mathtt{0} \\
S &= \mathtt{rec}\ X.\ end.end.end.end.\overline{st_1} \ldots \overline{st_4}.X \\
P_i &= \mathtt{rec}\ Y_i.\ st_i.a_i.b_i.\overline{end}.Y_i \qquad\qquad (1 \leq i \leq 4)
\end{aligned}
$$

Part 4.1. Explain why process P corresponds (or not) to the description above.

Part 4.2. Note that process S acts a *central scheduler* which coordinates the processes $P_1, \ldots, P_4$. Rewrite P so that it does not rely on a central scheduler and explain the reasoning behind your refactoring.

Part 4.3 (Hard). Use the tool mCRL2 to computationally validate your reasoning process.

What to submit: A report in `PDF` containing the solutions to the exercises. Please send it by email (`nevrenato@di.uminho.pt`) with the name "`cpp2122-N.pdf`", where "`N`" is your student number. The subject of the email should be "`cpp2122 N TPC-1`".