Topics in Concurrency

(a) Draw the transition systems of the following two pure CCS terms:

\[ P_1 \overset{\text{def}}{=} (a.(b + c) \parallel \bar{b}) \setminus \{b\} \quad P_2 \overset{\text{def}}{=} a.(c + \tau) \]

[3 marks]

(b) Write down pure CCS terms for the following two transition systems:

\[ P_3 : \quad P_4 : \]

[3 marks]

(c) Carefully justify your answers to the following two questions either by exhibiting a bisimulation or by providing a Hennessy–Milner logic formula satisfied by one process and not by the other:

(i) Are \( P_1 \) and \( P_2 \) bisimilar? [3 marks]

(ii) Are \( P_3 \) and \( P_4 \) bisimilar? [3 marks]

(d) A trace of a process \( p_0 \) is a finite sequence of action labels

\[ \pi = (\lambda_1, \ldots, \lambda_k) \]

for which, if \( \pi \) is nonempty, there exist \( p_1, \ldots, p_k \) such that \( p_{i-1} \xrightarrow{\lambda_i} p_i \) for all \( 0 < i \leq k \). Two processes \( p \) and \( p' \) are said to be trace-equivalent if, for all sequences of action labels \( \pi \),

\[ \pi \text{ is a trace of } p \text{ if, and only if, } \pi \text{ is a trace of } p' \]

(i) Are trace-equivalent processes always bisimilar?

(ii) Are bisimilar processes always trace-equivalent?

In each case, provide either a proof or a counterexample. [8 marks]