1999 Paper 7 Question 13

Communicating Automata and Pi Calculus

Concurrent processes are defined by the syntax

$$P \quad ::= \quad A\langle b_1, \ldots, b_n \rangle \;\Big|\; \Sigma \alpha_i . P_i \;\Big|\; P_1 \mid P_2 \;\Big|\; \mathsf{new}\, a\, P$$

where each process identifier A is equipped with a defining equation $A(a_1, \ldots, a_n) \stackrel{\text{def}}{=} P_A$. Give the transition rules from which transitions of the form $P \stackrel{\alpha}{\to} P'$ can be inferred, where α is of the form a, $\overline{a}$ or τ. The rules should not use structural congruence ($\equiv$). [5 marks]

Enumerate the ways in which a transition of the form $P|Q \stackrel{\alpha}{\to} R$ can be inferred from transitions of P and/or Q, and indicate the form of R in each case. [5 marks]

Hence show that if $P|Q \stackrel{\alpha}{\to} R_1$, then there exists R_2 such that $Q|P \stackrel{\alpha}{\to} R_2$ and $R_1 \equiv R_2$. [5 marks]

Give an example of P and Q for which $\mathsf{new}\, a(P|Q)$ has a τ-transition but $P|\mathsf{new}\, a\, Q$ has no τ-transition. Now suppose that $\mathsf{new}\, a(P|Q) \stackrel{\alpha}{\to} R_1$; what syntactic condition on P ensures that $P|\mathsf{new}\, a\, Q \stackrel{\alpha}{\to} R_2$ for some R_2 with $R_1 \equiv R_2$? Justify your answer. [5 marks]