1994 Paper 7 Question 14

Concurrency

Define what is meant by *observational equivalence* of CCS agents. [5 marks]

A transmitter T, transmission medium M, and receiver R are modelled by CCS agents with the following definitions:

$$
\begin{aligned}
T &\stackrel{\text{def}}{=} in.\overline{i}.T' \\
T' &\stackrel{\text{def}}{=} r.\overline{i}.T' + a.T \\
M &\stackrel{\text{def}}{=} i.M' \\
M' &\stackrel{\text{def}}{=} \overline{o}.M + \tau.\overline{r}.M \\
R &\stackrel{\text{def}}{=} o.\overline{out}.\overline{a}.R
\end{aligned}
$$

M is an unreliable medium: having received an input message from T (action i) it either outputs the message to R (action $\overline{o}$), or loses it (represented by the τ action) and then sends a request for retransmission (action $\overline{r}$). If R does receive the message, after broadcasting it (action $\overline{out}$) it sends an acknowledgement directly to T (action $\overline{a}$).

Calculate the transition graph of $(T|M|R) \setminus \{i, o, r, a\}$ and hence show that this agent is observationally equivalent to a simple buffer B with definition

$$B \stackrel{\text{def}}{=} in.\overline{out}.B$$ [10 marks]

Are $(T|M|R) \setminus \{i, o, r, a\}$ and B observationally congruent? [3 marks]

Do the two agents have the same behaviour with respect to *divergence*, that is, the ability to perform a series of actions ending in an infinite sequence of τ-actions? [2 marks]