Topics in Concurrency

(a) You are reminded that the logic CTL has assertions of the form
\[ \text{EX } A, \text{ EG } A, \text{ E}[A_0 \text{ U } A_1]. \]

Explain their semantics in terms of paths. Describe their translation into the modal $\mu$-calculus with a single action label. [6 marks]

(b) Give a finite assertion $A$ in Hennessy–Milner logic with the following property
\[ p \models A \text{ iff } p \text{ is strongly bisimilar to the CCS process } a.nil, \]
for any CCS process $p$ with actions restricted to being within the set \{a, b\}. [7 marks]

(c) A simulation between CCS terms is a binary relation $S$ between CCS terms such that whenever $(t, u) \in S$, for all actions $a$ and terms $t'$
\[ t \xrightarrow{a} t' \Rightarrow \exists u'. u \xrightarrow{a} u' \land (t', u') \in S. \]

Define $t \leq u$ iff there is a simulation $S$ with $(t, u) \in S$.
Exhibit two CCS terms $t$ and $u$ for which $t \leq u$ and $u \leq t$ and yet where $t$ and $u$ are not strongly bisimilar. Briefly justify your answer. [7 marks]