Advanced Systems Topics

A computer system provides a compare-and-swap operation (CAS) which can be used in the following manner:

\[ \text{seen} = \text{CAS} (\text{address}, \text{old}, \text{new}) \]

It loads the contents of \text{address}, compares that value against \text{old} and if it matches stores the value \text{new} at the same address. All of this is performed atomically and the value loaded from the address is returned as \text{seen}.

(a) Write pseudo-code for a simple spin-lock using CAS. [4 marks]

(b) Why could this perform poorly on a large multi-processor system? [2 marks]

Consider a singly-linked list of \text{QNode} objects, each with a boolean field \text{value} and a reference \text{next} to its successor (holding \text{null} at the tail of the queue). A shared location \text{l} refers to the tail node (or is \text{null} if the queue is empty).

(c) Define the following concurrent operations using CAS:

\[
\begin{align*}
&\text{// Append a new node } q \text{ to the tail of the list, returning} \\
&\text{// the previous tail} \\
&\text{QNode pushTail} (\text{QNode } q); \\
\end{align*}
\]

\[
\begin{align*}
&\text{// Remove } q, \text{ which must have been at the head of the list,} \\
&\text{// returning the new head} \\
&\text{QNode popHead} (\text{QNode } q); \\
\end{align*}
\]

[Hint: note that \text{popHead} only needs to update memory when the queue becomes empty.] [8 marks]

(d) Define a \textit{queue-based spin lock} based on these operations. [6 marks]