Advanced Systems Topics

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

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

It loads the contents of \text{address}, compares the 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 read from the address is returned as \text{seen}.

(a) What does it mean for a processor instruction to be \textit{atomic}?

(b) Write pseudocode for a simple spin lock using CAS.

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

(c) Define the following concurrent operations using CAS:

\begin{verbatim}
// Append a new node \texttt{q} to the tail of the list, returning
// the previous tail
QNode pushTail (QNode q);

// Remove \texttt{q}, the current head of the list, returning
// the new head
QNode popHead (QNode q);
\end{verbatim}

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