Concept Quiz 2 Solution

Problem 1 (Software Mutual Exclusion)

Consider the following software approach to mutual exclusion between \( N \) processes numbered 0, 1, ..., and \( N-1 \). \texttt{num}[\texttt{N}] and \texttt{testing}[\texttt{N}] are shared global arrays (integer and boolean respectively). The initial value of all shared global variable elements is 0.

```plaintext
Process i:
1     testing[i] = TRUE;
2     num[i] = 1 + Max(num);  // Max() returns maximum of all num[]
3     testing[i] = FALSE;
4     for j=0 to N-1 {
5         while (testing[j]) { ... spin ... }
6         while ((num[j] != 0) and ((num[j], j) < (num[i], i))) {...spin...}
7     }  // NOTE: (a,b) < (x,y) if (a<x) OR ((a==x) AND (b<y))
8     ... critical section ...
9     num[i] = 0;
```

a) If there are \( N = 4 \) processes that each execute on their own processor and each processor runs at the same speed, in what order will the processes enter the critical section. Explain.

**Solution:** The order is 0, 1, 2, 3.

Since they execute in unison and \texttt{num}[\texttt{i}] is initially 0, every process will have \texttt{num}[\texttt{i}] = 1 when it gets to line 6. Line 6 will choose the one with the smallest process id, first process 0, then 1, then 2, and finally 3.

b) What is the purpose of line 5?

**Solution:** Line 5 ensures that every process that is trying to get a number has a number.

Suppose that the processes execute Line 1 in the order 0, 1, 2, 3 and get the numbers 1, 2, 3, and 4 but only process 3 has updated its \texttt{num[]} value and proceeded forward in the algorithm; i.e., \texttt{num}[0] = \texttt{num}[1] = \texttt{num}[2] = 0 and \texttt{num}[3] = 1. If Line 5 were not included in the algorithm, Process 3 would get into the critical section even though it is clear that Process 0 is the process that will have the smallest number.

c) What is the purpose of line 6?

**Solution:** If two processes that want to enter the critical section get the same number, the tie is broken by choosing the one with the smallest id first.