

# Parallel Programming and HPC

## Exercise Sheet 4: Synchronization and Memory Consistency

9th June 2010

### 1 Producer-Consumer Problem

A typical problem - especially from the field of operating systems - is the so-called Producer-Consumer Problem or Reader-Writer Problem. Assume there exists a resource (e.g. a shared buffer), which several processes or threads want to use at the same time. As long as all processes only have a read access to that resource, no complications arise. The moment one (or more) process(es) want(s) write access to the resource, it can not be shared any longer. Write access prohibits parallel read access and is restricted to one process only. Read access also prohibits parallel write access but has no restrictions to the overall amount of processes reading from the buffer. For reasons of simplicity, there exist only two processes in our scenario: one reader and one writer.

Find a solution (an algorithm) using locks, semaphores or monitors for the following situation: two threads compete for one resource, a buffer, and have alternate access to this resource. The writer thread tries to fill the buffer with random numbers, while the reader thread reads numbers from the buffer and prints them to the console. Be aware of the fact that the writer thread can not fill the buffer when it is full and that the reader thread cant read from the buffer when its empty.

### 2 Sleeping Barber Problem

Synchronization problems in shared memory environments date back to the early days of operating systems. Due to their long existence, a great variety of standard problems that are used for teaching have been developed. Two of the most famous problems are the Dining Philosophers and the Sleeping Barber. You will deal with the latter one in this exercise.

Assume there is a small barber shop with one barber and a waiting room of capacity  $n$ . If no customer is in his shop, the barber sits down in his chair and falls asleep. When a customer arrives, he has to check if there is enough space left in the waiting room. If the waiting room is full, he immediately leaves the shop. Otherwise he takes a seat and waits until the barber is ready to cut his hair. In case the shop is empty upon his arrival, he has to wake the barber. After the haircut, the customer leaves the shop.

There are two routines, the barber and the customer. Of the barber, only one instance (process) exists, of the customer an arbitrary number. Draw a draft of a system, using the two routines, which realizes the above described barber shop. Outline which problems could appear and how they can be solved using synchronization techniques (semaphores, ...).

### 3 Consistency Models

In figure 1, two sequences of operations in a DSM system are given. It depicts several read- and write-operations (R and W, respectively) on variables  $x$  and  $y$ . Which of the consistency models - strict, sequential and causal - allow for such a memory behavior? Justify your answer.

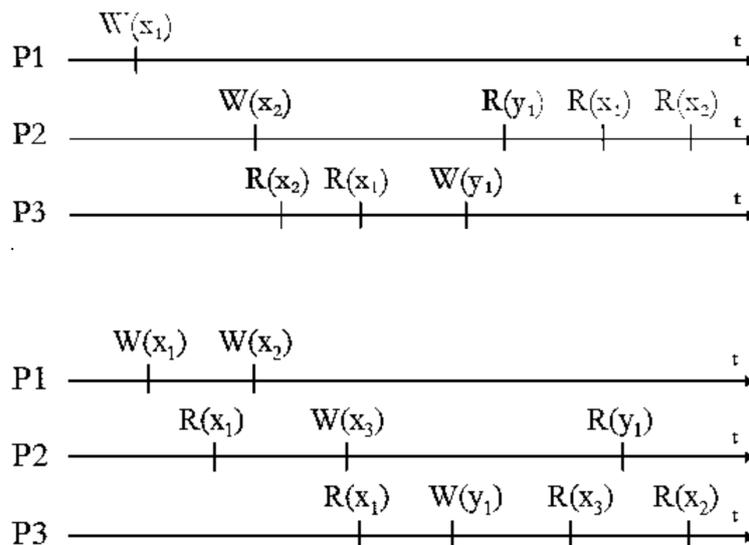


Figure 1: Diagram for operations in a DSM system