SOLUTIONS:
Software Systems

Comprehensive Exam: Software Systems Solutions (60 points)

Oct 20, 1994

1) (16 points) This question asks you to implement a barrier synchronization function using only semaphores and a small number of shared variables. A barrier synchronization function waits until the specified number of processes arrive at the "barrier" before allowing any of the processes to continue. For example assume N processes execute the following code fragment:

```
Func1();
barrier(N);
Func2();
barrier(N);
Func3();
```

The barrier should ensure that no process starts executing `Func2()` before all N of the processes have executed `Func1()`. Similarly, by the time that the first process calls `Func3()` all processes should have returned from `Func2()`. You function should take a single argument, N, the number of processes participating in the barrier. It should also work correctly on the above code fragment and contain no busy waiting.

```
int numwaiters = 0;
Semaphore mutex = 1;
Semaphore waiters = 0;
Semaphore release = 0;

barrier(int N) {
   P(mutex);
   numwatiers += 1;
   if (numwaiters == N) {
      for (int i = 1; i < N; i++) //Last one wakes all
         V(wait);
      for (i = 1; i < N; i++) // Wait for all to exit
         P(release);
      numwaiters = 0;
      V(mutex);
   } else {
      V(mutex);
      P(wait);
      V(release);
   }
}
```

2) (8 points) Some computer systems have been designed recently with a larger physical memory address space than they have virtual address space. In other words they have more fewer bits of virtual address space than physical memory address space. Explain why this is not a totally unreasonable design for a computer system. Be sure to indicate what limits the design imposes.

Having more memory than virtual address space means that a single process can not easily take advantage of the all the physical memory in the system. Multiple processes such as in a multiprogramming workload can take advantage of the extra memory. So can OS data structures such as the file cache.

3) (10 points) As the price of DRAM memory has improved relative to that of magnetic disk space, the ratio of the amount of physical memory to the amount of backing store has been has been getting larger. Some system have as much or more physical memory than backing store (swap space). In response to this, some virtual memory systems have been modified to allocate backing store in a different way. Rather than allocating the backing store when a virtual page is first created, the backing store is allocated only when the page is first paged out.

   a) Describe the benefits of this change.

Besides avoiding the extra work required to do the allocation and deallocation of the swap space, it also allows the amount of virtual memory in-use to be as big as the sum of the

swap space and the physical memory. On some machines this can be much larger than the amount of swap space.

b) Describe the problems introduced by it.

It possible to enter a deadlock condition because there is no space to page out of a page.

4) (8 points) In some computer systems the maximum size of a transfer to or from an I/O device is limited to a relatively small size (e.g. 32 kilobytes) due to historical artifacts. On these systems, would there be any advantages of using a file system with a block size larger than the maximum I/O transfer size?

Large file system block sizes also reduce the size of the metadata for the file. This reduces the amount of disk space needed by the file system metadata and can result in faster access to the file's contents.

5) (8 points) What is the difference between starvation and deadlock?

In both starvation and deadlock the system is not making forward progress. The difference is that in deadlock there is no way it can go forward while in starvation there is a way but it's not happening.

6) (10 points) Frequently when sending data over a network it is beneficial to both encrypt the data for security and compress the data to decrease the transfer time. Which order would you suggest these operations be performed? Be sure to justify your answer.

By compressing the data first we remove redundant information that can make the job of the person trying to break the encryption easier.