Innopolis University, Academic Year 2017/2018
Written Exam of Operating Systems
6th December 2017
Questions and Solutions
Max 20 points + 6 points (30%) extra credit – Total time: 90 minutes

1. (3 points) Is there any reason why you might want to mount a file system on a nonempty directory? If so, what is it??
Mounting a file system makes any files already in the mount-point directory inaccessible, so mount points are normally empty. Howev er, a system administrator might want to copy some of the most important files normally located in the mounted directory to the mount point so they could be found in their normal path in an emergency when the mounted device was being repaired.

2. (3 points) Multiple jobs can run in parallel and finish faster than if they had run sequentially. Suppose that two jobs, each needing 20 minutes of CPU time, start simultaneously. How long will the last one take to complete if they run sequentially? How long if they run in parallel? Assume 50% I/O wait.
If each job has 50% I/O wait, then it will take 40 minutes to complete in the absence of competition. If run sequentially, the second one will finish 80 minutes after the first one starts. With two jobs, the approximate CPU utilization is 1 − 0. 52. Thus, each one gets 0.375 CPU minute per minute of real time. To accumulate 20 minutes of CPU time, a job must run for 20/0.375 minutes, or about 53.33 minutes. Thus running sequentially the jobs finish after 80 minutes, but running in parallel they finish after 53.33 minutes.

3. (3 points) What is the biggest advantage of implementing threads in user space? What is the biggest disadvantage?
The biggest advantage is the efficiency. No traps to the kernel are needed to switch threads. The biggest disadvantage is that if one thread blocks, the entire process blocks..

4. (3 points) A machine has a 32-bit address space and an 8-KB page. The page table is entirely in hardware, with one 32-bit word per entry. When a process starts, the page table is copied to the hardware from memory, at one word every 100 nsec. If each process runs for 100 msec (including the time to load the page table), what fraction of the CPU time is devoted to loading the page tables?.
The page table contains $2^{32}/2^{13}$ entries, which is 524,288. Loading the page table takes 52 msec. If a process gets 100 msec, this consists of 52 msec for loading the page table and 48 msec for running. Thus 52% of the time is spent loading page tables.

5. (3 points) Suppose that a machine has 48-bit virtual addresses and 32-bit physical addresses.
   (a) If pages are 4 KB, how many entries are in the page table if it has only a single level? Explain.
   (b) Suppose this same system has a TLB (Translation Lookaside Buffer) with 32 entries. Furthermore, suppose that a program contains instructions that fit into one page and it sequentially reads long integer elements from an array that spans thousands of pages. How effective will the TLB be for this case?

Under these circumstances:

(a) We need one entry for each page, or 2^{24} = 16 × 1024 × 1024 entries, since there are 36 = 48 − 12 bits in the page number field.

(b) Instruction addresses will hit 100% in the TLB. The data pages will have a 100 hit rate until the program has moved onto the next data page. Since a 4-KB page contains 1,024 long integers, there will be one TLB miss and one extra memory access for every 1,024 data references..

6. (3 points) Suppose that there is a resource deadlock in a system. Give an example to show that the set of processes deadlocked can include processes that are not in the circular chain in the corresponding resource allocation graph.?

Consider three processes, A, B and C and two resources R and S. Suppose A is waiting for I that is held by B, B is waiting for S held by A, and C is waiting for R held by A. All three processes, A, B and C are deadlocked. However, only A and B belong to the circular chain..

7. (30% extra credit)

The banker's algorithm is being run in a system with m resource classes and n processes. In the limit of large m and n , the number of operations that must be performed to check a state for safety is proportional to $m^a n^b$. What are the values of a and b ?

Comparing a row in the matrix to the vector of available resources takes m operations. This step must be repeated on the order of n times to find a process that can finish and be marked as done. Thus, marking a process as done takes on the order of mn steps. Repeating the algorithm for all n processes means that the number of steps is then mn^2. Thus, a = 1 and b = 2.

This is the end of the questions and solutions of the exam.