Innopolis University, Academic Year 2016/2017
Written Exam of Operating Systems – Retake 1
18th January 2017
Questions and Solutions
Max 20 points + 6 points (30%) extra credit – Total time: 90 minutes

1. (3 points) For each of the following system calls, give a condition that causes it to fail: fork, exec, and unlink.
Fork can fail if there are no free slots left in the process table (and possibly if there is no memory or swap space left). Exec can fail if the file name given does not exist or is not a valid executable file. Unlink can fail if the file to be unlinked does not exist or the calling process does not have the authority to unlink it.

2. (3 points) A computer has 4 GB of RAM of which the operating system occupies 512 MB. The processes are all 256 MB (for simplicity) and have the same characteristics. If the goal is 99% CPU utilization, what is the maximum I/O wait that can be tolerated?
There is enough room for 14 processes in memory. If a process has an I/O of p, then the probability that they are all waiting for I/O is p14. By equating this to 0.01, we get the equation p14 = 0.01. Solving this, we get p = 0.72, so we can tolerate processes with up to 72% I/O wait.

3. (3 points) Suppose that we have a message-passing system using mailboxes. When sending to a full mailbox or trying to receive from an empty one, a process does not block. Instead, it gets an error code back. The process responds to the error code by just trying again, over and over, until it succeeds. Does this scheme lead to race conditions? Explain.
It does not lead to race conditions (nothing is ever lost), but it is effectively busy waiting.

4. (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 224 = 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..

5. (3 points) Given a disk-block size of 4 KB and block-pointer address value of 4 bytes, what is the largest file size (in bytes) that can be accessed using 10 direct addresses and one indirect block?
The indirect block can hold 1024 addresses. Added to the 10 direct addresses, there are 1034 addresses in all. Since each one points to a 4-KB disk block, the largest file is 4,235,264 bytes.

6. (3 points) In order to control traffic, a network router, A periodically sends a message to its neighbor, B, telling it to increase or decrease the number of packets that it can handle. At some point in time, Router A is flooded with traffic and sends B a message telling it to cease sending traffic. It does this by specifying that the number of bytes B may send (A's window size) is 0. As traffic surges decrease, A sends a new message, telling B to restart transmission. It does this by increasing the window size from 0 to a positive number. That message is lost. As described, neither side will ever transmit. What type of deadlock is this?
This is clearly a communication deadlock, and can be controlled by having A time out and retransmit its enabling message (the one that increases the window size) after some period of time (a heuristic). It is possible, however, that B has received both the original and the duplicate message. No harm will occur if the update on the window size is given as an absolute value and not as a differential. Sequence numbers on such messages are also effective to detect duplicates..

7. (30% extra credit)
A bitmap terminal contains 1600 by 1200 pixels. To scroll a window, the CPU (or controller) must move all the lines of text upward by copying their bits from one part of the video RAM to another. If a particular window is 80 lines high by 80 characters wide (6400 characters, total), and a character's box is 8 pixels wide by 16 pixels high, how long does it take to scroll the whole window at a copying rate of 50 nsec per byte? If all lines are 80 characters long, what is the equivalent baud rate of the terminal? Putting a character on the screen takes 5 μsec. How many lines per second can be dis- played?
Scrolling the window requires copying 79 lines of 80 characters or 6320 characters. Copying 1 character (16 bytes) takes 800 nsec, so the whole window takes 5.056 msec. Writing 80 characters to the screen takes 400 nsec, so scrolling and displaying a new line take 5.456 msec. This gives about 183.2 lines/sec.

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