Innopolis University, Academic Year 2016/2017
Written Exam of Operating Systems – Retake 2
7th February 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 direc- tory? 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. However, 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 nor- mal path in an emergency when the mounted device was being repaired.

2. (3 points) Consider a real-time system with two voice calls of periodicity 5 msec each with CPU time per call of 1 msec, and one video stream of periodicity 33 ms with CPU time per call of 11 msec. Is this system schedulable?
Each voice call needs 200 samples of 1 msec or 200 msec. Together they use 400 msec of CPU time. The video needs 11 msec 33 1/3 times a second for a total of about 367 msec. The sum is 767 msec per second of real time so the system is schedulable.

3. (3 points) Measurements of a certain system have shown that the average process runs for a time T before blocking on I/O. A process switch requires a time S, which is effectively wasted (overhead). For round-robin scheduling with quantum Q, give a formula for the CPU efficiency for each of the following:

(a) $Q = \infty$
(b) $Q > T$
(c) $S < Q < T$ (d) $Q = S$
(e) Q nearly 0

The CPU efficiency is the useful CPU time divided by the total CPU time. When $Q \geq T$, the basic cycle is for the process to run for T and undergo a process switch for S. Thus, (a) and (b) have an efficiency of $T /(S + T)$. When the quantum is shorter than T, each run of T will require T /Q process switches, wasting a time ST /Q. The efficiency here is then$(T/(T + ST/Q))$

4. (3 points) Consider the following C program:

```
int X[N];
int step = M; /* M is some predefined constant */
for (int i = 0; i < N; i += step) X[i] = X[i] + 1;
```

(a) If this program is run on a machine with a 4-KB page size and 64-entry TLB, what values of M and N will cause a TLB miss for every execution of the inner loop?
(b) Would your answer in part (a) be different if the loop were repeated many times? Explain.
For these sizes:
(a) M has to be at least 4096 to ensure a TLB miss for every access to an element of X. Since N affects only how many times X is accessed, any value of N will do.
(b) M should still be at least 4,096 to ensure a TLB miss for every access to an element of X. But now N should be greater than 64K to thrash the TLB, that is, X should exceed 256 KB.

5. (3 points) A certain file system uses 4-KB disk blocks. The median file size is 1 KB. If all files were exactly 1 KB, what fraction of the disk space would be wasted? Do you think the wastage for a real file system will be higher than this number or lower than it? Explain your answer.
If all files were 1 KB, then each 4-KB block would contain one file and 3 KB of wasted space. Trying to put two files in a block is not allowed because the unit used to keep track of data is the block, not the semiblock. This leads to 75% wasted space. In practice, every file system has large files as well as many small ones, and these files use the disk much more efficiently. For ex- ample, a 32,769-byte file would use 9 disk blocks for storage, given a space efficiency of 32,769/36,864, which is about 89%.

6. (3 points) A distributed system using mailboxes has two IPC primitives, send and receive. The latter primitive specifies a process to receive from and blocks if no message from that process is available, even though messages may be waiting from other processes. There are no shared resources, but processes need to communicate frequently about other matters. Is deadlock possible? Discuss.
Yes. Suppose that all the mailboxes are empty. Now A sends to B and waits for a reply, B sends to C and waits for a reply, and C sends to A and waits for a reply. All the conditions for a communications deadlock are now fulfilled.

7. (30% extra credit)
(a) Describe a situation in which balloon drivers do not work.
(b) A thin-client terminal is used to display a Web page containing an animated cartoon of size 400 pixels × 160 pixels running at 10 frames/sec. What fraction of a 100-Mbps Fast Ethernet is consumed by displaying the cartoon?
(a) Balloon drivers do not work if the hypervisor does not know anything about the guest operating systems running on its virtual machines. It also does not work if there is no way to include a balloon driver in them, for example, if they do not support loadable drivers and the source code is not available so they cannot be recompiled to include the balloon driver..
(b) The display size is 400 × 160 × 3 bytes, which is 192,000 bytes. At 10 fps this is 1,920,000 bytes/sec or 15,360,000 bits/sec. This consumes 15% of the Fast Ethernet.

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