# A Homework 3

# Problem 1

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 and 20 minutes of I/O time. How long will it take to run the two jobs sequentially? How long if they run in parallel?

## Problem 2

Consider the following piece of C code:

void main() {

fork();

fork();

exit();

}

Draw the process tree that is created by executing the above program.

# Problem 3

Can a measure of whether a process is likely to be CPU-bound or I/O-bound be determined by analyzing a program’s binary code? How can this be determined at run-time?

# Problem 4

Five batch jobs. A through E, arrive at a computer center at almost the same time. They have estimated running times of 10, 6, 2, 4, and 8 minutes. Their (externally determined) priorities are 3, 5, 2, 1, and 4, respectively, with 5 being the highest priority. For each of the following scheduling algorithms, determine the mean process turnaround time. Ignore process switching overhead.

(a) Round-robin.

(b) Priority scheduling.

(c) First-come, first-served (run in order 10, 6, 2, 4, 8).

(d) Shortest job first.

# Problem 5

Suppose that a machine has 38-bit virtual addresses and 32-bit physical addresses.

(a) Describe how to set up a single-level page table when the page size is 16KB. How large is the page table size assuming 4-byte entries in the page table?

(b) Describe how to set up a two-level page table using 16-KB pages and 4-byte entries page entries? How many bits should be allocated for the top-level page table field and how many for the next-level page table field? Explain.

# Problem 6

You are given the following data about a virtual memory system:

(a) The TLB can hold 1024 entries and can be accessed in 1 clock cycle (1 nsec).

(b) A page table entry can be found in 100 clock cycles or 100 nsec.

(c) The average page replacement time is 6 msec.

If page references are handled by the TLB 99% of the time, and only 0.01% lead to a page fault, what is the effective address-translation time?

# Problem 7

A machine has 48-bit virtual addresses and 32-bit physical addresses. Pages are 8 KB.

How many entries are needed for a single-level linear page table?

# Problem 8

Consider the following two-dimensional array:

int X[64][64];

Suppose that a system has four-page frames, and each frame is 128 words (an integer occupies one word). Programs that manipulate the X array fit into exactly one page and always occupy page 0. The data are swapped in and out of the other three frames. The X array is stored in row-major order (i.e., X[0][1] follows X[0][0] in memory). Which of the two code fragments shown below will generate the lowest number of page faults? Explain and compute the total number of page faults.

Fragment A

for (int j = 0; j < 64; j++)

for (int i = 0; i < 64; i++) X[i][j] = 0;

Fragment B

for (int i = 0; i < 64; i++)

for (int j = 0; j < 64; j++) X[i][j] = 0;