

Homework 5 **(Performance and Microprogramming)**

This assignment is due Tuesday, November 11, 2003 for Sections 1, 2 and 3.

Learning Objectives

In the process of completing this homework assignment, students will develop their abilities to

- Determine the absolute and relative performance of implementations of instruction set architectures.
- Apply Amdahl's law to determine how much speedup can be obtained by improving implementations of instruction set architectures.
- Design datapath control units using microprogramming.

General Instructions

Submit your solutions on a separate sheet of paper.

Problems

1. [5 points] Problem 2.14 from Patterson and Hennessy.
2. In this problem, you will analyze the performance of two implementations of the MULDER instruction set architecture.
 - a. [5 points] For the FOX implementation, the clock rate is 1 GHz, and instructions fall into two categories. Category X instructions require 4 cycles to execute, while category Y instructions require 5 cycles. If the File program executes 1.27×10^{11} category X instructions and 1.01×10^{11} category Y instructions, how long will it take to execute? Express your answer in seconds.
 - b. [5 points] The SPOOKY implementation is identical to the FOX implementation, except that the clock rate is 1.2 GHz and category Y instructions require 6 cycles. How long will the File program take to execute on this implementation?
 - c. [5 points] The AGENT implementation is identical to the FOX implementation, except that it includes a category Z instruction that requires 8 cycles to execute and does the same thing as a common combination consisting of one category X instruction and one category Y instruction. This combination accounts for 10% of the category X instructions used by the File program on the FOX implementation. How long will the File program take to execute on the AGENT implementation?
 - d. [5 points] Between the FOX and SPOOKY implementations, which is faster for the File program, and by how much?
3. [10 points] Problem 2.13 from Patterson and Hennessy.

4. [5 points] Suppose we could improve the speed of the CPU in a computer by a factor of 5 (without affecting I/O performance) for 5 times the cost. Also assume that the CPU is used 50% of the time, and the rest of the time the CPU is waiting for I/O. If the CPU is one-third of the total cost of the computer, is increasing the CPU speed by a factor of 5 a good investment from a cost/performance viewpoint?

5. [20 points] Figure 5.46 in Hennessy and Patterson, shows the microprogram for the control unit of the MIPS architecture that can handle `lw`, `sw`, `beq`, `j` and R-type instructions. Add microcode to this program to implement the MIPS instructions listed below. *Hint*: A line of microcode is equivalent to a state in a state transition diagram.
 - a. `addi`

 - b. `mfcc0`

 - c. `mtc0`

 - d. `jal`