

CSE 775: Computer Systems Architecture  
Autumn 2008  
Homework #1

Instructor: Panda

Due: Monday, 13th October

1. (20 points) A visualization program uses floating point operations and special graphics (shift, rotate, etc.) operations. By attaching a graphics coprocessor only, we can enhance the graphics operations by a factor of 2. This leads to a speed-up of  $\frac{10}{9}$ . By attaching a floating-point coprocessor only, we can enhance the floating-point operations by a factor of 4. This leads to a speed-up of  $\frac{10}{7}$ . There is no overlap between graphics and floating point instructions. How much speed-up we will get by attaching both graphics and floating-point coprocessors?
  
2. (20 points) The Whetstone benchmark contains a total of 195,578 basic floating-point operations in a single iteration. This Whetstone benchmark was run on a system X using F77 compiler with optimization turned on. This system runs at a speed of 16.67MHz, and it includes a floating-point coprocessor. The compiler allows the floating point to be calculated in two different ways based on the compiler flag: 1) with the coprocessor or 2) using the software routine. A single iteration of the Whetstone benchmark took 1.08 seconds using the coprocessor and 13.6 seconds using software routine. Assume that the CPI using the coprocessor was measured to be 10, while the CPI using the software routine was measured to be 6.
  - (a) What is the MIPS rating for both runs?
  - (b) What is the total number of instructions executed for both runs?
  - (c) On the average, how many integer instructions does it take to perform a floating-point operation in software?
  - (d) What is the MFLOPs rating for system X with the floating-point coprocessor running the Whetstone? (Assume each floating-point operation mentioned in this problem counts as one operation.)
  
3. (20 points) A typical scientific code running on a workstation has the following instruction mix: 30% memory, 40% floating point, and 30% other. These instruction types take the following number of clock cycles for execution on this workstation: memory (5) , floating point (10), and other (3).

The base cost of the workstation is \$10,000. It is being sold with three different upgrade options. *Option 1*: faster memory with an additional cost of \$1000, it can reduce the CPI of memory instructions to 4; *Option 2*: a floating-point coprocessor with an additional cost of \$2000, it can reduce the CPI of floating-point instructions to 7; *Option 3*: both of the above options with an additional cost of \$2500.

By doing a cost-performance analysis, indicate which option will be the best to buy.

4. (20 points) A set of three systems are being evaluated to be used in a laboratory environment. The environment uses three types of programs with a relative usage of 40% (pgm 1), 35% (pgm 2), and 25% (pgm 3), respectively. Each of these three programs have been

benchmarked on these three systems individually and their execution times are shown in the following table:

<i>Programs</i>	<i>System 1</i>	<i>System 2</i>	<i>System 3</i>
Program 1	1.0 sec	2.0 sec	1.5 sec
Program 2	10.0 sec	7.0 sec	5.0 sec
Program 3	5.0 sec	3.0 sec	4.0 sec

- (a) Determine which of the above three systems will provide the best performance for the laboratory.
  - (b) The three systems cost as follows: \$8,000 (systems 1), \$5,000 (system 2), and \$6,500 (system 3). By doing a cost-performance analysis, indicate which one of these systems you will choose and why.
5. (20 points) Refer to Fig. 1.26 on page 61 (4th edition) and the associated description on the top of page 61 about the data in this figure.
- (a) Create a table similar to that shown in Figure 1.26, except express the results as normalized to the fastest application for each benchmark.
  - (b) Calculate the geometric mean of the normalized performance of the dual processors and the geometric mean of the normalized performance of the single processor for the memory benchmark.