For More Practice

Cost-Effective Computing

4.4 [10] <§4.1> Suppose you had many more computers to consider besides M1 and M2 described in Exercises 4.1 and 4.3 (each with a cost and an execution time for program 1, which you need to run a large number of times). Could you use the cost divided by the execution time as a metric to help you in your purchasing decision? How about the cost multiplied by the execution time? If either of the two formulas cannot be used, present a simple example that demonstrates why not.

4.5 [5] <§4.1> {Ex. 4.1, 4.3} Another user is concerned with the throughput of the computers in Exercise 4.1, as measured with an equal workload of programs 1 and 2. Which computer has better performance for this workload? By how much? Assuming the costs for the computers from Exercise 4.3, which computer is more cost-effective for this workload? By how much?

Analyzing a Processor with Float?ing-Point Implemented in Hardware or Software

4.35 [10] <§§4.2, 4.3> In the embedded market, where cost is crucial, processors sometimes implement floating point only in software. We are interested in two implementations of a computer, one with and one without special floating-point hardware.

Consider a program, P, with the following mix of operations:

Floating-point multiply	10%
Floating-point add	15%
Floating-point divide	5%
Integer instructions	70%

Computer MFP (computer with floating point) has floating-point hardware and can therefore implement the floating-point operations directly. It requires the following number of clock cycles for each instruction class:

Floating-point multiply	6
Floating-point add	4
Floating-point divide	20
Integer instructions	2

Computer MNFP (computer with no floating point) has no floating-point hardware and so must emulate the floating-point operations using integer instructions. The integer instructions all take 2 clock cycles. The number of integer instructions needed to implement each of the floating-point operations is as follows:

Floating-point multiply	30
Floating-point add	20
Floating-point divide	50

Both computers have a clock rate of 1000 MHz. Find the native MIPS ratings for both computers.

4.36 [10] <§4.2> If the computer MFP in Exercise needs 300 million instructions for this program, how many integer instructions does the computer MNFP require for the same program?

4.37 [5] <§§4.2, 4.3> Assuming the instruction counts from Exercise , what is the execution time (in seconds) for the program in Exercise run on MFP and MNFP?

Analyzing Enhancements to a Processor

4.38 [10] <§§4.2, 4.3> You are the lead designer of a new processor. The processor design and compiler are complete, and now you must decide whether to produce the current design as it stands or spend additional time to improve it.

You discuss this problem with your hardware engineering team and arrive at the following options:

a. *Leave the design as it stands.* Call this base computer *Mbase*. It has a clock rate of 500 MHz, and the following measurements have been made using a simulator:

Instruction class	CPI	Frequency
A	2	40%
B	3	25%
C	3	25%
D	5	10%

b. *Optimize the hardware.* The hardware team claims that it can improve the processor design to give it a clock rate of 600 MHz. Call this computer *Mopt*. The following measurements were made using a simulator for Mopt:

Instruction class	CPI	Frequency
A	2	40%
B	2	25%
C	3	25%
D	4	10%

What is the CPI for each computer?

4.39 [5] <§§4.2, 4.3> What are the native MIPS ratings for Mbase and Mopt in Exercise ?

4.40 [10] <§§4.2, 4.3> How much faster is Mopt than Mbase in Exercise ?

4.41 [5] <§§4.2, 4.3> The compiler team has heard about the discussion to enhance the computer discussed in Exercises through . The compiler team proposes to improve the compiler for the computer to further enhance performance. Call this combination of the improved compiler and the base computer *Mcomp*. The instruction improvements from this enhanced compiler have been estimated as follows:

Instruction class	Percentage of instructions executed versus base computer
A	90%
B	90%
C	85%
D	95%

For example, if the base computer executed 500 class A instructions, Mcomp would execute $0.9 \times 500 = 450$ class A instructions for the same program. What is the CPI for Mcomp?

4.42 [5] <§§4.2, 4.3> Using the data of Exercise , how much faster is Mcomp than Mbase?

4.43 [10] <§§4.2, 4.3> The compiler group points out that it is possible to implement both the hardware improvements of Exercise and the compiler enhancements described in Exercise . If *both* the hardware and compiler improvements are implemented, yielding computer *Mboth*, how much faster is Mboth than Mbase?

4.44 [10] <§§4.2, 4.3> You must decide whether to incorporate the hardware enhancements suggested in Exercise or the compiler enhancements of Exercise (or both) to the base computer described in Exercise . You estimate that the following time would be required to implement the optimizations:

Optimization	Time to implement	Computer name
Hardware	6 months	Mopt
Compiler	6 months	Mcomp
Both	8 months	Mboth

Recall from Chapter 1 that CPU performance improves by approximately 50% per year, or about 3.4% per month. Assuming that the base computer has performance equal to that of its competitors, which optimizations (if any) would you choose to implement?