1st Homework for Computer Architecture

Submission deadline: April. 1, 11：59pm
（total 200 points）

1.1 [20/10/10/15] <1.6> In this exercise, assume that we are considering enhancing a machine by adding a vector mode to it. When a computation is run in vector mode it is 20 times faster than the normal mode of execution. We call the percentage of time that could be spent using vector mode the *percentage of vectorization*. Vectors are discussed in Appendix B, but you don't need to know anything about how they work to answer this question!

a. [20] <1.6> Draw a graph that plots the speedup as a percentage of the computation performed in vector mode. Label the *y* axis "Net speedup" and label the *x* axis "Percent vectorization."

b. [10] <1.6> What percentage of vectorization is needed to achieve a speedup of 2?

c. [10] <1.6> What percentage of vectorization is needed to achieve one-half the maximum speedup attainable from using vector mode?

d. [15] <1.6> Suppose you have measured the percentage of vectorization for programs to be 70%. The hardware design group says they can double the speed of the vector rate with a significant additional engineering investment. You wonder whether the compiler crew could increase the use of vector mode as another approach to increasing performance. How much of an increase in the percentage of vectorization (relative to current usage) would you need to obtain the same performance gain? Which investment would you recommend?

1.2 [15/10] <1.6> Assume—as in the Amdahl's Law Example on page 30—that we make an enhancement to a computer that improves some mode of execution by a factor of 10. Enhanced mode is used 50% of the time, measured as a percentage of the execution time *when the enhanced mode is in use*. Recall that Amdahl's Law depends on the fraction of the original, *unenhanced* execution time that could make use of enhanced mode. Thus, we cannot directly use this 50% measurement to compute speedup with Amdahl's Law.

a. [15] <1.6> What is the speedup we have obtained from fast mode?

b. [10] <1.6> What percentage of the original execution time has been converted to fast mode?

1.3 [10/10/15] Suppose that a processor with a load/store architecture and no delayed branches executes at a clock rate of 2GHz. Arithmetic and logic instructions require 1 cycle, load and store operations 2 cycles, and conditional branches 3 cycles because of the control hazard involved.

The typical applications run on this processor contain a mix of 60% arithmetic and logic instructions, 20% load and store instructions and 20% conditional branches instructions.

An engineer proposes a modification in the architecture which introduces speculation. The branch prediction algorithm would be correct 50% of the time. When correct, branches would take 1 cycle, when incorrect, 3 cycles as before. However, the modification requires the reduction of the clock frequency to 1.8GHz.

a)[10] What is the average cycles per instruction of the original processor?

b)[10] What is the average cycles per instruction of the speculative processor?

c) [15] Is the speculative processor faster or slower than the original one? By how much?

Instruction type	Frequency	Clock cycle count
ALU ops	43%	1
Loads	21%	2
Stores	12%	2
Branches	24%	2

FIGURE 1.17 Measurements of the load-store machine.

1.4 **[20/20]** <1.6> Figure 1.23 presents the power consumption of several computer system components. In this exercise, we will explore how the hard drive affects power consumption for the system.

a. [20] <1.6> Assuming the maximum load for each component, and a power supply efficiency of 70%, what wattage must the server's power supply deliver to a system with a Sun Niagara 8-core chip, 2 GB 184-pin Kingston DRAM, and two 7200 rpm hard drives?

b. **[20]** 1.6> How much power will the 7200 rpm disk drive consume if it is idle rougly 40% of the time?

Component type	Product	Performance	Power
Processor	Sun Niagara 8-core	1.2 GHz	72-79W peak
	Intel Pentium 4	2 GHz	48.9-66W
DRAM	Kingston X64C3AD2 1 GB	184-pin	3.7W
	Kingston D2N3 1 GB	240-pin	2.3W
Hard drive	DiamondMax 16	5400 rpm	7.0W read/seek, 2.9 W idle
	DiamondMax Plus 9	7200 rpm	7.9W read/seek, 4.0 W idle

Figure 1.23 Power consumption of several computer components.

1.13 [15/15/15] <1.6,1.9> Three enhancements with the following speedups are proposed for a new architecture:

$\text{Speedup}_1 = 30$

$\text{Speedup}_2 = 20$

$\text{Speedup}_3 = 10$

Only one enhancement is usable at a time.

a. [15] <1.6> If enhancements 1 and 2 are each usable for 30% of the time, what fraction of the time must enhancement 3 be used to achieve an overall speedup of 10?

b. [15] <1.6,1.9> Assume the distribution of enhancement usage is 30%, 30%, and 20% for enhancements 1, 2, and 3, respectively. Assuming all three enhancements are in use, for what fraction of the reduced execution time is no enhancement in use?

c. [15] <1.6> Assume for some benchmark, the fraction of use is 15% for each of enhancements 1 and 2 and 70% for enhancement 3. We want to maximize performance. If only one enhancement can be implemented, which should it be? If two enhancements can be implemented, which should be chosen?