CS 312 **Computer Organization and Architecture**

Assignment # 2 Due Date: February 25, 2003

Performance Evaluation

1. Consider two different implementations – M_1 and M_2 – of the same instruction set. There are four classes of instructions – A, B, C, and D, in the instruction set. The clock rates for M_1 and M_2 are 500 MHz and 750 MHz, respectively. The average number of cycles in each instruction class are:

Class	M_1 CPI	M_2 CPI
A	1	2
B	2	2
C	3	4
D	4	4

   (a) [5 pts] Assume that peak performance is defined as the fastest rate that a machine can execute an instruction sequence chosen to maximize that rate. What are the peak performances of M_1 and M_2 expressed as instructions per second?

   The fastest rate that a machine can execute a sequence is if the sequence contains all the instructions that require the least number of CPI.

   For machine M_1, it will be if all instructions are of class A, as they all require 1 CPI. With the clock rate of 500 MHz, it yields 500 million instructions per second.

   For machine M_2, it will be if all instructions are of class A, as they all require 2 CPI. With the clock rate of 750 MHz, it yields $\frac{750}{2}$, or 375 million instructions per second.

   (b) [10 pts] If the number of instructions executed in a certain program is divided equally among the classes of instructions, how much faster is M_2 than M_1?

   With equal distribution of instructions, the average number of CPI in M_1 is given by $\frac{1+2+3+4}{4} = 2.5$.

   The MIPS rating for M_1 is: $\frac{500\times10^6}{2.5} = 200 \times 10^6$.

   The average number of CPI in M_2 is given by $\frac{2+2+4+4}{4} = 3$.

   The MIPS rating for M_2 is: $\frac{750\times10^6}{3} = 250 \times 10^6$.

   M_2 is faster compared to M_1 by $\frac{250\times10^6}{200\times10^6} = 1.25$ times.

   (c) [5 pts] With equal distribution of instructions across classes, at what clock rate would M_1 have the same performance as 750 MHz M_2?

   Since M_2 is 1.25 times faster than M_1, the clock speed required for M_1 is $500 \times 1.25 = 625$ MHz.

   (d) [10 pts] Let us change the distribution of instruction classes from equal to as follows:

Class	M_1	M_2
A	31%	40%
B	5%	7%
C	29%	21%
D	35%	32%

   Which machine is faster, and by how much?

   Average CPI for $M_1 = \frac{0.31\times1+0.05\times2+0.29\times3+0.35\times4}{4} = 0.67$

   Average CPI for $M_2 = \frac{0.40\times2+0.07\times2+0.21\times4+0.32\times4}{4} = 0.76$

   MIPS rating for $M_1 = \frac{500\times10^6}{0.67} = 746.27 \times 10^6$

   MIPS rating for $M_2 = \frac{750\times10^6}{0.76} = 986.84 \times 10^6$

   M_2 is faster by $\frac{986.84\times10^6}{746.27\times10^6} = 1.32$ times.

The following problems are from your main text (Patterson and Hennessy)

1. [10 pts] Problem 2.15
2. [10 pts] Problem 2.16
3. [5 pts] Problems 2.17