Computer Science 605.611

Problem Set 1

1. (12) Use the letter X to indicate whether each of the phrases below applies to a CISC or to a RISC. Select either “CISC” or “RISC” in each case and base your choice on the information provided in module 1.

* + more likely to employ a load/store architecture CISC \_\_\_\_\_ RISC\_\_\_X\_\_\_
  + tends to have higher average CPI CISC \_\_\_\_\_ RISC\_\_\_X\_\_\_
  + needs fewer machine instructions to implement

a given algorithm or program CISC \_\_X\_\_ RISC\_\_\_\_\_\_\_

* + usually contains more CPU registers CISC \_\_\_\_\_ RISC\_\_\_X\_\_\_
  + more likely to employ a Harvard architecture CISC \_\_X\_\_ RISC\_\_\_\_\_\_\_
  + more likely to use hardwired logic control CISC \_\_X\_\_ RISC\_\_\_\_\_\_\_

2. (3) Only certain MIPS instructions can reference operands in memory. What machine code format (R-format, I-format or J-format) is used for these MIPS instructions?

The I format type would be used for these MIPS instructions as it stores the operands as an immediate value.

3. (7) Each of the following MIPS instructions uses two operands. For each instruction, write “yes” if the instruction is executed by the CPU or write “no” if the instruction is not executed by the CPU.

Div no

Mult no

cvt.w.s no

mtc1 no

lwc1 yes

mfc1 yes

swc1 yes

4. (3) If the clock rate for a processor is increased 25%, will the cycle time increase of will it decrease? By what percentage will the cycle time change? Percent change = \_8\_ %.

The Cycle time will Decrease. The Percentage Change would be 8%.

5 = 1/0.2,

5 \*.25 = 1.25

6.25 = 1/0.16

.2/.16 = .8 = **8%**

5. A processor has a clock rate of 2 GHz and executes 150 million instructions from a program with an average CPI of 4.

Among the techniques that can be used to improve the performance of the program are:

* Option 1: optimize the program so that it only executes 100 million instructions.
* Option 2: double the clock rate of the processor.
* Option 3: carefully select the instructions in the program so that the average CPI is reduced from 4 to 2.5.

For each of these options used alone, compute the resulting speedup for the program. Recall that speedup is defined as the ratio of the execution time before the change to the execution time after the change.

(3) Speedup provided by option 1 = \_\_1.5\_\_\_

(3) Speedup provided by option 2 = \_\_\_2\_\_\_

(3) Speedup provided by option 3 = \_\_1.6\_\_\_

6. A processor with a clock rate of 2.5 GHz requires 0.28 seconds to execute the 175 million instructions contained in a program.

a) (3) What is the average CPI (cycles per instruction) for this program?

The Average CPI would be **4**

(0.28 \* (2.5 \*10^9))/175\*10^6 = 4

b) (5) Suppose that the clock rate is increased, but the higher clock rate results in an average CPI of 5 for the program. With this average CPI of 5, what value is required for the higher clock rate to achieve a speedup of 1.6 for the program compared to the original execution time of 0.28 seconds? Recall that speedup is defined as the ratio of the execution time before the change to the execution time after the change.

The higher clock rate needed would be **3.125 GHz**

5 \* (175\*10^6)/.28 – 3.125\*10^9

c) (5) Suppose that rather than increasing the processor clock rate, the program is rewritten to reduce the number of instructions executed from 175 million down to 159090910. The processor clock rate is 2.5 GHz for both the original program and the rewritten program. The average CPI is 4 for both programs. What speedup does the rewritten program provide compared to the original program? Express your answer to two decimal places.

The Speedup would be **1.10**

(4 \* 159090910)/(2.4 \* 10^9) = 0.2545…

.28/0.2545 = 1.10

7. A C++ program is translated into machine code that runs on processor A and executes a total of 28 million instructions. The machine code on processor A contains twelve million instructions with CPI = 2, seven million instructions with CPI=3 and nine million instructions with CPI=4.

The same C++ program is translated into machine code that runs on a different processor B. The machine code on processor B executes 32 million instructions. Ten million of the instructions have CPI = 1, seventeen million instructions have CPI=2 and five million instructions have CPI=4. Processor A and processor B both run at a 2 GHz clock rate.

a) (3) What is the peak MIPS rating for the program that runs on processor A? Express your answer to two decimal places.

**1321.43**

((12\*2)+(7\*2)+(9\*2)) \* 10^6/((12+7+9)\*10^6) =1.514513513…

2 GHz/1.514\*10^6 = 1321.43

b) (3) What is the peak MIPS rating for the program that runs on processor B? Express your answer to two decimal places.

**2000.00**

((10\*1)+(17\*1)+(5\*1)) \*10^6/10+17+5 \* 10^6 = 1

((12\*2)+(7\*2)+(9\*2)) \* 10^6/((12+7+9)\*10^6) = 2.18919

2 GHz/1\*10^6 = 2000

c) (3) What is the native MIPS rating for the program that runs on processor A? Express your answer to two decimal places.

**913.58**

((12\*2)+(7\*3)+(9\*4)) \* 10^6/((12+7+9)\*10^6) = 2.18919

2 GHz/2.18919\*10^6 = 913.58

8. (5) The native MIPS rating for a machine code program on processor 1 is 800. The program on processor 1 has an average CPI of 2.5. Compiling the same program for processor 2 produces a machine code program that executes the same number of machine instructions but with an average CPI of 4. Both processors run at a 2 GHz clock rate. What is the relative MIPS rating for the program running on processor 2 compared to the program running on processor 1?

The Relative MIPS would be 500

I used an IC of 1 million for simplicity.

CPU Time1 = ((1\*10^6) \* 2.5)/2\*10^9 = 0.00125

CPU Time2 = ((1\*10^6) \* 4)/2\*10^9 = 0.002

Relative MIPS = CPU Time­1/CPU Time2 \* MIPS1 = (0.00125/0.002)\*800 = **500**

9. The sub-module on Computer performance metrics defines the geometric mean, the harmonic mean and the arithmetic mean as techniques for assessing the performance of a group of programs. Some processors, especially those used in laptops or mobile devices, have a lower execution speed to conserve power and extend battery charge.

Suppose that such a processor runs in the slower low power mode and executes 2,520,000 instructions for a program in 14 milli-seconds.

Next the processor switches to the higher speed mode and executes the same program instructions again. This second execution at the higher speed takes only 9 milli-seconds. Answer the following questions and show how you obtained your answer for each:

a) (5) What is the native MIPS rating for the program in the slower low power mode?

MIPS = IC/ET\*10^3 = 2520000/14\*10^3 = **180**

(10^3 because its in milli-seconds instead of micro-seconds which would be 10^6)

b) (5) What is the native MIPS rating for the program in the higher speed mode?

MIPS = IC/ET\*10^3 = 2520000/9\*10^3 = **280**

c) (5) What is the arithmetic mean of these two native MIPS ratings?

(180 + 280)/2 = **230**

d) (5) What is the harmonic mean of the two native MIPS ratings?

2 / ((1/180) + (1/280)) = **219.130**

e) (5) What is the geometric mean of the two native MIPS ratings?

(180\*280)^-2 = **224.499**

f) (5) Using the total combined number of instructions in the two executions of the program and the total combined execution time for the two program executions, compute the MIPS rating for the combined two executions of the program?

Total combined number of instructions = 5,040,000

Total combined execution time = 23 milli-seconds

MIPS = 5040000/23\*10^3 = **219.130**

10. When a certain program is run, the CPU executes a total of 7 million instructions. The average CPI for the program is 2.5 and the CPU clock rate is 4 GHz.

a) (3) What is the CPU clock cycle time in nano-seconds?

**0.25 nanoseconds**

b) (3) What number is obtained by evaluating the expression: clock\_rate / (average\_CPI\*106) using the values provided above for clock\_rate and average CPI?

4\*10^9 / (2.5 \* 10^6) = **1600**

c) (3) What number is obtained by evaluating the expression: IC / (execution\_time\*106)

for this program using the values provided above for the instruction count (IC), clock\_rate and average CPI?

Execution time = CPU Time = ((7\*10^6)\*2.5)/4\*10^9 = 0.004375

(7\*10^6)/(0.004375\*10^6) = **1600**