**CS 365 Homework #1**

**Solution: please double check answers. Divide scores among sub-problems in any reasonable way. If suspect or found cheating, give 0 to this assignment and write a big warning comment. Thank you.**

1. Suppose you wish to run a program P with 8.1 \* 109 instructions on a 3 GHz machine with a CPI (average CPI) of 1.5. What is the expected CPU time?

**Answer: CPU time = 8.1\*10^9 \* 1.5\*(1/(3\*10^9))=4.05 seconds**

1. Consider three different processors P1, P2, and P3 executing the same instruction set. P1 has a 3 GHz clock rate and a CPI of 1.5. P2 has a 2.5 GHz clock rate and a CPI of 1.0. P3 has a 4.0 GHz clock rate and has a CPI of 2.2.
2. Which processor has the highest performance expressed in instructions per second?

**Answer: Execution time = IC \* CPI /clock\_rate**

**1 second = IC \* CPI /clock\_rate IC\_one\_sec = clock\_rate/CPI**

**P1: 3 \* 10^9 /1.5 = 2 \* 10^9**

**P2: 2.5 \* 10^9 /1.0 = 2.5 \* 10^9**

**P3: 4.0 \* 10^9 /2.2 = 1.8 \* 10^9**

**P2 has highest performance.**

1. If processor P1 executes a program in 10 seconds, find the number of cycles and the number of instructions.

**Answer:**

**10 second = # of clock cycle /clock\_rate**

**# of CC = 3 \*10^9 \* 10 = 3 \* 10^10 cycles**

**IC = # of CC / CPI = 3 \* 10^10 /1.5 = 2 \* 10^10**

1. For processor P2, we are trying to reduce the execution time by 30% but this leads to an increase of 20% in CPI. What clock rate (for P2) should we have to get this time reduction?

**Answer:**

**t: execution time; IC: instruction count; CPI, r, new\_r: clock rate**

**t = IC \* CPI /r r = IC \* CPI / t**

**0.7t = 1.2\*IC \* CPI / new\_r**

**new\_r =1.2\*IC\*CPI /0.7t = 1.714 \* IC\*CPI/t = 1.714\*r = 1.714\*2.5GHz=4.3GHz**

1. Consider two different implementations of the same instruction set architecture. The instructions can be divided into four classes according to their CPI (class A, B, C, and D). P1 has a clock rate of 2.5 GHz and P2 of 3 GHz. For a program with (dynamic) instruction count of 1012 instructions divided into classes as 10% class A, 20% class B, 50% class C, and 20% class D.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class** | **CPI on P1 (@2.5 GHz)** | **CPI on P2 (@3GHz)** | | **Instruction Frequency** |
| A | 1 | 2 |  | 10% |
| B | 2 | 2 | | 20% |
| C | 3 | 2 | | 50% |
| D | 4 | 4 | | 20% |

1. What is the average CPI for each of the implementations?

**Answer:**

**CPI for P1: 1\*10%+2\*20%+3\*50%+4\*20% = 2.8**

**CPI for P2: 2\*10% + 2\*20%+2\*50%+4\*20% = 2.4**

1. What is the execution time of the program for each of implementations?

**Answer:**

**Execution time for P1: IC \* CPI /clock\_rate = 10^12 \* 2.8 /(2.5 \* 10^9) = 1120 seconds**

**P2: 10^12 \* 2.4 / (3 \* 10^9) = 800 seconds**

1. We are comparing the performance of two different microprocessors, M1 and M2. Assume a program P will be compiled into M2 instructions counting 20% more than M1 instructions. M1 has a 2 GHz clock rate while M2 has a 3 GHz clock rate. Instructions on these two machines can be classified into 3 classes as shown in the following table. Which machine has better MIPS? Which machine has better performance? By how much? Justify your answers.

|  |  |  |  |
| --- | --- | --- | --- |
| Instruction Class | Cycles needed | | Instruction Frequency |
| M1 | M2 |
| A | 1 | 2 | 25% |
| B | 4 | 3 | 35% |
| C | 5 | 5 | 40% |

**Answer:**

**CPI M1 = 1\*0.25+4\*0.35+5\*0.4=3.65, CPI M2 = 2\*0.25+3\*0.35+5\*0.4=3.55**

**MIPS M1 = 2\*10^9/(3.65\*10^6)=548**

**MIPS M2 = 3\*10^9/(3.55\*10^6) = 845**

**M2 has higher MIPS**

**(2) Performance M2 / Performance M1 = Exe M1 / Exe M2**

**= (n\*3.65\*1/(2\*10^9))/(1.2n\*3.55\*1/(3\*10^9)) = (3.65/2)/(1.2\*3.55/3)=1.29**

**M2’s performance is better by 29%.**

1. Use SPEC benchmark as an example, answer the following questions: (1) Why do we need benchmark for CPU/processor performance evaluation? (2) What programs are used by the most current SPEC benchmark to evaluate integer and floating-point performance?

**Suggested answer: (note: answer varies, any reasonable answer acceptable)**

**(1) to have independent or practical evaluation/testing of performance;**

**(2) students should use Spec 2017 examples (see** [**http://spec.org/cpu2017/Docs/overview.html#benchmarks**](http://spec.org/cpu2017/Docs/overview.html#benchmarks)**)**

**Note: For those using Spec 2006, make sure they’re not copying previous solutions (my previous solution as follows):**

**(2) integer performance: a list of commonly used or typical integer programs such as gcc compiler etc.; floating-point performance: a list of commonly used or typical programs that extensively use floating point operations such as bwaves a fluid dynamics program.**