**Homework Assignment #1**

***Due Date: 9/20, 11:59 p.m. Please submit via Blackboard. Late submissions are accepted till 9/25, 11:59 p.m., with 10% penalty each day. For all questions, please note that you need to show the steps how you obtain your result and please do NOT just provide the final answer.***

***Please name your submission file starting with “LastName\_FirstName\_HW1”.***

**Q1. (5 points)** Please briefly describe the steps that transform a program written in a high-level language such as C into a representation that is directly executed by a computer processor.

**Q2.** **(5 points)** What are the five classic components in all kinds of computers?

**Q3. (10 points)** Please briefly describe: 1) what the Moore’s Law is; and 2) what the Pollack’s rule is.

**Q4**. **(10 points)** Please briefly explain the following acronyms/terminologies we discussed in the class: **SISD, SIMD, MISD, and MIMD.**

**Q5.** 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.

a. **(5 points)** Which processor has the highest performance expressed in instructions per second?

b. **(5 points)** If the processors each execute a program in 10 seconds, find the number of cycles and the number of instructions.

c. **(5 points)** We are trying to reduce the execution time by 30% but this leads to an increase of 20% in the CPI. What clock rate should we have to get this time reduction?

**Q6. (10 points)** 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 with a clock rate of 2.5 GHz and CPIs of 1, 2, 3, and 3, and P2 with a clock rate of 3 GHz and CPIs of 2, 2, 2, and 2.

Given a program with a dynamic instruction count of 1.0E6 instructions divided into classes as follows: 10% class A, 20% class B, 50% class C, and 20% class D, which implementation is faster: P1 or P2? What is the global CPI (i.e., weighted average CPI) for each implementation?

**Q7.** The results of the SPEC CPU2006 bzip2 benchmark running on an AMD Barcelona has an instruction count of 2.389E12, an execution time of 750 s, and a reference time of 9650 s.

a. **(5 points)** Find the CPI if the clock cycle time is 0.333 ns.

b. **(5 points)** Find the SPECratio.

c. **(5 points)** Suppose that we are developing a new version of the AMD Barcelona processor with a 4 GHz clock rate. We have added some additional instructions to the instruction set in such a way that the number of instructions has been reduced by 15%. The execution time is reduced to 700 s and the new SPECratio is 13.7. Find the new CPI.

**Q8. (5 points)** Suppose a new CPU reduces the voltage by 20% and reduces the frequency by 40%, while having the same capacitive load as the old CPU, how much power savings would be achieved compared with the old CPU?

**Q9. (10 points)** We discussed the paper “Amdahl’s Law in the Multicore Era” by Prof. Mark Hill (University of Wisconsin-Madison) and Dr. Michael R. Marty (Google) in class, and analyzed the speedup formula of one type of asymmetric architecture, as shown as below (Lecture 4, Slide 21). However, for this asymmetric multicore architecture (Lecture 4, Slide 18), we assume there’s only one powerful *r*-BCE core and the rest are *n-r* base cores (i.e., 1 *+ n - r* cores in total per chip). Assume we create another asymmetric multicore architecture, with **two *r*-BCE cores** (large cores) and **the rest are all *q*-BCE cores *(r > q)*** (small cores). What is the speedup formula for this asymmetric multicore architecture?

Diagram

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**Q10. (15 points)** Please pick one of the papers listed below, read the paper in detail, and write a short summary of the paper you studied. Please limit to maximum 400 words, and please focus on what problem is studied in the paper and what are the key conclusions.

[1] Gene M. Amdahl, “Validity of the Single-Processor Approach to Achieving Large Scale Computing Capabilities”, 1967.

[2] John L. Gustafson, “Reevaluating Amdahl’s Law”, 1988.

[3] Hill & Marty, “Amdahl’s Law in the Multicore Era”, IEEE Computer 2008.

[4] X.-H. Sun and Y. Chen, "Reevaluating Amdahl's Law in the Multicore Era,” Journal of Parallel and Distributed Computing, vol. 70, no. 2, pp. 183-188, Feb 2010.

THE END.