

2021 Fall Computer Architecture

Homework 1

Due date: 10/12 (Tue) 23:59

- You need to give an explanation about your answer or show how you derive the answers.
 - Submit your homework to NTU COOL.
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1. Consider three different processors P1, P2, and P3 executing the same instruction set. And the clock rate and CPI of each processor is in the following table.

Processor	Clock rate (GHz)	CPI
P1	2.7	1.5
P2	3.0	2.0
P3	4.0	2.5

- (10 points) Please calculate the MIPS (million instructions per second) of P1, P2 and P3.
 - (10 points) If the processors each execute a program in 8 seconds, find the number of cycles and the number of instructions of P1, P2 and P3.
 - (10 points) We are trying to reduce the execution time by 40%, but this leads to an increase of 35% in CPI. What clock rate of P1, P2 and P3 should we have to get this time reduction?
2. Assume for arithmetic, load/store, and branch instructions, a processor has CPIs of 2, 11, and 7, respectively, with a 2.4 GHz clock frequency. A program requires the executions of 2.6×10^9 arithmetic, 1.3×10^9 load/store instructions, and 3.9×10^8 branch instructions on a single processor.
- Assume that, as the program is parallelized to run over multiple cores, the number of arithmetic and load/store instructions per processor is divided by $0.65 \times p$ (where p is the number of processors) but the number of branch instructions per processor remain the same.
- (18 points) Find the total execution time for this program on 1, 2, 4, and 8 processors, and show the relative speedup of the 2, 4, and 8 processors result relative to the single processor result.
 - (12 points) If the CPI of the arithmetic instructions was halved and the CPI of the load/store instructions was doubled, calculate the execution time of the program on 1, 2, 4, and 8 processors.
 - (9 points) How much CPI of load/store instructions should be reduced, in order for a single processor to match the performance of two processors using the original CPI values?

3. The results of the SPEC CPU2006 bzip2 benchmark running on a processor P has an instruction count of 2.123×10^{12} , an execution time of 772 seconds, and a reference time of 9,650 seconds.
- (5 points) Find the CPI if the clock rate is 2.2 GHz.
 - (5 points) Find the SPECratio.
 - (6 points) Find the increase in CPU time if the number of instructions of the benchmark is increased by 15% without affecting the CPI.
4. Consider two different implementations of the same ISA. The instructions can be divided into four classes according to their CPI (classes A, B, C, and D). P1 with a clock rate of 2.4 GHz and CPIs of 1, 2, 3, and 2, and P2 with a clock rate of 2.2 GHz and CPIs of 1.5, 3, 2 and 2.
- Given a program with a dynamic instruction count of 2.0×10^6 instructions divided into classes as follows: 20% class A, 25% class B, 45% class C, and 10% class D.
- (8 points) What is the global CPI for each implementation?
 - (7 points) Which processor is faster?