2021 Computer Architecture Problem Set #1

1. We have two processors of which specification is as follows:

	Processor A	Processor B
Clock frequency (= clock rate)	2GHz	3GHz
CPI when running workload C	1.0	2.0
CPI when running workload D	2.0	2.5

   A. Assuming that the number of the instructions executed for workload C and D are 1000 and 2000, respectively, calculate the execution time of processor A and processor B when running workload C and D.

   B. Assuming that a user uses workload C and D for 80% and 20% of the usage ratio respectively, which processor is better choice for the user? And why (please quantitatively compare)?

2. What is potential problem when using MIPS (Million Instructions Per Second) instead of execution time as a performance metric? Please describe it with an example.

3. Assume for arithmetic, load/store, and branch instructions, a processor has CPIs of 1, 12, and 5, respectively. Also assume that on a single processor a program requires the execution of 2.56×10^9 arithmetic instructions, 1.28×10^9 load/store instructions, and 256 million branch instructions. Assume that each processor has a 2 GHz clock frequency. 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 0.7 × p (where p is the number of processors) but the number of branch instructions per processor remains the same.

   A. 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.

   B. If the CPI of the arithmetic instructions was doubled, what would the impact be on the execution time of the program on 1, 2, 4, or 8 processors?

   C. To what should the CPI of load/store instructions be reduced in order for a single processor to match the performance of four processors using the original CPI values?

4. Assume a program requires the execution of 50 $\times10^6$ FP instructions, 110 $\times10^6$ INT instructions, 80 $\times10^6$ Load/Store instructions, and 16 $\times10^6$ branch instructions. The CPI for each type of instruction is 1, 1, 4, and 2, respectively. Assume that the processor has a 2 GHz clock rate.

   A. By how much must we improve the CPI of FP instructions if we want the program to run two times faster?

   B. By how much must we improve the CPI of Load/Store instructions if we want the program to run two times faster?

   C. By how much is the execution time of the program improved if the CPI of INT and FP instructions is reduced by 40% and the CPI of Load/Store and Branch is reduced by 30%?

5. We have a system and need to improve it. There are three parts (A, B, and C) in the system. We can only improve one part due to the human resource constraints. We can improve the system performance as follows:

	How much each part affects system performance	Possible improvements
A	**30%**	**2X**
B	**50%**	**1.5X**
C	**20%**	**4X**

   If you are a system designer, which part will you improve? And why?

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