Assignment # 1
(CLO2 -> PLO1)
Computer System Architecture

Submission Deadline: 28th Sept 2015

Note: Students should score 40% in OBE specific questions to ensure their accumulated scores towards respective PLOs are above 40%

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.
    a. Which processor has the highest performance expressed in instructions per second?
    b. If the processors each execute a program in 10 seconds, find the number of cycles and the number of instructions.
    c. 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?

2. 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?
    a. What is the global CPI for each implementation?
    b. Find the clock cycles required in both cases.

3. Computer A has an overall CPI of 1.3 and can be run at a clock rate of 600MHz. Computer B has a CPI of 2.5 and can be run at a clock rate of 750 Mhz. We have a particular program we wish to run. When compiled for computer A, this program has exactly 100,000 instructions. How many instructions would the program need to have when compiled for Computer B, in order for the two computers to have exactly the same execution time for this program?

4. Suppose a program segment consists of a purely sequential part which takes 25 cycles to execute, and an iterated loop which takes 100 cycles per iteration. Assume the loop iterations are independent, and cannot be further parallelized. If the loop is to be executed 100 times, what is the maximum speedup possible using an infinite number of processors (compared to a single processor)?

5. Computer A has an overall CPI of 1.3 and can be run at a clock rate of 600MHz. Computer B has a CPI of 2.5 and can be run at a clock rate of 750 MHz. We have a particular program we

wish to run. When compiled for computer A, this program has exactly 100,000 instructions. How many instructions would the program need to have when compiled for Computer B, in order for the two computers to have exactly the same execution time for this program?

6. Assume a color display using 8 bits for each of the primary colors (red, green, blue) per pixel and a frame size of 1280 × 1024.
    a. What is the minimum size in bytes of the frame buffer to store a frame?
    b. How long would it take, at a minimum, for the frame to be sent over a 100 Mbit/s network?

7. A common transformation required in graphics processors is square root. Implementations of floating-point (FP) square root vary significantly in performance, especially among processors designed for graphics. Suppose FP square root (FPSQR) is responsible for 20% of the execution time of a critical graphics benchmark. One proposal is to enhance the FPSQR hardware and speed up this operation by a factor of 10. The other alternative is just to try to make all FP instructions in the graphics processor run faster by a factor of 1.6; FP instructions are responsible for half of the execution time for the application. The design team believes that they can make all FP instructions run 1.6 times faster with the same effort as required for the fast square root. Compare these two design alternatives.

8. Your company has just bought a new dual Pentium processor, and you have been tasked with optimizing your software for this processor. You will run two applications on this dual Pentium, but the resource requirements are not equal. The first application needs 80% of the resources, and the other only 20% of the resources.
    a. Given that 40% of the first application is parallelizable, how much speedup would you achieve with that application if run in isolation?
    b. Given that 99% of the second application is parallelizable, how much speedup would this application observe if run in isolation?
    c. Given that 40% of the first application is parallelizable, how much *overall system speedup* would you observe if you parallelized it?
    d. Given that 99% of the second application is parallelizable, how much overall system speedup would you get?

9. Suppose you have a machine which executes a program consisting of 50% floating point multiply, 20% floating point divide, and the remaining 30% are from other instructions.
    a. Management wants the machine to run 4 times faster. You can make the divide run at most 3 times faster and the multiply run at most 8 times faster. Can you meet management's goal by making only one improvement, and which one?

b. Dogbert has now taken over the company removing all the previous managers. If you make both the multiply and divide improvements, what is the speed of the improved machine relative to the original machine?

10. If processor A has a higher clock rate than processor B, and processor A also has a higher MIPS rating than processor B, explain whether processor A will always execute faster than processor B. Suppose that there are two implementations of the same instruction set architecture. Machine A has a clock cycle time of 20ns and an effective CPI of 1.5 for some program, and machine B has a clock cycle time of 15ns and an effective CPI of 1.0 for the same program. Which machine is faster for this program, and by how much?