

Assignment 1

Due: Thursday, October 3, 2013

- There are 12 questions and you are required to answer 10 questions. Last two questions are exercise purpose only.
 - **Show your work clearly and legibly for all your answers.**
 - The numbers under [] indicate the marks allotted to each question.
 - The assignment (written or printed) must be stapled and put in a folder
 - You may hand in your assignment
 - to the instructor on due date by end of the class or
 - deposit it on hand-in lockers on 4th floor of the E2 building besides the elevator by 430 pm on the due date
 - For questions that require on-line searching (for example, cpu-world.com), you must provide the source link (URL).
 - A hardcopy “Honesty Declaration” (available in the course web site) appropriately filled and signed must accompany your submission to receive marks for your assignments.
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Problem Solving

1. [2] Machine M1 does a task in 10s, machine M2 does the same task in 15s.
 - a. What is the performance of each machine?
 - b. How much faster is M1 than M2? (what is the speedup?)
2. [2] Machine M2 executes a program in 15s.
 - a. If machine M1 is 1.3 times faster than machine M2, what is the execution time on machine M1?
 - b. If machine M3 is 1.1 times slower than machine M2, what is the execution time on machine M3?
3. [2] If a program P1 takes 5s on a 2 GHz machine,
 - a. how many cycles will it take to complete?
 - b. What clock rate would be needed to achieve a 1.1 times speedup (hint: assume clock cycles remains same)
4. [2] Machine M1 runs at 500MHz and Machine M2 runs at 650MHz. A program (P1) requires 100 million cycles on machine M1 and 1.3 times as many on Machine M2

- a. Which machine is faster?
 - b. By how much?
5. [2] Assume 3 types of instructions in a program
- i. Arithmetic takes 3 cycles
 - ii. Conditional takes 2 cycles
 - iii. Input/Output takes 4 cycles

Consider the following code

```

Xin >> num1;
Xout >> num2;
num3 = num1 + num2;
if (num3 > 10)
    Xout << "yes";
else
    Xout << "no";

```

- a. How many cycles are needed to complete?
 - b. What is the average number of cycles per instruction?
6. [15] Consider different processors P1, P2 and P3 executing the same instruction set with the clock rates and CPIs given in the following table:
- a. Which processor has the highest performance?
 - b. If the processors each execute a program in 7 seconds, find the number of clock cycles and the number of instructions
 - c. We are trying to reduce the time by 25% but this leads to an increase in 20% in the CPI. What clock rate should we have to get this time reduction?

Processor	Clock rate	CPI
P1	2.5 GHz	2.5
P2	1.9 GHz	1.5
P3	3 GHz	2.5

7. [25] Given the information about the 3 CPUs in the following table answer the questions below explaining briefly how you got your answers:

Feature	CPU-1	CPU-2	CPU-3
Clock rate	2.6 GHz	1.9 GHz	3.6 GHz
Average CPI	2.8	2.8	4.3
Number of cores	2	4	1
Cost	\$225	\$385	\$310

- a. [1] How long does it take to run a 30×10^9 instruction program on CPU-3?
 - b. [1] How long does it take to run 30 such programs on CPU-1?
 - c. [1] How long does it take to run 30 such programs on CPU-2?
 - d. [5] Which CPU offers the best throughput? Show your work clearly.
 - e. [3] How much faster is CPU-2 than CPU-1? Consider both cases: single job executed on a processor and stream of jobs executed on a processor.
 - f. [2] Which CPU will run a single job the fastest?
 - g. [5] Which CPU is most cost effective in terms of throughput?
 - h. [3] Which CPU is most likely to appeal to a computational scientist? Assume that a computational scientist is likely interested in doing a lot of computation to solve a single large problem and has a large grant to pay for computing equipment. Assume cost is not an issue and that the program does not make use of multiple cores in the CPU.
 - i. [4] Which CPU is most likely to appeal to a business executive? Assume that a business executive is a “low-end multi-tasker”. That is, they are not terribly demanding in terms of computation for any single task but they may need to have several interactive programs running efficiently at once (e.g. spreadsheet, financial planning software, web browser, etc.). Assume cost is an issue.
Note: since actual number of jobs is not provided for this part of the question, this is a subjective question and could lead to multiple answers depending on the scenario you are considering. Discuss your conclusions.
8. [10] Given the table below. Assume that computes take 1 cycle, loads and store instructions take 10 cycles and branches take 3 cycles. Find the execution time of each program on a 3GHz MIPS processor.

	Compute	Load	Store	Branch	Total
Program 1	1000	400	100	50	1550
Program 2	1500	300	100	100	1750

9. [5]
 - a. [1] The set of instructions understood by a computer is known as _____

- b. [2] Name 2 architectures that are RISC architectures and two architectures that are CISC architectures
 - c. [2] Name 4 different devices from 4 different companies that use RISC architecture
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Descriptive Answer

10. [10] Read the article by David Kanter (that compares between Intel's Sandy Bridge (SB) architecture and its previous Nehalem (NH) architecture; <http://www.realworldtech.com/page.cfm?ArticleID=RWT091810191937>):
 - a. How many single precision FLOPs/cycle can SB sustain?
 - b. How does this compare to NH's capabilities?
 - c. Next, what is SB's speedup in total L1 cache bandwidth over NH and how is it achieved?
 - d. What is the relative performance of SB's L2 cache's load-to-use latency compared to NH?
 - e. What about the speedup of SB's L3 cache (take the best numbers) over NH's L3 cache?
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11. This question is for Exercise purposes ONLY!! You don't have to include your solution in your submission.

The cost of a manufactured computer component decreases over time even without major improvements in the basic implementation technology. This is called the *learning curve*. The learning curve is best measured by change in *yield*-the percentage of manufactured devices that survives the testing procedure. Whether it is a chip, a board, or a system that have twice the yield will have half the cost. The formula for yield is given below:

$$\text{Yield} = \left(1 + \frac{\text{defects} \cdot \text{dis area}}{\alpha \cdot \text{unit area}}\right)^{-\alpha} * 100\%$$

where α is a parameter that measures manufacturing complexity. $\alpha=4.0$.

Chip	Die size(mm^2)	Estimated defect rate (per cm^2)	Manufacturing size (nm)	Transistors(millions)
Sun Niagara (8 core)	380	0.75	90	279
AMD Opteron	199	0.75	90	233

- a. What is the yield of the AMD Opteron?
- b. What is the yield for an 8-core Sun Niagara processor?
- c. What do you observe? Which chip gives better yield?

12. This question is for Exercise purposes ONLY!! You don't have to include your solution in your submission.

Let's say your current computer is a 4 year old AMD 3rd generation opteron (model 6272) where your program takes 15 sec to run. You want to get a machine with a Intel processor in which you expect your program to run 20% faster (in terms of time) than your current computer and it is alright if the new computer has a clock cycle up to 10% quicker (faster) than your current computer. What would be the clock rate of your new Intel processor would be? Which of the Intel core i series processors would you choose that is close to the clock rate that you look for? Include the model number in your answer.