

CIS 775: Computer Systems Architecture
Autumn 2003
Homework #1

Instructor: Parthasarathy

Due: Thursday, 9th October

1. (25 points) You have been assigned the job of an architect to design a web server. For a typical access to a web page, let's assume that 20% time is spent on processing, 30% on disk access, and 50% on network transfer. You have a *base* system consisting of a 500 MHz processor and a disk with 20 MBytes/sec data transfer rate. This system costs \$5K and can support 10,000 average web page accesses/sec.

You are considering three options to enhance the system: Option 1: replacing the existing disk with a disk supporting 40 MBytes/sec data transfer rate with an additional (compared to the base) cost of \$1000; Option 2: replacing the processor with a 800 MHz processor with an additional (compared to the base) cost of \$800; and Option 3: using the two enhancements indicated in Options 1 and 2 together with an additional cost (compared to the base) of \$1500.

- (a) Determine what will be the new performance (in terms of average web page accesses per second) with each of the enhancement options.
 - (b) By doing a cost-performance analysis, determine which option will be cost-effective to go for and why?
2. (25 points) The Amdahl's law (as we discussed in the class) is based on the assumption that when an enhancement is performed to some part of the system, the enhancement does not have any negative impact on the non-enhanced part. However, in real life, it could lead to negative impact on the non-enhanced part. However, the Amdahl's law can be modified to take care of this situation.

Consider a computer system with two components A and B which can be enhanced. There is an interdependency between these components. An enhancement in one component affects the other. There exists three options for enhancement as suggested below. All options involve the same amount of cost.

Option A: Let us assume that f_A , the fraction of instructions using the component A, can be sped up by 10 times. However, due to the dependency of A on B, another fraction $2f_A$ will get slowed down by 5 times.

Option B: The instructions using the component B, fraction f_B , can be sped up by 20 times. The dependency forces another fraction $0.5f_B$ to get slowed down by 2 times.

Option C: A fraction f_A of instructions using the component A, can be sped up by a factor of 4. Unfortunately, the dependency forces another fraction f_A to get slowed down by 1.8 times.

- (a) Derive the parameterized speed-up equations (in terms of f_A , f_B) for each of the above three options.
 - (b) As a beginner architect which option will you prefer and why? Give convincing reasonings. Assume for a reasonable enhancement, you need to have $f_A > 0$ and $f_B > 0$.
3. (25 points) A set of three systems are being evaluated to be used in a laboratory environment. The environment uses three types of programs with a relative usage of 45% (pgm 1), 35% (pgm 2), and 20% (pgm 3), respectively. Each of these three programs have been benchmarked on these three systems individually and their execution times are shown in the following table:

<i>Programs</i>	<i>System 1</i>	<i>System 2</i>	<i>System 3</i>
Program 1	1.0 sec	2.0 sec	1.5 sec
Program 2	10.0 sec	7.0 sec	5.0 sec
Program 3	5.0 sec	3.0 sec	4.0 sec

- (a) Determine which of the above three systems will provide the best performance for the laboratory.
 - (b) The three systems cost as follows: \$8,000 (systems 1), \$5,000 (system 2), and \$6,500 (system 3). By doing a cost-performance analysis, indicate which one of these systems you will choose and why.
4. (25 points) An application running on a 500 MHz pipelined processor has 40% load-store, 35% arithmetic, and 25% branch instructions. The individual CPIs of these instructions are 5, 4, and 4, respectively.
- (a) Determine the overall CPI of this program execution on the given processor.
 - (b) The processor is being enhanced to operate at 300 MHz. Under this enhancement, the individual CPIs of load-store and arithmetic instructions are remaining unchanged. However, the individual CPI of branch instruction is getting stretched to 6 clock cycles. A new compiler is also developed for the new processor which eliminates 25% of load-store and 15% of arithmetic instructions for the given application.
 - i. Determine the overall CPI of this program execution on the new processor together with the new compiler technology.
 - ii. Determine the factor by which the application will run faster or slower on the new processor with the new compiler technology.