Northwestern Polytechnic University

EE488 - Computer Architecture
Homework Assignment #1

Due day: 9/29/2021

Instruction:

1. Push the answer sheet to Github in word file
2. Overdue homework submission could not be accepted.
3. Takes academic honesty and integrity seriously (Zero Tolerance of Cheating & Plagiarism)

1. Assuming that a web server with the architecture spends 20% on processing, 30% on disk access, and 50% on network transfer, you have a base system consisting of a 500MHz processor and a disk with 20Mbytes/sec data transfer rate. This system costs $5K and can support 10,000 average web page accesses/sec. Considering the following three options to enhance system performance:

   a. Option-1: replacing the existing disk with a disk supporting 40Mbytes/sec data transfer rate with an additional(compared to the base) cost of $1,000

   b. Option-2: replacing the processor with a 800MHz processor with an additional (compared to the base) cost of $800

   c. Option-3: using the two enhancements indicated in Option-1 & Option-2 together with an additional (compared to the base) cost of $1,500

   (1) Determine what will be the new performance (in terms of average web page accesses per second) with each of the enhancement options
   (2) By doing a cost-performance analysis, determine which option will be cost-effective to go for and why?

Answer : 1] Following are the performance considerations:

Performance = 1/(Execution Time)………..(i)

Case I : Data transfer rate for base system is 20 Mbytes/sec and for replaced disk is 40Mbytes/sec.
According to equation (i),
P=20/40 =0.5

Performance is 0.5 time better than the base system.

Case II: Base system had a 500MHZ processor and new processor was 800 MHz

$ET_{org}=1/(500*10^6)$ $=0.5nSec$

$ETnew=1/(800*10^6)$ $=0.8nSec$

Substituting these value in eq. (i) we get,
$ExecutionTime_{new}/ ExecutionTime_{old=} Performance_{old/} Performance_{new}=0.6$

This suggest that performance is 0.6 times better than old processor.
Case III : The performance of both disk and processor enhanced system will be 0.5 +0.6 =1.1 which is better than all other options but the expense is not suitable.

2] **Cost - Performance analysis:**

Based on above calculations considering ,
each 1% of improvement of processor cost 800/20=$40
each 1% of improvement of disk cost 1000/30=$33.33
So,second option 2 is cost effective .

2. The Amdahl's law is based on the assumption that when an enhancement is performed to some part of the system, the enhancement doesn't have any negative impact on the non-enhanced part. However, in the real life, it could lead to negative impact on these parts. Thus, 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 interdependency between these components. And enhancement in one component affects the other. There exist three options for enhancement as suggested below. All options involve the same amount of cost.

   a. Option-A: Let us assume that f_A, the fraction of instructions using component A, can be sped up by 10 times. However, due to the dependency of A on B, another fraction $2f_A$ will be get slowed down by 5 times
   b. Option-B: The instructions using component B, fraction f_B, can be sped up by 20 times. The dependency forces another fraction $0.5f_B$ to get slow down by 2 times
   c. 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.

   (1) Derive the parameterized speed-up equations (in terms of f_A, f_B) for each of the above three options

   (2) As a beginner architect, which option will be preferred and why? Give convincing reasoning. Assuming for a reasonable enhancement, you need to have $f_A > 0$ and $f_B > 0$

Awnser : 1]. The speed up equations are as below :-
S=1/(1-f)+ (f/k)
S= overall speed.
K= speed of faster comp
F= fraction of work performed by faster component.

Here in option (a) the system performance is sped up by 10 times but the negative impact on the system(slow down) is 5 times. So the total system sped up (10-5) =5

K=5

S= 1/ (1-3fa)+(3fa/5)……………….(i)

For option (b) the system performance is sped up by 20 times but the negative impact on the system(slow down) is 2 times. So the total system sped up (20-2) =18

K=18

S= 1/ (1-1.5fb)+(1.5fb/18)……………….(ii)

In option (c) the system performance is sped up by 4 times but the negative impact on the system(slow down) is 1.8 times. So the total system sped up (4-1.8) =2.2

K=2.2

S= 1/ (1-2fa)+(2fa/2.2)……………….(iii)

2]. Assuming fa fraction of work performed by component A is = 0.1 for eq (i) and (iii) and fb=0.1 for eq. (ii)

Speedup for the eq'n (i)

S=1/[(1-0.3)+(0.3/5)]

=1/(0.7+0.06)

=1.31

Speedup for the eq'n (ii)

S=1/[(1-0.15)+(0.15/18)]

=1/(0.85+0.008)

=1.17

Speedup for the eq'n (iii)

S=1/[(1-0.2)+(0.2/2.2)]

=1/(0.8+0.09)

=1.12

The preferred option will be third option , because it is better to have smaller speed up on most of the execution time than a huge part speedup on very small part of it.

3. A set of three systems are being evaluated to be used in a laboratory environment. This environment uses three types of programs with a relative usage of 45% (Program 1), 35% (Program 2), and 20% (Program 3) respectively. Each of these three programs has been benchmarked on these three systems individually and their execution times are shown as follows.

Programs	System 1	System 2	System 3
Programs 1	1.0 sec	2.0 sec	1.5 sec
Programs 2	10.0 sec	7.0 sec	5.0 sec
Programs 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 (System 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?

Answer: a) Calculating execution times for all the systems:

Sys 1:
45% * (ET1)+35% * (ET2)+20% * (ET3)
= 0.45*1 + 0.35*10 + 0.20*5
= 0.45+3.5+1.0
Exe. time= 4.95 sec …………………….(i)

Sys 2:
45% * (ET1)+35% * (ET2)+20% * (ET3)
= 0.45*2 + 0.35*7 + 0.20*3
= 0.9+2.45+0.6
Exec. time 2= 3.95 sec……………………..(ii)

Sys 3:
45% * (ET1)+35% * (ET2)+20% * (ET3)
= 0.45*1.5 + 0.35*5 + 0.20*4
= 0.675+1.75+0.8
Exec. time 3= 3.225 sec…………………(iii)

Comparing(i),(ii)&(iii), execution time of system 3 is less
So sys 3 provides the best performance in the laboratory.

(b) **Cost - Performance analysis:**

Sys1:
Cost /second for sys 1 = 8000/4.95 = $1616.16
Sys2:
Cost / second for sys 2 = 5000/3.95 = $1265.82
Sys3:
Cost /second for sys3 = 8000/4.95 = $2015.50

The sys 2 will be cost effective as compared to other two systems .