Nang Thiri Wutyi
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Assignment 1

1. (1) $f_{processing} = 0.2$
$f_{disk} = 0.3$
$f_{network} = 0.5$
Base system can handle 10,000 web page accesses/sec and costs $5k.

Amdahl's Law,
$$S = \frac{1}{(1-f)+\frac{f}{k}}$$

(a) Option 1: Replacing the disk with a disk supporting 40 Mbytes/sec with an additional cost of $1000,
The disk speedup , k_{disk} = 40/20 =2

Using Amdahl's law, $S_1 = \frac{1}{(1-0.3)+\frac{0.3}{2}} = 1.176$

New performance = 1.176 x 10000 = 11760 web page accesses/sec

(b) **Option 2 : Replacing the processor with an 800 MHz processor with an additional cost of $800**,
The processor speedup, $k_{processor}$ = 800/500 = 1.6

Using Amdahl's law, $S_2 = \frac{1}{(1-0.2)+\frac{0.2}{1.6}} = 1.081$

New performance = 1.081 x 10000 = 10810 web page accesses/sec

(c) **Option 3 : Using both enhancements with an additional cost of $1500,**

$S_3 = \frac{1}{(1-(0.3+0.2))+\frac{0.3}{2}+\frac{0.2}{1.6}} = 1.29$

New performance = 1.29 x 10000 = 12900 web page accesses/sec

(2) **cost-performance ratio =** $\frac{Additional\ cost}{Performance\ improvement}$

(a) Option 1: Replacing the disk with a disk supporting 40 Mbytes/sec with an additional cost of $1000,
Performance improvement = 11760 - 10000 = 1760
cost-performance ratio = $\frac{1000}{1760} = 0.568$

(b) Option 2 : Replacing the processor with an 800 MHz processor with an additional cost of \$800,

Performance improvement = 10810 - 10000 = 810

cost-performance ratio = $\frac{800}{810}$ = 0.988

(c) **Option 3 : Using both enhancements with an additional cost of \$1500,**

Performance improvement = 12900 - 10000 = 2900

cost-performance ratio = $\frac{1500}{2900}$ = 0.517

Based on the cost-performance analysis, **option 3**(using both enhancements) has the lowest cost-performance ratio of **0.517**, making it the best cost-effective choice.

2. f - fraction of work performed on the enhanced component
k - speedup factor of the enhanced component
f_d - fraction of work performed by dependent component
s_d - slowdown factor of the dependent component

To derive the parameterized speed-up equations for each of the given options, we'll take into account both the speedup of the enhanced component and the slowdown of the dependent component.

Modified Amdahl's law that includes the negative impact on the dependent component,

$$\mathbf{S} = \frac{1}{(1-f-fd) + \frac{f}{k} + fd.sd}$$

(1) Option A :

Speedup of component A, $k_A = 10$

Fraction of instructions using A, $f_A = f$

Slowdown of component B, $s_B = 5$

Fraction of instructions using B affected by A, $f_B = 2 . f$

The speedup equation for Option A is

$$S_A = \frac{1}{(1-f-2f)+\frac{f}{10}+2f.5}$$

$$\mathbf{S_A} = \frac{1}{1+6.9f}$$

Option B :

Speedup of component B, $k_B = 20$

Fraction of instructions using B, $f_B = f$

Slowdown of component A, $s_A = 2$

Fraction of instructions using A affected by B, $f_A = 0.5 \,.\, f$

The speedup equation for Option B is

$$S_B = \frac{1}{(1-f-0.5f)+\frac{f}{20}+0.5f.2}$$

$$\mathbf{S_B} = \frac{1}{1-0.45f}$$

Option C :
Speedup of component A, $k_A = 4$
Fraction of instructions using A, $f_A = f$
Slowdown of component B, $s_B = 1.8$
Fraction of instructions using B affected by A, $f_B = f$

The speedup equation for Option C is

$$S_C = \frac{1}{(1-f-f)+\frac{f}{4}+f.\,1.8}$$

$$\mathbf{S_C} = \frac{1}{1-1.55f}$$

(2) Option A : $\mathbf{S_A} = \frac{1}{1+6.9f}$
Option A offers a significant speed-up S_A with the speedup factor of component A being 10. However, it also imposes a slowdown factor of 5 on the dependent component B, affecting a fraction of 2f of its instructions. This means that while component A sees a substantial improvement, component B experiences a considerable slowdown due to the dependency.

Option B : $\mathbf{S_B} = \frac{1}{1-0.45f}$
Option B offers a moderate speed-up S_B with the speedup factor of component B being 20. However, it imposes a smaller slowdown factor of 2 on the dependent component A, affecting a fraction of 0.5f of its instructions.

Option C : $\mathbf{S_C} = \frac{1}{1-1.55f}$
Option C offers a modest speed-up S_C the speedup factor of component A being 4. It imposes a slowdown factor of 1.8 on the dependent component B, affecting the same fraction (f) of its instructions as component A.

Option B may be the preferred choice for a beginner architect. It offers a significant speedup for component B while imposing a relatively small slowdown on component A. This option provides a more predictable performance improvement and is less sensitive to variations in the workload distribution between components A and B compared to the other options.

3. **Amdahl's Law,**

$$S = \frac{1}{(1-f)+\frac{f}{k}}$$

(a) System 1,

$f_1 = 0.45$

$$k_1 = \frac{Execution\ time\ without\ enhancement}{Execution\ time\ with\ enhancement} = \frac{10}{1} = 10$$

$$S_1 = \frac{1}{(1-0.45)+\frac{0.45}{10}} = 1.68$$

System 2,

$f_2 = 0.35$

$$k_2 = \frac{Execution\ time\ without\ enhancement}{Execution\ time\ with\ enhancement} = \frac{7}{2} = 3.5$$

$$S_2 = \frac{1}{(1-0.35)+\frac{0.35}{3.5}} = 1.33$$

System 3,

$f_3 = 0.20$

$$k_3 = \frac{Execution\ time\ without\ enhancement}{Execution\ time\ with\ enhancement} = \frac{5.0}{1.5} = 3.33$$

$$S_3 = \frac{1}{(1-0.20)+\frac{0.20}{3.33}} = 1.16$$

Comparing the speedups, System 1 has the highest speedup and will provide the best performance for the laboratory.

(b) System 1:

Cost = \$8000

Performance Speedup $S_1 = 1.68$

Cost-performance ratio $= \frac{8000}{1.68} = 4761.90$

System 2:

Cost = \$5000

Performance Speedup $S_2 = 1.33$

Cost-performance ratio = $\frac{5000}{1.33}$ = 3759.40

System 3:

Cost = $6500

Performance Speedup $S_3 = 1.16$

Cost-performance ratio = $\frac{6500}{1.16}$ = 5603.45

Comparing the cost-performance ratio, **System 2** has the lowest ratio, and provides a reasonable balance between cost and performance.