



INSTITUTO SUPERIOR TÉCNICO

DEPARTAMENTO DE ENGENHARIA INFORMÁTICA

ORGANIZAÇÃO DE COMPUTADORES

LEIC

Conjunto de Exercícios II

Métricas de Desempenho

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Exercise 1

A design optimization was applied to a computer system in order to increase the performance of a given execution mode by a factor of 10. The optimized mode is used 50% of the time, measured as a percentage of the execution time *after* the optimization has been applied.

- (a) What is the global speedup value that is achieved with this optimization?

Remind: Amdahl's law defines the global speedup as a function of the optimized fraction *before* the optimization is applied. As a consequence, the 50% ratio cannot be directly used to evaluate this speedup value.

- (b) What is the percentage of the original execution time that is affected by this optimization?
- (c) How much should such execution mode be optimized in order to achieve a global speedup of 6? Can a global speedup of 12 be achieved? And 11?

Exercise 2 *

Consider three different processors P1, P2, and P3 executing the same instruction set with the clock rates and CPIs given in the following table.

Processor	Clock Rate	CPI
P1	3 GHz	1.5
P2	2.5 GHz	1.0
P3	4 GHz	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 of the program by increasing the clock speed but this leads to an increase of 20% in the CPI. What clock rate is necessary to get a time reduction of 30%(compared to the original time)?

Exercise 3 †

The following table shows the number of instructions for a program.

Arith	Store	Load	Branch	Total
650	100	600	50	1400

- (a) Assuming that arithmetic instructions take 1 cycle, load and store 5 cycles, and branches 2 cycles, what is the execution time of the program in a 2 GHz processor?
- (b) Find the CPI for the program.
- (c) If the number of load instructions can be reduced by one half, what is the speedup and the CPI?

*Exercises 1.3.1—1.3.3 from [1].

†Exercises 1.4.4—1.4.6 from [1].

Exercise 4[‡]

Consider two different implementations of the same instruction set architecture. There are four classes of instructions: A, B, C, and D. The clock rate and CPI of each implementation are given in the following table.

Processor	Clock Rate	CPI Class A	CPI Class B	CPI Class C	CPI Class D
P1	2.5 GHz	2	1.5	2	1
P2	3 GHz	1	2	1	1

- (a) Consider a program executing 10^6 instructions divided into classes as follows: 10% class A, 20% class B, 50% class C, and 20% class D. Determine which implementation is faster for this program.
- (b) What is the global CPI for each implementation for this program?
- (c) Find the clock cycles required in both cases.

References

- [1] David Patterson and John Hennessy. *Computer Organization and Design: The Hardware/Software Interface*. Morgan Kaufmann, 4th edition, 2011.

[‡]Exercises 1.4.1—1.4.3 from [1].

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Soluções

Exercise 1

- (a) 5.5
- (b) 91%
- (c) Yes it can with an optimization by a factor of 12. No, because factor can't be negative, so it is impossible. Also no, because ∞ optimization \rightarrow impossible.

Exercise 2

- (a) P2.
- (b) $\text{cycles}(P1) = 10 \times 3 \times 10^9 = 30 \times 10^9$
 $\text{cycles}(P2) = 10 \times 2.5 \times 10^9 = 25 \times 10^9$
 $\text{cycles}(P3) = 10 \times 4 \times 10^9 = 40 \times 10^9$

 $\text{inst}(P1) = 30 \times 10^9 / 1.5 = 20 \times 10^9$
 $\text{instr}(P2) = 25 \times 10^9 / 1 = 25 \times 10^9$
 $\text{instr}(P3) = 40 \times 10^9 / 2.2 = 18.18 \times 10^9$
- (c) $F_{\text{new}} = \frac{1.2}{0.7} \times \text{Fold}$

Exercise 3

- (a) 2125 ns.
- (b) 3.03
- (c) Speedup = 1.54,
CPI = 2.5

Exercise 4

- (a) P2
- (b) $\text{CPI}(P1) = 1.7$
 $\text{CPI}(P2) = 1.2$
- (c) clock cycle (P1) = 17×10^5
clock cycle (P2) = 12×10^5