ARQUITECTURA DE COMPUTADORES

UNIT 1. COMPUTER ABSTRACTIONS AND TECHNOLOGY

1.3 A program P consists of the following mix of operations: Floating Point Multiplication (MCF) 10%, Floating Point Addition (SCF) 15%, Floating Point Division (DCF) 5%, and Integer Operations (INT) 70%. A basic system does not have floating point unit, so it must emulate the corresponding operations by software. The number of integer instructions required in each emulation is MCF = 30 INT, SCF = 20 INT, DCF = 50 INT. Suppose that any integer instruction takes two clock cycles, and the working frequency is 100MHz.

a) A floating point unit has been designed as an improvement of the basic system. The number of clock cycles for each type of operation is reduced to MCF = 6 cycles, SCF = 4 cycles, and DCF = 10 cycles.
b) A floating point unit has been designed as an improvement of the basic system. The number of clock cycles for each type of operation is reduced to MCF = 15 cycles, SCF = 2 cycles, and DCF = 10 cycles.

In both cases, calculate in MIPS the frequency for the machine with and without the improvement. Applying Amdahl's law, calculate the global acceleration (AG) of the improved system.

1.7 The theoretical analysis of a system improvement allows to obtain an overall speedup of -2. Explain briefly the reasons of this result, if possible.

1.9 A specific workload running on certain system is represented by the following set of instructions:

Instruction	**Control**	**Arithmetic**	**Data transfer**	**Floating Point**
% of use	15%	47%	32%	6%
CPI	2	1	4	6

A new improvement consists on including an index addressing mode. For that, the compiler is modified to replace the following instructions:

ADD R1, R1, R2
LOAD R3, inm(R1) ; *R3 <- MEM(inm+R1)*

by a new instruction for data transfer that makes use of the new addressing mode:

$LOAD_{index}$ R3, R1, R2 ; *R3 <- MEM(R1+R2)*

The new addressing mode is used by the 25% of data transfer operations and requires increasing the clock cycle by 5%. Which system is faster? How much?

1.12 Two development groups from a tech company have independently improved a microprocessor design. The first group redesigned the multiplication unit and improved it by 25%. The second added a new memory system and now memory access is 3 times faster. These changes do not affect the system clock or the number of instructions. A test program takes 100 seconds to run, and uses 10% of the time in multiplication and 57% in memory accesses. The remaining time is used in other types of operations. It is required to calculate the overall acceleration after applying both improvements, using Amdahl's law.

1.13 There are two options for upgrading a computer. The first one makes floating point instructions run 4 times faster. The other option is to improve the memory interface by making accesses twice as fast. To check the performance, a program runs for a while, and before the improvements, 25% of the time is used in floating point operations, 50% in memory access and the rest in other tasks. Using Amdahl's Law:

a) Indicate which of the two improvements is more effective, if only one of them can be applied.

b) Calculate the global acceleration of the system after applying both improvements consecutively.

1.15 Part of a computer is improved, reducing the execution time of some instructions by a factor of 10. After upgrade, these instructions will use 50% of the total system time. Answer the following questions:

a) What is the improvement obtained?

b) What is the fraction of execution time enhanced?

1.16 While a system for running a video processing algorithm is under development, a problem is detected: the system is not able to work at real time. It requires 65 ms to process an image, while the video camera transfers 25 images per second.

a) What is the speedup necessary to work at real time?

A first proposed solution is to increase the clock frequency from 250 MHz to 400 MHz. This improvement does not affect the memory system, and for this specific image processing algorithm, 30% of the execution time is used for accessing memory. A second solution is to improve the memory system adding a cache memory. This cache memory duplicates the performance of the system.

b) What is the speedup if these two solutions are used independently? Based on the results, which improvement is the best? Is it possible to work at real time?

c) What is the speedup if these two solutions are used simultaneously? Is it possible to work at real time?

Solve questions b) and c) using Amdhl's law.