IFT 307
Computer Organization and Architecture

Mr. Ibrahim Lawal

Example

- Consider computing the overall CPI for a machine A for which the following performance measures were recorded when executing a set of benchmark programs. Assume that the clock rate of the CPU is 200 MHz.

Instruction category	Percentage of occurrence	No. of cycles per instruction
ALU	38	1
Load & store	15	3
Branch	42	4
Others	5	5

$$CPI = \frac{\sum_{i=1}^{n} CPI_i \times I_i}{Instruction\ count}$$

Assuming the execution of 100 instructions, the overall CPI can be computed as

$$CPI_a = \frac{\sum_{i=1}^{n} CPI_i \times I_i}{Instruction\ count} = \frac{38 \times 1 + 15 \times 3 + 42 \times 4 + 5 \times 5}{100} = 2.76$$

Example

- Suppose that the same set of benchmark programs considered above were executed on another machine, call it machine B, for which the following measures were recorded.

Instruction category	Percentage of occurrence	No. of cycles per instruction
ALU	35	1
Load & store	30	2
Branch	15	3
Others	20	5

What is the MIPS rating for the machine considered in the previous example(machine A) and machine B assuming a clock rate of 200 MHz?

$$CPI_a = \frac{\sum_{i=1}^{n} CPI_i \times I_i}{Instruction\ count} = \frac{38 \times 1 + 15 \times 3 + 42 \times 4 + 5 \times 5}{100} = 2.76$$

$$MIPS_a = \frac{Clock\ rate}{CPI_a \times 10^6} = \frac{200 \times 10^6}{2.76 \times 10^6} = 70.24$$

$$CPI_b = \frac{\sum_{i=1}^{n} CPI_i \times I_i}{Instruction\ count} = \frac{35 \times 1 + 30 \times 2 + 20 \times 5 + 15 \times 3}{100} = 2.4$$

$$MIPS_b = \frac{Clock\ rate}{CPI_a \times 10^6} = \frac{200 \times 10^6}{2.4 \times 10^6} = 83.67$$

Thus $MIPS_b > MIPS_a$.
It is interesting to note here that although MIPS has been used as a performance measure for machines, one has to be careful in using it to compare machines having different instruction sets.

This is because MIPS does not track execution time.
Consider, for example, the following measurement made on two different machines running a given set of benchmark programs.

Instruction category	No. of instructions (in millions)	No. of cycles per instruction
Machine (A)		
ALU	8	1
Load & store	4	3
Branch	2	4
Others	4	3
Machine (B)		
ALU	10	1
Load & store	8	2
Branch	2	4
Others	4	3

$$CPI_a = \frac{\sum_{i=1}^{n} CPI_i \times I_i}{Instruction\ count} = \frac{(8 \times 1 + 4 \times 3 + 4 \times 3 + 2 \times 4) \times 10^6}{(8 + 4 + 4 + 2) \times 10^6} \cong 2.2$$

$$MIPS_a = \frac{Clock\ rate}{CPI_a \times 10^6} = \frac{200 \times 10^6}{2.2 \times 10^6} \cong 90.9$$

$$CPU_a = \frac{Instruction\ count \times CPI_a}{Clock\ rate} = \frac{18 \times 10^6 \times 2.2}{200 \times 10^6} = 0.198\,\text{s}$$

$$CPI_b = \frac{\sum_{i=1}^{n} CPI_i \times I_i}{Instruction\ count} = \frac{(10 \times 1 + 8 \times 2 + 4 \times 4 + 2 \times 4) \times 10^6}{(10 + 8 + 4 + 2) \times 10^6} = 2.1$$

$$MIPS_b = \frac{Clock\ rate}{CPI_a \times 10^6} = \frac{200 \times 10^6}{2.1 \times 10^6} = 95.2$$

$$CPU_b = \frac{Instruction\ count \times CPI_a}{Clock\ rate} = \frac{20 \times 10^6 \times 2.1}{200 \times 10^6} = 0.21\ \text{s}$$

$$MIPS_b > MIPS_a \qquad \text{and} \qquad CPU_b > CPU_a$$

- The example above shows that although machine B has a higher MIPS compared to machine A, it requires longer CPU time to execute the same set of benchmark programs.

Thank You