2.5 Other metrics

- CPU time - recommended => real execution time
- MIPS, MFLOPS
- MIPS - Million Instructions Per Second $MIPS = \frac{\text{Instruction Count}}{\text{Execution time} \times 10^6} = \frac{\cancel{IC}}{\cancel{IC} \times CPI \times \text{Clock cycle time} \times 10^6} = \boxed{\frac{\text{Clock ratio}}{CPI \times 10^6}}$

Proof for MIPS inconsistence

1. MIPS is dependent of the instruction set
2. MIPS depends on the program
3. Sometimes MIPS varies inversely with performance

Comp. A   Comp B

$\boxed{MIPS_A > MIPS_B}$

$\Downarrow$

$CPU_{time_A} > CPU_{time_B}$

$\boxed{Perf_A < Perf_B}$

Example We consider a machine with the following characteristics when running a workload:

Operation	Frequency	Clock cycle count
ALU	43%	1
Loads	21%	2
Stores	12%	2
Branches	24%	2

- Compiler optimization → a reduction with 50% of arithmetic operations
- Clock cycle time = 20 ns
- Is the compiler optimization investment good or not?

$MIPS = \frac{\text{Clock rate}}{CPI \times 10^6}$ $\text{Clock rate} = \frac{1}{20ns} = \frac{1}{20 \cdot 10^{-9}} \frac{1}{s} = \frac{10^9}{20} Hz = \frac{\overset{50}{\cancel{1000}}}{\cancel{20}} \cdot 10^6 Hz = 50 MHz$

$MIPS_{original} = \frac{50 \cdot \cancel{10^6} Hz}{CPI \times \cancel{10^6}}$ $CPI_{original} = 0.43 \times 1 + 0.57 \times 2 = 0.43 + 1.14 = 1.57$ c.c.

$MIPS_{original} = \frac{50}{1.57} = \boxed{31.85}$ $CPU_{time_{original}} = IC_{original} \times 1.57 \times 20ns = \boxed{IC_{original} \times 31.4 ns}$

$IC_{optimized} = IC_{original} \left(1 - \frac{0.43}{2}\right)$

0.215
0.48
0.24
0.48
1.355

$CPI_{optimized} = \frac{\left(\frac{0.43}{2} \times 1 + 0.21 \times 2 + 0.12 \times 2 + 0.24 \times 2\right) \times IC_{\cancel{original}}}{\left(1 - \frac{0.43}{2}\right) IC_{\cancel{original}}} = \frac{1.355}{0.785} = 1.73$

Original is better!

$MIPS_{optimized} = \frac{50 \cdot \cancel{10^6} Hz}{1.73 \cdot \cancel{10^6}} = \boxed{28.9}$

Optimized is better!

$CPU_{time_{optimized}} = IC_{original} \cancel{\left(1 - \frac{0.43}{2}\right)} \cdot \frac{\left(\frac{0.43}{2} \times 1 + 0.21 \times 2 + 0.12 \times 2 + 0.24 \times 2\right)}{\cancel{\left(1 - \frac{0.43}{2}\right)}} \times 20ns =$

$= IC_{original} \cdot 1.355 \times 20ns = \boxed{27.2 ns} \times IC_{original}$

- Until now we discussed Native MIPS
- Possible solution: RELATIVE MIPS $= \frac{\text{Time reference}}{\text{Time unrated}} \times MIPS_{reference}$
- VAX 11/780 — 1 MIPS machine
- Extreme caution when analyzing performance w/ MIPS

MFLOPS - Million Floating Point Operations Per Second

$MFLOPS = \frac{\text{No of FP operations}}{\text{Execution time} \times 10^6}$

Pros and cons

1. Relevant only when the computing system operates in FP
2. MFLOPS is more "fair" than MIPS (less variation in FP ops)
3. Different machines have different FP instruction <instr. set> sets

(2) MFLOPS is more "fair" than MIPS (less variation in FP ops)
(3) Different machines have different FP instruction <inst. set> sets.
(4) Different FP / Fixed Point Ratios in instruction sets.

Solution → Normalized FLOPS

Livermore Loops

McMahon from Lawrence Livermore Laboratory

Real FP op	Normalized FP operation
+, *, COMP	1
/, Sqrt	4
Exp, Sin	8