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Computer Architecture Exercise 2

1. The formula for the SPEC score of a computer under test is:

$$SPEC_{REF}(test) = \left[\prod_{i=1}^{n} \frac{T_i^{REF}}{T_i^{test}}\right]^{1/n}$$

Given the SPEC scores for two computers, the test computer and computer A, prove that the score for computer test relative to computer A (using computer A instead of the reference computer REF) is given by

$$SPEC_A(test) = \frac{SPEC_{REF}(test)}{SPEC_{REF}(A)}$$

We will prove that it's possible to calculate the score for computer test relative to computer A by the next formula:

$$SPEC_A(test) = \frac{SPEC_{REF}(test)}{SPEC_{REF}(A)} = \frac{\left[\prod_{i=1}^{n}\frac{T_i^{REF}}{T_i^{test}}\right]^{\frac{1}{n}}}{\left[\prod_{i=1}^{n}\frac{T_i^{REF}}{T_i^{A}}\right]^{\frac{1}{n}}} = \left[\frac{\prod_{i=1}^{n}\frac{T_i^{REF}}{T_i^{test}}}{\prod_{i=1}^{n}\frac{T_i^{REF}}{T_i^{A}}}\right]^{\frac{1}{n}} = \left[\prod_{i=1}^{n}\left(\frac{\frac{T_i^{REF}}{T_i^{test}}}{\frac{T_i^{REF}}{T_i^{A}}}\right)\right]^{\frac{1}{n}} =$$

$$\left[\prod_{i=1}^{n}\left(\frac{T_i^{A}}{T_i^{test}}\right)\right]^{\frac{1}{n}} = s(\text{test machine on A}).$$

2. The following are test results on SPEC CINT2017 for two Intel CPUs: (http://www.spec.org/cpu2017/results/cint2017.html)

CPU	Clock Rate	Cores	Parallel Compilation	Cint2017
Xeon Gold 6146	3.40 GHZ	48	Yes	10.57
Xeon Platinum 8153	2.20 GHZ	64	Yes	7.70

A. Which processor is faster? Explain.

The faster processor is the Xeon Gold 6146 processor because the score it received in the Cint2017 SPEC test is higher.

B. Find the speedup of the 6146 relative to the 8153.

$SPEC_{\text{Xeon Gold 6146 3.40 GHZ}}(\text{Xeon platinum 8153 2.20 GHZ}) = \frac{10.57}{7.70} \approx 1.3727$

C. According to the formula

$$S = \frac{T^{old}}{T^{new}} = \frac{\text{program clock cycles}^{old}}{\text{program clock cycles}^{new}} \times \frac{\text{clock rate}^{new}}{\text{clock rate}^{old}}$$

Find the ratio of the clock cycles required to run a program on the 8153 relative to the 6146.

$$1.137 = \frac{T^{old}}{T^{new}} = \frac{\text{program clock cycles}^{\text{Xeon Platinum 8153}}}{\text{program clock cycles}^{\text{Xeon Gold 6146}}} \times \frac{3.40\ \text{GHZ}}{2.20\ \text{GHZ}}$$

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$$\frac{1.137}{\frac{\text{program clock cycles}^{\text{Xeon Platinum 8153}}}{\text{program clock cycles}^{\text{Xeon Gold 6146}}}} = \frac{3.40\ \text{GHZ}}{2.20\ \text{GHZ}}$$

$$\frac{\text{program clock cycles}^{\text{Xeon Platinum 8153}}}{\text{program clock cycles}^{\text{Xeon Gold 6146}}} = \frac{1}{1.137} \times \frac{3.40\ \text{GHZ}}{2.20\ \text{GHZ}} \approx 1.3592$$

D. If the clock rate for both CPUs were the same, which processor would be faster?

If the clock rate for both CPUs were the same, we would get that the ratio between the number of clock cycles that is needed to run a program on the 8153 processor and the number on the 6146 processor is 0.879.
It means that the faster processor is the Xeon Platinum 8153.

3. Translate the following instructions to the formal definition language, as in the example

ADD R2, R9, (1001) **Regs[R2] ← Regs[R9] + Mem[1001]**

1) SUB R2, 12, 4(R4) : Regs[R2] ← 12 + Mem[4 + Regs[R4]]
2) MULT R2, R3, 10(R4) : Regs[R2] ← Regs[R3] * Mem[10 + Regs[R4]]
3) ADD R4, R5, (R2 + R3) : Regs[R4] ← Regs[R5] + Mem[Regs[R2] + Regs[R3]]
4) ADD (R2)+, R4, R5 : Regs[R2] ← Regs[R2] + 4 ← Regs[R4] + Regs[R5]
   (d = 4)
5) SUB 100(R6) [R4], R9, 12 : Mem[100 + Regs[R6] + Regs[R4]*8] ← Regs[R9] – 12
   (d = 8)

4. Write the sequence of operations required to perform **Z = 5*W + 2*X - 4*Y** for each of the four processor structures:

Stack

push w
push 5
mult
push x
push 2
mult
add
push y

push 4
mult
sub
pop z

b. Accumulator

load w
mult 5
store first
load x
mult 2
add first
store second
load y
mult 4
sub second

c. Register-memory

mult R1, w, 5
mult R2, x, 2
mult R3, y, 4
sub R4, R2, R3
add z, R1, R4

d. Register-register

load R1, w
load R2, x
load R3, y
mult R1, R1, 5
mult R2, R2, 2
mult R3, R3, 4
sub R2, R2, R3
add R1, R1, R2
store z, R1