Chapter 1

Mathematical Problems

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- For a specific machine, total instruction count = 2x10^9, Avg CPI = 3 cycles/instruction, clock rate = 100MHz. We want to improve the compiler to have instruction count = 10^9, new CPI = 4 cycles/instruction, clock rate =250MHz. By what percentage is the new compiler improved?

$$\text{CPU Time} = \text{Instructio n Count} \times \text{CPI} \times \text{Clock Cycle Time}$$

CPU Time for Computer A = (2x10^9 x 3) / 100 MHz

CPU Time for Computer B = (10^9 x 4)/ 250 MHz

Percentage of Improvement = ((CPU Time for Computer A - CPU Time for Computer B)/ CPU Time for Computer A)) x 100

Percentage of Improvement = (44x10^6)/6x10^7 x100% = 73.33%

- assume a new CPU has 6% less capacitive load compared to an existing CPU and has an 2% reduction in voltage . Now **calculate the reduction in overall power use**.

$$\text{Power} = \text{Capacitive load} \times \text{Voltage}^2 \times \text{Frequency}$$

P(new) = Capacitive Load (1-.06) x (Voltage (1-.02))^2 x F

P(new) = (0.94) Capacitive Load x ((.98)Voltage)^2 x F

P(new)/ P(old) = (0.94) Capacitive Load x ((.98)Voltage)^2 x F/ Capacitive Load x (Voltage)^2 x F

P(new)/ P(old) = 0.902

Reduction in Power = (1- 0.902) x 100%

SPEC Ratio

- SPEC Ratio for a specific program = Reference Time/ Current CPU Time

- Given 2 Programs,
- Program A, Instruction Count = 10 , CPI=3, **Clock Period = 3 s**
  Reference Time = 500s
- Program B , Instruction Count = 50 , CPI=7, **Clock Period = 3 s**
  Reference Time = 2000s

CPU Time for A = 90s

SPEC Ratio= 500/90 = 5.55

CPU Time for B = 1050s

SPEC Ratio= 2000/1050 = 1.9

Geometric Mean = (a0x a1x ....x an)^1/n

Geometric Mean = (5.55x1.9)^1/2 =3.24

- Now, assume that a particular operation takes **2.5X%** of the total execution time. What improvement is required if we want **2.5** times speedup in that operation, where **X** is equal to 10.

$$T_{improved} = \frac{T_{affected}}{improvemen\ \ t\ factor} + T_{unaffected}$$

100/2.5 = 25/n + 75

- Suppose you are training a face recognition model, which is heavily dependent on a process **(80%)**. So, you installed a graphics card with to speed up that process. Now, you observe that it is taking only **3 days** to execute, as opposed to **6 days** before installing the card. What is the improvement?

$$T_{improved} = \frac{T_{affected}}{\text{improvemen t factor}} + T_{unaffected}$$

Improved time = 3 days, Affected Time = 6x0.8 = 4.8

3=4.8/n + 1.2

N = 2.67