國立清華大學資訊工程學系
CS 4100 -- 計算機結構
100 學年度下學期
Homework #1 Solution

1.1

Clock cycles = $\sum_{i=1}^{n}(CPI_i \times \text{instruct. count}_i)$

Clock cycles_{P1}= $(1\times10^6\times10\%) + (2\times10^6\times20\%) + (3\times10^6\times50\%) + (4\times10^6\times20\%)$

$= 10^6\times(0.1+0.4+1.5+0.8) = 2.8\times10^6$

Clock cycles_{P2}= $(2\times10^6\times10\%) + (2\times10^6\times20\%) + (2\times10^6\times50\%) + (2\times10^6\times20\%)$

$= 10^6\times(0.2+0.4+1.0+0.4) = 2.0\times10^6$

CPU time = clock cycles / clock rate

CPU time_{P1} = $(2.8\times10^6) / (2\times10^9) = 1.4\times10^{-3}$ s, CPU time_{P2} = $(2.0\times10^6) / (1.5\times10^9) = 1.33\times10^{-3}$ s

=> CPU time_{P2} < CPU time_{P1}, P2 is faster

1.2

CPI = clock cycles / instruct. count

$CPI_{P1} = 2.8\times10^6 / 10^6 = 2.8$, $CPI_{P2} = 2.0\times10^6 / 10^6 = 2.0$

1.3

From 1.1

Clock cycles_{P1} = 2.8×10^6, Clock cycles_{P2} = 2.0×10^6

1.4

Clock cycles = (500×1) + (50×6) + (100×6) + (50×2) = 500 + 300 + 600 + 100 = 1500

Execution time = clock cycles / clock rate = 1500 / (4×10^9) = 375 ns

1.5

CPI = clock cycles / instruct. Count = 1500 / (500+50+100+50) = 1500 / 700 = 2.14

1.6

Clock cycles = (500×1) + (50×6) + (100/2×6) + (50×2) = 500 + 300 + 300 + 100 = 1200

Execution time = clock cycles / clock rate = 1200 / (4×10^9) = 300 ns

Speed-up = old execution time / new execution time = 375 ns / 300 ns = 1.25

CPI = clock cycles / instruct. Count = 1200 / (500+50+50+50) = 1200 / 650 = 1.85

2.1

$\text{Power}_1 = C_1\times V_1^2\times\text{clock rate}_1$, $\text{Power}_2 = C_2\times V_2^2\times\text{clock rate}_2 = 0.9\times\text{Power}_1$

$C_2 / C_1 = (0.9\times V_1^2\times\text{clock rate}_1) / (V_2^2\times\text{clock rate}_2)$

$= (0.9\times5^2\times0.8\times10^9) / (3.2^2\times1\times10^9) = 1.76$

2.2

$Power_2 / Power_1 = (V_2^2 \times clock\ rate_2) / (V_1^2 \times clock\ rate_1)$

$= (3.2^2 \times 1 \times 10^9) / (5^2 \times 0.8 \times 10^9) = 0.512$ => Reduction of 48.8%

2.3

$Power_2 = (0.8 \times C_1) \times V_2^2 \times clock\ rate_2 = 0.8 \times C_1 \times V_2^2 \times 1 \times 10^9 = 0.6 \times Power_1$

$Power_1 = C_1 \times V_1^2 \times clock\ rate_1 = C_1 \times 5^2 \times 0.8 \times 10^9$

$0.8 \times C_1 \times V_2^2 \times 1 \times 10^9 = 0.6 \times C_1 \times 5^2 \times 0.8 \times 10^9$

$V_2 = ((0.6 \times 5^2 \times 0.8 \times 10^9) / (0.8 \times 1 \times 10^9))^{1/2} = (15)^{1/2} = 3.87$ v

3.1

CPU time = instruct. count × CPI / clock rate

$CPU\ time_{P1} = (10^6 \times 1.5) / (4 \times 10^9) = 0.375 \times 10^{-3}$ s

$CPU\ time_{P2} = (10^6 \times 0.8) / (3 \times 10^9) = 0.267 \times 10^{-3}$ s

=> $CPU\ time_{P1} > CPU\ time_{P2}$, so $performance_{P1} < performance_{P2}$

=> $clock\ rate_{P1} > clock\ rate_{P2}$, but $performance_{P1} < performance_{P2}$, so it's false.

3.2

$CPU\ time_{P1} = (10^6 \times 1.5) / (4 \times 10^9) = 0.375 \times 10^{-3}$ s

$CPU\ time_{P2} = CPU\ time_{P1}$

Assume the number of instructions of P2 is N

$(N \times 0.8) / (3 \times 10^9) = 0.375 \times 10^{-3}$ s

=> $N = 1.41 \times 10^6$

3.3

$MIPS = (clock\ rate / CPI) \times 10^{-6}$

$MIPS_{P1} = (4 \times 10^9 / 1.5) \times 10^{-6} = 2667$

$MIPS_{P2} = (3 \times 10^9 / 0.8) \times 10^{-6} = 3750$

$MIPS_{P1} < MIPS_{P2}$, and $performance_{P1} < performance_{P2}$(From 3.1), so it's true in this case.

4

SPECratio = reference time / your execution time

Geometric mean = (the multiplication of five SPECratio)$^{1/5}$

The "CPU spec" means the specification of CPU.

If you use the CS workstation, you can use the instruction "more /proc/cpuinfo" to see the CPU spec.