Com S 321 Homework 2 Due: Thursday, Sept. 7, Midnight
Fall 2017

1. For the purpose of solving a given application problem, you benchmark a program on two computer systems. On system A, the object code executed 30 million Arithmetic Logic Unit operations (ALU ops), 75 million load instructions, and 45 million branch instructions. On system B, the object code executed 30 million ALU ops, 60 million loads, and 30 million branch instructions. In both systems, assume that each ALU op takes 1 clock cycles, each load takes 2 clock cycles, and each branch takes 4 clock cycles.

(a) Compute the relative frequency of occurrence of each type of instruction executed in both systems. Show all your work.
(b) Find the CPI for each system. Show all your work.
(c) Assuming that the clock on system A is 20% faster than the clock on system B, which system is faster for the given application problem and by how much percent? Justify your answer quantitatively. Show all your work. (Note: A system with a faster clock rate produces a smaller clock cycle time.)

2. For the purpose of solving a given application problem, you benchmark a program on two computer systems. On system A, the object code executed 20 million Arithmetic Logic Unit operations (ALU ops), 40 million load instructions, and 30 million branch instructions. On system B, the object code executed 25 million ALU ops, 50 million loads, and 20 million branch instructions. In both systems, each ALU op takes 2 clock cycles, each load takes 4 clock cycles, and each branch takes 6 clock cycles.
(a) Compute the relative frequency of occurrence of each type of instruction executed in both systems. Show all your work.
(b) Find the CPI for each system. Show all your work.
(c) Assuming that the clock cycle rate on system B is 15% faster than system A, which system is faster for the given application problem and by how much percent? Justify your answer quantitatively and show all your work.

3. Let us assume that we would like to budget our monthly shopping expenditures for clothes. We go shopping quite often, and rather than monitor each individual purchase, we are willing to settle for some average figure for the price per item. We do not care how many individual items are purchased as long as the average price per item does not exceed our budgeted average. Suppose, for example, that during the last month the following items were purchased:

Name	Quantity	Price per item	Total Price
Item A	4	$ 100	$ 400
Item B	4	$ 200	$ 800
Item C	7	$ 300	$ 2,100

(a) Compute the average price per item using the above data.
(b) Use Method 5 described in class (adjust the old relative frequencies) to compute the new average price per item when you return one piece each of items A, B, and C.

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Inst. Type	# of C.C	# of Inst. A	# of Inst. B
ALU Ops	1	30M	30M
L.I	2	75M	60M
B.I	4	45M	30M

(a) $R.F = \frac{\text{\# of Int.}}{\text{Total \# of Inst.}}$

* CPU Exec.T = I.C * CPI * $\frac{1}{\text{Clock Rate}}$
* // // // = // // // * Clock Cycle Time (CCT)
* CPI = Average # of clock cycles per instr. = $\frac{\text{Total \# of C.C}}{\text{total \# of Inst.}}$

For System A:

$ALU = \frac{30}{150} = 0.2$

$L.I = \frac{75}{150} = 0.5$

$B.I = \frac{45}{150} = 0.3$

For System B:

$ALU = \frac{30}{120} = 0.25$

$L.I = \frac{60}{120} = 0.5$

$B.I = \frac{30}{120} = 0.25$

(b) $CPI = \frac{\text{Total \# of C.C}}{\text{Total \# of Inst.}}$

$$CPI_A = \frac{(1 \cdot 30M) + (2 \cdot 75M) + (4 \cdot 45M)}{150M} = 2.4$$

$$CPI_B = \frac{(1 \cdot 30 \cdot 10^6) + (2 \cdot 60 \cdot 10^6) + (4 \cdot 30 \cdot 10^6)}{120 \cdot 10^6} = 2.25$$

(c) $CCT_B = 1.2 * CCT_A$

CPU Exec. Time = I.C * CPI * CCT

$$\text{CPU Exec. Time}_A = 150 * 10^6 * 2.4 * CCT_A$$
$$= 360 * 10^6 * CCT_A$$

$$\text{CPU Exec. Time}_B = 120 * 10^6 * 2.25 * 1.2 * CCT_A$$
$$= 324 * 10^6 * CCT_A$$

$$\frac{360}{324} = 1 + \frac{N}{100}, \quad N = 11.11$$

$\boxed{\text{Thus, System B is faster by 11.11\% than System A.}}$

2)

Inst. Type	# of C.C	# of Inst. A	# of Inst. B
ALU Ops	2	$20 \cdot 10^6$	$25 \cdot 10^6$
L.I	4	$40 \cdot 10^6$	$50 \cdot 10^6$
B.I	6	$30 \cdot 10^6$	$20 \cdot 10^6$

(a) $R.F = \dfrac{\text{\# of Inst.}}{\text{Total \# of Inst.}}$

System A:

$$ALU = \frac{20 \cdot 10^6}{90 \cdot 10^6} \approx 0.22$$

$$L.I = \frac{40 \cdot 10^6}{90 \cdot 10^6} \approx 0.44$$

$$B.I = \frac{30 \cdot 10^6}{90 \cdot 10^6} \approx 0.33$$

System B:

$$ALU = \frac{25}{95} \approx 0.26$$

$$L.I = \frac{50}{95} \approx 0.53$$

$$B.I = \frac{20}{95} \approx 0.21$$

(b) $CPI = \dfrac{\text{Total \# of C.C}}{\text{Total \# of Inst.}}$

$$CPI_A = \frac{(2\cdot 20\cdot 10^6) + (4\cdot 40\cdot 10^6) + (6\cdot 30\cdot 10^6)}{90\cdot 10^6} \approx 4.22$$

$$CPI_B = \frac{(2\cdot 25\cdot 10^6) + (4\cdot 50\cdot 10^6) + (6\cdot 20\cdot 10^6)}{95\cdot 10^6} \approx 3.89$$

(c) $CCT_A = 1.15 * CCT_B$

CPU Exec.Time = I.C * CPI * CCT

$$\text{CPU Exec.Time}_A = 90 * 10^6 * 4.22 * 1.15 * CCT_B$$
$$= 436.77 * 10^6 * CCT_B$$

$$\text{CPU Exec.Time}_B = 95 * 10^6 * 3.89 * CCT_B$$
$$= 369.55$$

$$\frac{436.77}{369.55} = 1 + \frac{N}{100}, \quad N = 18.19$$

Thus, System B is faster by approximately 18.19% than System A

3 (a) $A = \dfrac{400}{15} \approx 26.67$

$B = \dfrac{800}{15} \approx 53.33$

$C = \dfrac{2100}{15} \approx 140$

Total Avg. $= \dfrac{3300}{15} = 220$

(b)

Items	Quantiy	Price
A	4	100 \$
B	4	200 \$
C	7	300 \$

$$\text{Old R.F} = \left(\frac{4}{15} * 100\right) + \left(\frac{4}{15} * 200\right) + \left(\frac{7}{15} * 300\right) = 220\,\$$$

→ Adjusted :

Items	Quantity	Price
A	3	100 \$
B	3	200 \$
C	6	300 \$

$$\text{Adjusted R.F} = \frac{\left[\left(\frac{4}{15} - \frac{1}{15}\right) * 100\right] + \left[\left(\frac{4}{15} - \frac{1}{15}\right) * 200\right] + \left[\left(\frac{7}{15} - \frac{1}{15}\right) * 300\right]}{1 - \frac{3}{15}}$$

$$\boxed{= 225\,\$}$$