Computer Architecture
Spring 2019
Homework No. 2
(Due on April 1)

1. a)

CPI = $\frac{Clock\ Cycle}{Instruction\ Count} = \frac{\frac{Execution\ Time}{Clock\ Cycle\ Time}}{Instruction\ count} = \frac{Execution\ Time}{Instruction\ Count \times Clock\ Cycle\ Time}$

CPI of A = $\frac{1.1\ sec}{1.0 \times 10^9 \times 10^{-9}\ sec} = 1.1$

CPI of B = $\frac{1.5\ sec}{1.2 \times 10^9 \times 10^{-9}\ sec} = 1.25$

1. b)

Clock cycle time = $\frac{Execution\ Time}{Clock\ Cycle} = \frac{Execution\ Time}{Instruction\ Count \times CPI}$

Clock cycle time of A = $\frac{Execution\ Time}{1 \times 10^9 \times 1.1}$

Clock cycle time of B = $\frac{Execution\ Time}{1.2 \times 10^9 \times 1.25}$

Rate between clock cycle time of A and B = $\frac{Clock\ Cycle\ Time\ of\ A}{Clock\ Cycle\ Time\ of\ B} = \frac{1.2 \times 10^9 \times 1.25}{1 \times 10^9 \times 1.1} = \frac{1.5}{1.1} \approx 1.36$

Therefore, B is 1.36 times faster than A

1. c)

Since they use same processors, clock cycle time of every processor is same

Execution time = Clock cycle time $\times$ Instruction Count $\times$ CPI $= 10^{-9} sec \times 6.0 \times 10^8 \times 1.1 = 0.66\ sec$

Speedup versus A = $\frac{1.1\ sec}{0.66\ sec} \approx 1.67$

Speedup versus B = $\frac{1.5\ sec}{0.66\ sec} \approx 2.27$

Therefore, 1.67 times faster than A, 2,27 times faster than B

2. 1

$$\text{Execution Time} = \frac{Instruction\ Count\ \times CPI}{Clock\ Cycle\ rate}$$

$$\text{Execution Time for 1 processor} = \frac{1 \times 2.56 \times 10^9 + 12 \times 1.28 \times 10^9 + 5 \times 2.56 \times 10^8}{2 \times 10^9\ Hz} = \frac{19.2}{2} sec$$

$$= 9.6 sec$$

$$\text{Execution Time for 2 processor} = \frac{\frac{1 \times 2.56 \times 10^9 + 12 \times 1.28 \times 10^9}{0.7 \times 2} + 5 \times 2.56 \times 10^8}{2 \times 10^9\ Hz}$$

$$= \frac{14.08}{2} \text{sec} = 7.04\ sec$$

$$\text{Execution Time for 4 processor} = \frac{\frac{1 \times 2.56 \times 10^9 + 12 \times 1.28 \times 10^9}{0.7 \times 4} + 5 \times 2.56 \times 10^8}{2 \times 10^9\ Hz}$$

$$= \frac{7.68}{2} \text{sec} = 3.84\ sec$$

$$\text{Execution Time for 8 processor} = \frac{\frac{1 \times 2.56 \times 10^9 + 12 \times 1.28 \times 10^9}{0.7 \times 8} + 5 \times 2.56 \times 10^8}{2 \times 10^9\ Hz}$$

$$= \frac{4.48}{2} \text{sec} = 2.24\ sec$$

$$\text{Relative speedup of using 2 processor} = \frac{9.6\ sec}{7.04\ sec} = 1.36$$

$$\text{Relative speedup of using 4 processor} = \frac{9.6\ sec}{3.84\ sec} = 2.5$$

$$\text{Relative speedup of using 8 processor} = \frac{9.6\ sec}{2.24\ sec} = 4.29$$

2. 2

$$\text{Execution Time for 1 processor} = \frac{2 \times 2.56 \times 10^9 + 12 \times 1.28 \times 10^9 + 5 \times 2.56 \times 10^8}{2 \times 10^9\ Hz}$$

$$= \frac{21.76}{2} sec = 10.88 sec$$

$$\text{Execution Time for 2 processor} = \frac{\frac{2 \times 2.56 \times 10^9 + 12 \times 1.28 \times 10^9}{0.7 \times 2} + 5 \times 2.56 \times 10^8}{2 \times 10^9\ Hz}$$

$$\approx \frac{15.91}{2} \text{sec} \approx 7.95\ sec$$

$$\text{Execution Time for 4 processor} = \frac{\frac{2 \times 2.56 \times 10^9 + 12 \times 1.28 \times 10^9}{0.7 \times 4} + 5 \times 2.56 \times 10^8}{2 \times 10^9\ Hz}$$

$$\approx \frac{8.59}{2} \text{sec} \approx 4.30\ sec$$

$$\text{Execution Time for 8 processor} = \frac{\frac{2 \times 2.56 \times 10^9 + 12 \times 1.28 \times 10^9}{0.7 \times 8} + 5 \times 2.56 \times 10^8}{2 \times 10^9\ Hz}$$

$$\approx \frac{4.94}{2} \text{sec} \approx 2.47\ sec$$

2. 3

We can construct following equality.

$$\frac{1 \times 2.56 \times 10^9 + x \times 1.28 \times 10^9 + 5 \times 2.56 \times 10^8}{2 \times 10^9\ Hz} = 3.84 sec$$

$$\frac{2.56 + x \times 1.28 + 1.28}{2} = 3.84$$

$$0.64 \times (x + 3) = 3.84$$

$$x = 3$$

Therefore, it must be reduced to 3

3.

Execution time for 2 processor: $\frac{100}{2} + 4sec$ = 54 sec

Speedup for 2 processor = $\frac{100}{54} \approx 1.85$

Ratio between original one $\approx \frac{50}{54} \approx 0.93$

Execution time for 4 processor: $\frac{100}{4} + 4sec$ = 29 sec

Speedup for 4 processor = $\frac{100}{29} \approx 3.45$

Ratio between original one $\approx \frac{25}{29} \approx 0.86$

Execution time for 8 processor: $\frac{100}{8} + 4sec$ = 16.5 sec

Speedup for 8 processor = $\frac{100}{16.5} \approx 6.06$

Ratio between original one $\approx \frac{12.5}{16.5} \approx 0.76$

Execution time for 16 processor: $\frac{100}{16} + 4sec$ = 10.25 sec

Speedup for 16 processor = $\frac{100}{10.25} \approx 9.76$

Ratio between original one $\approx \frac{6.25}{10.25} \approx 0.61$

Execution time for 32 processor: $\frac{100}{32} + 4sec \approx$ 7.13 sec

Speedup for 32 processor = $\frac{100}{7.13} \approx 14.03$

Ratio between original one $\approx \frac{3.13}{7.13} \approx 0.44$

Execution time for 64 processor: $\frac{100}{64} + 4sec \approx$ 5.56 sec

Speedup for 64 processor = $\frac{100}{5.56} \approx 17.99$

Ratio between original one $\approx \frac{1.56}{5.56} \approx 0.28$

Execution time for 128 processor: $\frac{100}{128} + 4sec \approx$ 4.78 sec

Speedup for 128 processor = $\frac{100}{4.78} \approx 20.92$

Ratio between original one $\approx \frac{0.78}{4.78} \approx 0.16$

4. a)

Average CPU time for A = $\frac{1}{3}(5 + 50 + 30) = \frac{85}{3} \approx 28.33\ sec$

Average CPU time for B = $\frac{1}{3}(20 + 10 + 100) = \frac{130}{3} \approx 43.33\ sec$

Average CPU time for C = $\frac{1}{3}(40 + 30 + 5) = \frac{75}{3} = 25\ sec$

4. b)

Average MIPS for A = $\frac{3}{\frac{1}{40}+\frac{1}{4}+\frac{1}{2}} = \frac{120}{31} \approx 3.87\ MIPS$

Average MIPS for B = $\frac{3}{\frac{1}{30}+\frac{1}{10}+\frac{1}{1}} = \frac{90}{34} \approx 2.65\ MIPS$

Average MIPS for C = $\frac{3}{\frac{1}{20}+\frac{1}{8}+\frac{1}{50}} = \frac{600}{39} \approx 15.38\ MIPS$

4. c)

	A(Normalized to B)	B(Reference Machine)	C(Normalized to B)
Program 1	25%	100%	200%
Program 2	500%	100%	300%
Program 3	30%	100%	20%
Geometric Mean	72%	100%	106%

Because

A: $\sqrt[3]{\frac{1}{4} \cdot \frac{5}{1} \cdot \frac{3}{10}} = \sqrt[3]{\frac{3}{8}} \approx 0.72$

B: $\sqrt[3]{\frac{2}{1} \cdot \frac{3}{1} \cdot \frac{2}{10}} = \sqrt[3]{\frac{6}{5}} \approx 1.06$