COSE222 Computer Architecture
Assignment #2

Solutions

Prepared by Sunhee Kong
Edited by Sangwoo and Boeui on 20170918 – exercise1.2.3

Exercise 1.2.1

a.	Config 1. 900 KB (921,600 Bytes) $8\ \text{bits} \times 3\ \text{colors} = 3\ \text{bytes/pixel}$ $640 \times 480\ \text{pixels} \times 3\ \text{bytes} = 921600\ \text{bytes} = 921600/2^{10}\ \text{KB}$ Config 2. 3.75 MB (3,932,160 Bytes) $1280 \times 1024\ \text{pixels} \times 3\ \text{bytes} = 3932160\ \text{bytes} = 3932160/2^{20}\ \text{MB}$
b.	Config 1. 2.25 MB (2,359,296 Bytes) $1024 \times 768\ \text{pixels} \times 3\ \text{bytes} = 2359296\ \text{bytes} = 2359296/2^{20}\ \text{MB}$ Config 2. 11.7 MB (12,288,000 Bytes) $2560 \times 1600\ \text{pixels} \times 3\ \text{bytes} = 12288000\ \text{bytes} = 12288000/2^{20}\ \text{MB}$

Exercise 1.2.2

a.	Config 1. 2330 Frames $\lfloor 2\ \text{GB}/900\ \text{KB} \rfloor = \lfloor 2{,}147{,}483{,}648\ \text{bytes}/921{,}600\ \text{bytes} \rfloor = 2330$ Config 2. 1092 Frames $\lfloor 4\ \text{GB}/3.75\ \text{MB} \rfloor = \lfloor 4{,}294{,}967{,}296\ \text{bytes}/3{,}932{,}160\ \text{bytes} \rfloor = 1092$
b.	Config 1. 910 Frames $\lfloor 2\ \text{GB}/2.25\ \text{MB} \rfloor = \lfloor 2{,}147{,}483{,}648\ \text{bytes}/2{,}359{,}296\ \text{bytes} \rfloor = 910$ Config 2. 349 Frames $\lfloor 4\ \text{GB}/11.7\ \text{MB} \rfloor = \lfloor 4{,}294{,}967{,}296\ \text{bytes}/12{,}288{,}000\ \text{bytes} \rfloor = 349$

Exercise 1.2.3

a. **b.**	Config 1. 20.97152 ms $100\ \text{Mbits/sec} = (100{,}000{,}000/8)\ \text{B/sec} = 12{,}500{,}000\ \text{B/sec}$ $262144\ \text{B}\ /12{,}500{,}000\ \text{B/sec} = 20.97152\ \text{ms}$ Config 2. 2.097152 ms $1\ \text{Gbits/sec} = (1{,}000{,}000{,}000/8)\ \text{B/sec} = 125{,}000{,}000\ \text{B/sec}$ $262144\ \text{B}\ /125{,}000{,}000\ \text{B/sec} = 2.097152\ \text{ms}$

Exercise 1.3.1

a.	P2 has the highest performance. $\text{Instr/sec} = f/CPI$ $\text{P1}\ \text{Instr/sec} = 3\ \text{GHz}/1.5 = 2\ \text{G} = 2 \times 10^9$ $\text{P2}\ \text{Instr/sec} = 2.5\ \text{GHz}/1.0 = 2.5\ \text{G} = 2.5 \times 10^9$ $\text{P3}\ \text{Instr/sec} = 4\ \text{GHz}/2.2 = 1.8\ \text{G} = 1.8 \times 10^9$
b.	P2 has the highest performance. $\text{Instr/sec} = f/CPI$ $\text{P1}\ \text{Instr/sec} = 2\ \text{GHz}/1.2 = 1.7\ \text{G} = 1.7 \times 10^9$ $\text{P2}\ \text{Instr/sec} = 3\text{GHz}/0.8 = 3.75\ \text{G} = 3.75 \times 10^9$ $\text{P3}\ \text{Instr/sec} = 4\ \text{GHz}/2 = 2\ \text{G} = 2 \times 10^9$

Exercise 1.3.2

a.	cycles (P1) = $10\ \text{sec} \times 3\ GHz = 10 \times 3 \times 10^9 = 30\ \times 10^9\ cycles$ cycles (P2) = $10\ \text{sec} \times 2.5\ GHz = 10 \times 2.5 \times 10^9 = 25 \times 10^9\ cycles$ cycles (P3) = $10\ \text{sec} \times 4\ GHz = 10 \times 4 \times 10^9 = 40 \times 10^9\ cycles$ $\text{CPU clock cycles} = \text{CPU time} \times f$ #insts (P1) = $30\ \times 10^9\ cycles/1.5 = 20 \times 10^9$ #insts (P2) = $25 \times 10^9\ cycles/1.0 = 25 \times 10^9$ #insts (P3) = $40 \times 10^9\ cycles/2.2 = 18.2 \times 10^9$ $\#\text{insts} = \text{CPU time} \times f/CPI$
b.	cycles (P1) = $10\ \text{sec} \times 2\ GHz = 10 \times 2 \times 10^9 = 20\ \times 10^9\ cycles$ cycles (P2) = $10\ \text{sec} \times 3\ GHz = 10 \times 3 \times 10^9 = 30 \times 10^9\ cycles$ cycles (P3) = $10\ \text{sec} \times 4\ GHz = 10 \times 4 \times 10^9 = 40 \times 10^9\ cycles$ $\text{CPU clock cycles} = \text{CPU time} \times f$ #insts (P1) = $20\ \times 10^9\ cycles/1.2 = 16.7 \times 10^9$ #insts (P2) = $30 \times 10^9\ cycles/0.8 = 37.5 \times 10^9$ #insts (P3) = $40 \times 10^9\ cycles/2.0 = 20 \times 10^9$ $\#\text{insts} = \text{CPU time} \times f/CPI$

Exercise 1.3.3

a.	f(P1) = $(20 \times 10^9) \times (1.2 \times 1.5)/(0.7 \times 10) = 5.14\ GHz$ f(P2) = $(25 \times 10^9) \times (1.2 \times 1.0)/(0.7 \times 10) = 4.28\ GHz$ f(P3) = $(18.2 \times 10^9) \times (1.2 \times 2.2)/(0.7 \times 10) = 6.86\ GHz$ $f = \#\text{insts} \times CPI/\text{CPU time}$ $f_{new} = \#\text{insts} \times (1.2\ \times CPI)/(0.7 \times \text{CPU time})$
b.	f(P1) = $(16.7 \times 10^9) \times (1.2 \times 1.2)/(0.7 \times 10) = 3.43\ GHz$ f(P2) = $(37.5 \times 10^9) \times (1.2 \times 0.8)/(0.7 \times 10) = 5.14\ GHz$ f(P3) = $(20 \times 10^9) \times (1.2 \times 2.0)/(0.7 \times 10) = 6.85\ GHz$ $f = \#\text{insts} \times CPI/\text{CPU time}$ $f_{new} = \#\text{insts} \times (1.2\ \times CPI)/(0.7 \times \text{CPU time})$

Exercise 1.3.4

a.	IPC (P1) = $20 \times 10^9/(7\ sec \times 3\ GHz) = 0.95$ IPC (P2) = $30 \times 10^9/(10\ sec \times 2.5\ GHz) = 1.2$ IPC (P3) = $90 \times 10^9/(9\ sec \times 4\ GHz) = 2.5$ $IPC = 1/CPI = \#\text{insts}/(\text{CPU time} \times f)$
b.	IPC (P1) = $20 \times 10^9/(5\ sec \times 2\ GHz) = 2$ IPC (P2) = $30 \times 10^9/(8\ sec \times 3\ GHz) = 1.25$ IPC (P3) = $25 \times 10^9/(7\ sec \times 4\ GHz) = 0.89$ $IPC = 1/CPI = \#\text{insts}/(\text{CPU time} \times f)$

Exercise 1.3.5

a.	f = $3.57\ GHz$ $f_{new} = f_{old}/(\text{CPU time}_{new}/\text{CPU time}_{old})$ $f = 2.5\ GHz/(7\ sec/10\ sec)$
b.	f = $4.8\ GHz$ $f_{new} = f_{old}/(\text{CPU time}_{new}/\text{CPU time}_{old})$ $f = 3\ GHz/(5\ sec/8\ sec)$

Exercise 1.3.6

a.	#insts = 27×10^9 $\#insts_{new} = \#isnts_{old} \times (\text{CPU time}_{new}/\text{CPU time}_{old})$ $\#\text{insts} = 30 \times 10^9 \times (9\ sec/10\ sec)$
b.	#insts = 26.25×10^9 $\#insts_{new} = \#isnts_{old} \times (\text{CPU time}_{new}/\text{CPU time}_{old})$ $\#\text{insts} = 30 \times 10^9 \times (7\ sec/8\ sec)$

Exercise 1.4.1

a.	P2 is faster. CPU time (P1) = $10.4 \times 10^{-4}\ sec$ CPU time (P2) = $6.6 \times 10^{-4}\ sec$ $\text{CPU time} = \#insts \times CPI/f$ $\#insts\ (Class\ A) = 10^5$ $\#insts\ (Class\ B) = 2 \times 10^5$ $\#insts\ (Class\ C) = 5 \times 10^5$ $\#insts\ (Class\ D) = 2 \times 10^5$ $\text{CPU time (P1)} = [(10^5 \times 1) + \{(2 \times 10^5) \times 2\} + \{(5 \times 10^5) \times 3\} + \{(2 \times 10^5) \times 3\}]/2.5\ GHz$ $\text{CPU time (P2)} = [(10^5 \times 2) + \{(2 \times 10^5) \times 2\} + \{(5 \times 10^5) \times 2\} + \{(2 \times 10^5) \times 2\}]/3\ GHz$
b.	P2 is faster. CPU time (P1) = $6.8 \times 10^{-4}\ sec$ CPU time (P2) = $4 \times 10^{-4}\ sec$ $\text{CPU time (P1)} = [(10^5 \times 2) + \{(2 \times 10^5) \times 1.5\} + \{(5 \times 10^5) \times 2\} + \{(2 \times 10^5) \times 1\}]/2.5\ GHz$ $\text{CPU time (P2)} = [(10^5 \times 1) + \{(2 \times 10^5) \times 2\} + \{(5 \times 10^5) \times 1\} + \{(2 \times 10^5) \times 1\}]/3\ GHz$

Exercise 1.4.2

a.	CPI (P1) = 2.6 CPI (P2) = 2.0 $\text{CPI} = \text{CPU time} \times f/\#insts$ $\text{CPI (P1)} = (10.4 \times 10^{-4} sec) \times 2.5\ \text{GHz}\ /\ 10^6 = 2.6$ $\text{CPI (P2)} = (6.6 \times 10^{-4} sec) \times 3\ \text{GHz}\ /\ 10^6 = 2.0$
b.	CPI (P1) = 1.7 CPI (P2) = 1.2 $\text{CPI (P1)} = (6.8 \times 10^{-4} sec) \times 2.5\ \text{GHz}\ /\ 10^6 = 1.7$ $\text{CPI (P2)} = (4 \times 10^{-4} sec) \times 3\ \text{GHz}\ /\ 10^6 = 1.2$

Exercise 1.4.3

a.	CPU clock cycles (P1) = 2.6×10^6 CPU clock cycles (P2) = 2.0×10^6 $\text{CPU clock cycles} = \#insts \times CPI$ $\text{CPU clock cycles (P1)} = 10^6 \times 2.6$ $\text{CPU clock cycles (P2)} = 10^6 \times 2.0$
b.	CPU clock cycles (P1) = 1.7×10^6 CPU clock cycles (P2) = 1.2×10^6 $\text{CPU clock cycles (P1)} = 10^6 \times 1.7$ $\text{CPU clock cycles (P2)} = 10^6 \times 1.2$