Homework 1

Wednesday, April 06, 2016 4:18 PM

Matthew Koken
COEN122 9:15

Chapter 1.3-7, 12, 14

1.3) HLL → machine executable.

1) Compilation The HLL is translated into a low level language, such as assembly.
2) Assembly. An assembler translates the Assembly code into a binary executable, that is machine code that can be executed by the processor.

1.4) a) Min size in bytes

8 bits per color → 1 byte per color

3 colors per pixel => 3 * 1 byte = 3 bytes per pixel

(1280×1024) pixels * 3 bytes = $\boxed{3932160 \text{ bytes for a frame buffer}}$

= 3.93216 MB

b) 100 Mbit/s => 12.5 MB/s

÷ 8 bytes

To send 1 frame: 3.93216 MB / 12.5 MB = $\boxed{.3145728 \text{ seconds}}$

1.5) P1 3 GHz, CPI = 1.5
P2 2.5 GHz, CPI = 1.0
P3 4.0 GHz, CPI = 2.2

a) Highest instructions/second?

$$MIPS = \frac{\text{Clock Rate}}{CPI \times 10^6}$$

$$P1 \Rightarrow \frac{3 \times 10^9}{1.5 \times 10^6} = 2000 \text{ MIPS}$$

$$P2 \Rightarrow \frac{2.5 \times 10^9}{1.0 \times 10^6} = 2500 \text{ MIPS}$$

=> $\boxed{\text{P2 is the fastest}}$

$$P3 \Rightarrow \frac{4.0 \times 10^9}{2.2 \times 10^6} = 1818.18\ldots \text{ MIPS}$$

b) Program in 10s => # cycles, # instructions

$$MIPS = \frac{\# instructions}{\text{Execution time} * 10^6} \Rightarrow \# instructions = MIPS(time * 10^6)$$

$$CPI = \frac{cycles}{instructions} \Rightarrow cycles = CPI * Instructions$$

P1: # Instructions = $2000(10s * 10^6)$ = $\boxed{2 \times 10^{10}}$ instructions

cycles = $1.5(2 \times 10^{10})$ = $\boxed{3 \times 10^{10}}$ cycles

P2: # instructions = $2500(10s \times 10^6)$ = $\boxed{2.5 \times 10^{10}}$ instructions

cycles = $1.0(2.5 \times 10^{10})$ = $\boxed{2.5 \times 10^{10}}$ cycles

P3: # instructions = $1818.18(10s \times 10^6)$ $\boxed{= 1.81 \times 10^{10}}$ instructions

cycles = $2.2(1.81 \times 10^{10})$ $\boxed{\approx 4.0 \times 10^{10}}$ cycles

c) exec. time ↓ 30%, +20% CPI. Find clock rate?

$$\text{exec time} = \frac{(\text{instructions} * CPI)}{\text{clock rate}}$$

$$.7\,(\text{exec time}) = \frac{(\text{instructions} * CPI * 1.2)}{\text{new clock rate}}$$

$$\text{clock rate} = 1.71\,(\text{old clock})$$

$$\boxed{\begin{aligned} P1&: 3\ GHz * 1.71 = 5.13\ GHz \\ P2&: 2.5\ GHz * 1.71 = 4.275\ GHz \\ P3&: 4.0\ GHz * 1.71 = 6.84\ GHz \end{aligned}}$$

1.6)

		A	B	C	D
P1	2.5 GHz	1	2	3	3
P2	3 GHz	2	2	2	2
		10%	20%	50%	20%

a) P1 $CPI = 10\% \cdot 1 + 20\% \cdot 2 + 50\% \cdot 3 + 20\% \cdot 3 = \boxed{2.6}$

P2 $CPI = 10\% \cdot 2 + 20\% \cdot 2 + 50\% \cdot 2 + 20\% \cdot 2 = \boxed{2}$

b) Clock cycles

Cycles = CPI · Instructions

P1: $2.6 \cdot 1\times10^6 = \boxed{2.6\times10^6 \text{ cycles}}$

P2: $2 \cdot 1\times10^6 = \boxed{2\times10^6 \text{ cycles}}$

Running time:

$$t = \frac{\text{cycles}}{\text{clock rate}}$$

P1 = $2.6\times10^6 / 2.5 \Rightarrow 1.04\ s$

P2 = $2.0\times10^6 / 3 \Rightarrow 0.6667\ s \Rightarrow \boxed{\text{P2 faster}}$

1.7)

1.0×10^9 instructions, $t = 1.1s$

1.2×10^9 instructions, $t = 1.5s$

a) $$CPI = \frac{\text{cycles}}{\text{instructions}} = \frac{\text{running time} / \text{cycle time}}{\text{instructions}}, \quad 1ns$$

A: $\frac{1.1s / 1ns}{1\times10^9} = \boxed{1.1}$

B: $\frac{1.5s / 1ns}{1.2\times10^9} = \boxed{1.25}$

b) $$\text{clock rate} = \frac{CPI * \text{instructions}}{\text{running time}}$$

A: $\frac{1.1 * 1.0\times10^9}{1.1} = \boxed{1.1\ GHz}$

B: $\frac{1.25 \times 1.2\times10^9}{1.5} = \boxed{1.5\ GHz}$

c) 6×10^8 CPI 1.1

$$\frac{[CPI \times instructions]}{[CPI \times instructions]\ new}$$

A: $\frac{1.1 \times 1.0 \times 10^9}{1.1 \times 6\times10^8} = 1.66667 \Rightarrow$ $\boxed{66.7\%\ \text{faster vs A}}$

B: $\frac{1.25 \times 1.2\times10^9}{1.1 \times 6\times10^8} = 2.2727 \Rightarrow$ $\boxed{127.27\%\ \text{faster vs B}}$

1.12) P1 4 GHz CPI = 0.9 instructions = 5×10^9
P2 3 GHz CPI = 0.75 instructions = 1×10^9

1.12.1) clock rate as highest performance
check execution time

P1 $0.9 \times 5\cdot10^9 / 4\cdot10^9 = 1.125$
P2 $0.75 * 1\cdot10^9 / 3\cdot10^9 = 0.25 \Rightarrow$ P2 has a lower execution time, is faster
but has a lower clock rate

1.12.2) need a larger CPU time?

P1 $1\cdot10^9$
CPU time = CPI · Instructions / clock rate
$= 0.9 * 1\cdot10^9 / 4\cdot10^9 = 0.225$

P2:
instructions $= 0.225 * 3\cdot10^9 / 0.75 = 0.9\cdot10^9$ instructions

1.12.3) $MIPS = \frac{1\cdot10^{-6}}{CPI/\text{Clock rate}}$

P1: $\frac{1\cdot10^{-6}}{0.9/4\cdot10^9} = 4444$ mips

P2: $\frac{1\cdot10^{-6}}{0.75/3\cdot10^9} = 4000$ mips

=> but P2 is faster in execution time (1.12.1)

1.12.4) MFLOPS = FP ops / (exec time * $1\cdot10^6$)
40% FP

P1: $\frac{.4 * 1\cdot10^{-6}}{0.9/4\cdot10^9} = 1777.6$ FLOPS

P2: $\frac{.4 * 1\cdot10^{-6}}{0.75/3\cdot10^9} = 1600$ FLOPS

1.14) 50×106 FP, 110×106 INT, 80×106 L/S, 16×106 branch
CPI: 1 1 4 2
2GHz

1.14.1) improve CPI for FP to get 2x faster program execution

1.14.1) improve CPI for FP to get 2x faster program execution

Execution time $= \sum \left(\frac{\text{Clock cycle}}{\text{clock rate}} \right)$

clock cycle $= (50 \cdot 10^6 \times 1) + (110 \times 10^6 \times 1) + (80 \times 10^6 \times 4) + (16 \times 10^6 \times 2)$

$= 5.12 \times 10^8$

$\text{time}_0 = \frac{5.12 \times 10^8}{2 \times 10^9} = .256 \text{ sec}$

$$CPI_{new} = \frac{\frac{5.12 \times 10^8}{2} - \left[(110 \cdot 10^6) + (80 \cdot 10^6 \cdot 4) + (16 \cdot 10^6 \cdot 2) \right]}{50 \cdot 10^6 * 1}$$

$= -4.12$ X cannot be negative

↳ we cannot improve enough to ½ the execution time

1.14.2) CPI of L/S to run 2x faster

$$CPI_{new} = \frac{\frac{5.12 \times 10^8}{2} - \left[(50 \cdot 10^6) + (110 \cdot 10^6) + (16 \cdot 10^6 \cdot 2) \right]}{80 \cdot 10^6 \cdot 4}$$

$= \underline{0.2}$

to run 2x faster $\frac{4}{0.2} = \boxed{20}$

=> L/S CPI must improve by **20** times

1.14.3) CPI of Int & FP => 40% CPI L/S 30%

New execution time $= \sum \frac{\text{Clock cycle}}{\text{Clock rate}}$

New Clock rate $= (50 \cdot 10^6 \cdot 1(.6)) + (110 \cdot 10^6 \cdot 1(.6)) + (80 \cdot 10^6 \cdot 4(.7)) + (16 \times 10^6 \cdot 2(.7))$

$= 3.424 \cdot 10^8$

new execution time $= \frac{3.424 \cdot 10^8}{2 \cdot 10^9} = .1712$ sec

$\frac{\text{old time}}{\text{new time}} = \frac{.256}{.1712} = \boxed{1.495 \text{ times faster}}$