Ch1 1.3, 1.4, 1.5, 1.6, 1.7, 1.11, 1.12

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1.3

High level Language Progrem

Compiler

Assembly language Program

assembler

Machine language Program

Machine interpretation

control signal spec

1.4 a. pixels = 1280 · 1024 = 1310720

3byte perpixel

byte = 3 · 1310720 = 3932160 minbyte

b. $\dfrac{3932160 \text{ min byte} \cdot 8 \text{ bit}}{100 \text{ M bit/s}}$

= .31 seconds

1.5

	clockrate	CPI
P1:	3 GHz	1.5
P2	2.5 GHz	1.0
P3	4.0 GHz	2.2

a. highest performance in intruction per second

$$IPS = \frac{\text{Clockrate}}{\text{CPI}}$$

P1: $\frac{3 \cdot 10^9}{1.5} = 2 \cdot 10^9$ I per sec

highest

P2: $\frac{2.5 \cdot 10^9}{1.1} = 2.273 \cdot 10^9$ I per sec

P3: $\frac{4 \cdot 10^9}{2.2} = 1.818 \cdot 10^9$ I per sec

6. # cycle = time · clock rate

time = (#instruction · CPI) \ clock rate

#instruction = $\frac{\boxed{\text{clockrate} \cdot \text{time}}}{\text{CPI}}$ (#ofcycle above box)

6. con.

P1: $\# \text{cycle} = 10 \text{ sec} \cdot 3 \cdot 10^9 = 30 \cdot 10^9$

$\# \text{instruction} = \dfrac{30 \cdot 10^9}{1.5} = 20 \cdot 10^9$

P2: $\# \text{cycle} = 10 \text{ sec} \cdot 2.5 \cdot 10^9 = 25 \cdot 10^9$

$\# \text{instruction} = \dfrac{25 \cdot 10^9}{1.0} = 25 \cdot 10^9$

P3: $\# \text{cycle} = 10 \cdot 4 \cdot 10^9 = 40 \cdot 10^9$

$\# \text{ of instruction} = \dfrac{40 \cdot 10^9}{2.2} = \underline{18.182 \cdot 10^9}$

c. time decrease by 30% and CPI increased by 20%

$\text{time}_{new} = \dfrac{\# \text{instruction} \cdot \text{CPI}_{new}}{\text{clock rate}_{new}}$

$\text{CPI}_{new} = 1.2 \text{ CPI}_{old}$

$\text{time}_{new} = \text{time}_{old} \cdot .7$

$\dfrac{\text{time}_{new}}{.7} = \text{time}_{old} =$

$\dfrac{\cancel{\# \text{instruction} \cdot \text{CPI}_{old}} \cdot 1.2}{\text{clock rate}_{new} \cdot .7} = \dfrac{\cancel{\# \text{instruction} \cdot \text{CPI}_{old}}}{\text{clock rate}_{old}}$

A

5) → $\frac{1.2}{\text{Clockrate}_{new} \cdot .7} = \frac{1}{\text{Clockrate}_{old}}$

↓

$\text{Clockrate}_{new} = \frac{1.2}{.7} \cdot \text{Clockrate}_{old}$

$\text{Clockrate}_{new} = 1.71 \cdot \text{clock rate}_{old}$

P1: $\text{Clockrate}_{new} = 1.71 \cdot 3\,GHz$
$= 5.13\,GHz$

P2: $\text{Clockrate}_{new} = 1.71 \cdot 2.5\,GHz$
$= 4.27\,GHz$

P3: $\text{clockrate}_{new} = 1.71 \cdot 4\,GHz$
$= 6.84\,GHz$

1.6

P1: 2.5 GHz, CPI: 1, 2, 3, 3

P2: 3 GHz, CPI: 2, 2, 2, 2

$1 \cdot 10^6$ instruction
divided into classes 10%, 20%, 50%, 20%

1.6 con.

a. instructions: Class A: $1 \cdot 10^5$ instructions

Class B: $2 \cdot 10^5$

Class C: $5 \cdot 10^5$

Class D: $2 \cdot 10^5$

P1:

CPU Clock Cycle: $10^5 \cdot 1 + 2 \cdot 10^5 \cdot 2 + 5 \cdot 10^5 \cdot 3 + 2 \cdot 10^5 \cdot 3 = 2.6 \cdot 10^6$

$$\text{Avg. CPI: } \frac{2.6 \cdot 10^6}{10^6} = 2.6$$

P2: CPU clock cycle $= 10^5 \cdot 2 + 2 \cdot 10^5 \cdot 2 + 5 \cdot 10^5 \cdot 2 + 2 \cdot 10^5 \cdot 2 = 2 \cdot 10^6$

$$\text{Avg CPI: } \frac{2 \cdot 10^6}{10^6} = 2.0$$

b. P1: already found: $2.6 \cdot 10^6$

P2: " ": $2 \cdot 10^6$

P2 faster

1.7

Complier A: $1.0 \cdot 10^9$ instructions
1.1 sec

Complier B: $1.2 \cdot 10^9$ instructions
1.5 sec

a. find average CPI with clockcycle = 1ns

Clock rate $\frac{1}{1ns} = 1\,GHz$

Complier A:

$$\text{clockcycles} = \frac{1.1\,sec}{1ns} = 1.1 \cdot 10^9$$

$$CPI = \frac{1.1 \cdot 10^9 \text{ clockcycle}}{1.0 \cdot 10^9 \text{ instructions}} = 1.1$$

Complier B: $\text{clockcycle} = \frac{1.5\,sec}{1ns} = 1.5 \cdot 10^9$

$$CPI = \frac{1.5 \cdot \cancel{10^9}}{1.2 \cdot \cancel{10^9}} = 1.25$$

b. execution time = $\frac{\#\text{instruction} \cdot CPI}{\text{clockrate}}$

1.7 b. con.

$$\frac{\#instruction_a \cdot CPI_a}{Clockrate_a} = \frac{\#instruction_b \cdot CPI_b}{Clockrate_b}$$

$$Clockrate_a = \frac{clockrate_b \cdot \#instruction_a \cdot CPI_a}{\#intruction_b \cdot CPI_b}$$

$$= \frac{clockrate_b \cdot \cancel{10^9} \cdot 1.1}{1.2 \cdot \cancel{10^9} \cdot 1.25}$$

$$clockrate_a = .73 \, clockrate_b$$

c. time = # instction · cycletime · CPI

cycletime = 1ns

Complier C: $time_c = 6 \cdot 10^8 \cdot 1 \cdot 10^{-9} \cdot 1.1$

$= .66$

A: $time_a = \cancel{10^9} \cdot 1 \cdot \cancel{10^{-9}} \cdot 1.1 = 1.1$

$$\frac{1.1}{.66} = 1.67$$

C is 1.67 faster then A

B: $time_B = 1.2 \cdot \cancel{10^9} \cdot \cancel{10^{-9}} \cdot 1.25 = 1.5$

1.5/.66 = 2.27 C is 2.27 faster then B.

1.11

$2.389 \cdot 10^{12}$ instrucution count

execution count of 750 sec reference time of 9650 sec

1.11.1

clock cycles time $= .333 \cdot 10^{-9}$ s

time $=$ # instruction $\cdot$ cycle time $\cdot$ CPI

↓

$$CPI = \frac{\text{time}}{\#\text{of instruction} \cdot \text{cycle time}}$$

$$= \frac{750}{2.389 \cdot 10^{12} \cdot .333 \cdot 10^{-9}} = .94$$

1.11.2

$$\text{SPEC ratio} = \frac{\text{reference time}}{\text{excution time}}$$

$$= \frac{9650}{750} = 12.87$$

1.11.3 CPU time $=$ # instruction $\cdot$ 1.1 $\cdot$ cycle time $\cdot$ CPI

$$\text{CPU time new} = \frac{\text{CPU time}}{1.1} = \frac{750}{1.1}$$

$$= 681.82 \text{ sec}$$

1.11.4

$$\text{CPU time} = \#\text{instruction} \cdot 1.1 \cdot \text{cycle time} \cdot \text{CPI} \cdot 1.05$$

$$\text{CPU time}_{new} = \frac{\text{CPU time}}{1.1 \cdot 1.05} = \frac{750}{1.1 \cdot 1.05} = 649.35$$

1.11.5 $\text{SPEC ratio} = \frac{9650}{649.35} = 14.86$

1.11.6

$$\text{CPU time} = \frac{\#\text{instruction} \cdot .85 \cdot \text{CPI}_{new}}{4\text{GHz}}$$

$$\text{CPI}_{new} = \frac{\text{CPU time} \cdot 4\text{GHz}}{\#\text{instruction} \cdot .85}$$

$$= \frac{700 \cdot 4 \cdot 10^9}{2.389 \cdot 10^{12} \cdot .85} = 1.38$$

1.11.7 $\frac{\text{CPI}_{old}}{\text{CPI}_{new}} = \frac{.94}{1.38} = .68$

$$\frac{\text{Clock rate}_{old}}{\text{Clock rate}_{new}} = \frac{3\text{GHz}}{4\text{GHz}} = .75$$

its a similar increase

1.11.8 $\frac{700}{750} = .93$

execution time was reduced by 7%

1.11.9 $\text{CPU time} \cdot .9 = \frac{\#\text{instructions} \cdot \text{CPI}}{\text{Clock rate}}$

$\#\text{instruction} = \frac{\text{CPU time} \cdot .9 \cdot \text{Clock rate}}{\text{CPI}}$

$= \frac{960 \cdot \cancel{10^{-9}} \cdot .9 \cdot 4 \cdot \cancel{10^{9}}}{1.61}$

$= 2146.58 \Rightarrow$ 2146 instructions

1.11.10 $\text{CPU time} \cdot .9 \cdot .9 = \frac{\#\text{instruction} \cdot \text{CPI}}{\text{clock rate}}$

$\text{Clock rate} = \frac{\#\text{instruction} \cdot \text{CPI}}{\text{CPU time} \cdot .9 \cdot .9}$

$= \frac{2146 \cdot 1.61}{960 \cdot 10^{-9} \cdot .9 \cdot .9} = 4.4 \cdot 10^{9}$ Hz

1.11.11 $\#\text{ intruction} = \frac{\text{CPU time} \cdot \text{clock rate}}{\text{CPI}}$

$= \frac{960 \cdot 10^{-9} \cdot 3 \cdot 10^{9}}{1.61} = 1788.81$

≈ 1788

$\text{CPU time} \cdot .8 = \frac{\#\text{instruction} \cdot \text{CPI} \cdot .85}{\text{clock rate}}$

$\text{clockrate} = \frac{\#\text{ instruction} \cdot \text{CPI} \cdot .85}{\text{CPU time} \cdot .8}$

$= \frac{1788 \cdot 1.61 \cdot .85}{960 \cdot 10^{-9} \cdot .8} = 3.186 \cdot 10^{9}\ \text{Hz}$

1.12 P1: 4 GHz, CPI = .9, $5.0 \cdot 10^{9}$ instructions

P2: 3 GHz, CPI = .75, $1 \cdot 10^{9}$ instructions

1.12.1 $\text{CPU time} = \frac{\#\text{Instruction} \cdot \text{CPI}}{\text{clockrate}}$

P1: $\text{CPU time} = \frac{5 \cdot 10^{9} \cdot .9}{4 \cdot 10^{9}}$

$= 1.125\ \text{sec}$

P2: $\text{CPU time} = \frac{\cancel{1e2} \cdot .75}{3 \cdot 10^{9}} = .25\ \text{sec}$

P2 lower clock rate and lower CPU time

1.12.2

$$\text{CPU time} = \frac{\#\text{instruction} \cdot \text{CPI}}{\text{Clock rate}}$$

P2 with P1 CPU time: $\#\text{instructions} = \text{clock rate} \cdot \frac{\text{CPU time}}{\text{CPI}}$

$$= \frac{3 \cdot 10^9 \cdot 1.125}{.75}$$

$$= 4.5 \cdot 10^9$$

1.12.3 $\text{MIPS} = \frac{\text{Clock rate}}{\text{CPI} \cdot 10^6}$

P1: $\text{MIPS} = \frac{4 \cdot 10^9}{.9 \cdot 10^6} = 4.44 \cdot 10^3$

P2: $\text{MIPS} = \frac{3 \cdot 10^9}{.75 \cdot 10^6} = 4 \cdot 10^3$

P2 lower MIPS but higher performs as seen in 1.12.1

1.12.4 $MFLOPS = \frac{\#instruction \cdot .4}{cputime \cdot 10^6}$

$P1: MFLOPS = \frac{5 \cdot 10^9 \cdot .4}{1.125 \cdot 10^6} = 1.78 \cdot 10^3$

$P2: MFLOPS = \frac{1 \cdot 10^9 \cdot .4}{.25 \cdot 10^6} = 1.6 \cdot 10^3$