# HW1

b09902004 郭懷元

## 1.5

### a.

P1: $\frac{3\times10^9}{1.5} = 2 \times 10^9$ instructions per second
P2: $\frac{2.5\times10^9}{1.0} = 2.5 \times 10^9$ instructions per second
P3: $\frac{4.0\times10^9}{2.2} = 1.8 \times 10^9$ instructions per second

P2 has the highest instructions per second.

### b.

P1: $(3 \times 10^9) \times 10 = 3 \times 10^{10}$ cycles; $\frac{3\times10^{10}}{1.5} = 2 \times 10^{10}$ instructions
P2: $(2.5 \times 10^9) \times 10 = 2.5 \times 10^{10}$cycles; $\frac{2.5\times10^{10}}{1.0} = 2.5 \times 10^{10}$ instructions
P3: $(4.0 \times 10^9) \times 10 = 4 \times 10^{10}$ cycles; $\frac{4\times10^{10}}{2.2} = 1.8 \times 10^{10}$ instructions

### c.

$$time = instructions \times \frac{cycle}{instruction} \times \frac{time}{cycle} = instructions \times \frac{CPI}{clock\ rate}$$
$$clock\ rate = instructions \times \frac{CPI}{time}$$

P1: $3 \times 10^9 \times (1 \times \frac{1.2}{0.7}) = 5.1$ GHz
P2: $2.5 \times 10^9 \times (1 \times \frac{1.2}{0.7}) = 4.3$ GHz
P3: $4 \times 10^9 \times (1 \times \frac{1.2}{0.7}) = 6.9$ GHz

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## 1.6

### a.

P1: $1 \times 0.1 + 2 \times 0.2 + 3 \times 0.5 + 3 \times 0.2 = 2.6$ CPI
P2: $2 \times 0.1 + 2 \times 0.2 + 2 \times 0.5 + 2 \times 0.2 = 2$ CPI

### b.

P1: $2.6 \times 10^6$ cycles
P2: $2 \times 10^6$ cycles

P1 runs for $\frac{2.6\times10^6}{2.5\times10^9} = 1.04$ ms; P2 runs for $\frac{2\times10^6}{3\times10^9} = 0.67$ ms
P2 is faster.

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## 1.7

### a.

Compiler A: $\frac{1.1/10^{-9}}{10^9} = 1.1$ CPI
Compiler B: $\frac{1.5/10^{-9}}{1.2\times10^9} = 1.25$ CPI

### b.

$\frac{10^9}{1.2\times10^9} \times \frac{1.1/1.25}{1/1} = 0.73$ times faster

### c.

New compiler time: $6 \times 10^8 \times 1.1 \times 10^{-9} = 0.66$ s
Reduce $40\%$ of time versus compiler A; Reduce $56\%$ of time versus compiler B.

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## 1.11

### 1.11.1

$\frac{750/(0.333\times10^{-9})}{2.389\times10^{12}} = 0.943$ CPI

### 1.11.2

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

### 1.11.3

CPU time increase $750 \times 0.1 = 75$ s.

### 1.11.4

CPU time increase $750 \times (1.1 \times 1.05 - 1) = 116.25$ s.

### 1.11.5

SPECratio decreased by $1 - \frac{750}{750+116.25} = 13.4\%$

### 1.11.6

$\frac{700\times4\times10^9}{2.389\times10^{12}\times0.85} = 1.379$ CPI

### 1.11.7

Clock rate increased by $33.3\%$, and CPI increased by $46.2\%$. They are dissimilar because the new processor is using a different instruction set.

### 1.11.8

CPU time is reduced by $1 - \frac{700}{750} = 6.67\%$

### 1.11.9

$\frac{4\times10^9\times0.9\times960\times10^{-9}}{1.61} = 2147$ instructions

### 1.11.10

$3\times10^9\times(\frac{1}{0.9}) = 3.33$ GHz

### 1.11.11

$3\times10^9\times(\frac{0.85}{0.8}) = 3.19$ GHz

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## 1.14

### 1.14.1

Number of cycles needed is $(50\times1+110\times1+80\times4+16\times2)\times10^6 = 5.12\times10^8$
Number of cycles of FP instructions is $50\times10^6\times1 = 5\times10^7$
By Amdahl's Law, $0.5\times5.12\times10^8 = \frac{5\times10^7}{n} + 4.62\times10^8$ where $n$ is the improvement of the CPI. But there are no positive solution of $n$, so it's impossible to run two times faster by only improving CPI of FP instruction.

### 1.14.2

Number of cycles of L/S instructions is $80\times10^6\times4 = 3.2\times10^8$
By Amdahl's Law, $0.5\times5.12\times10^8 = \frac{3.2\times10^8}{n} + 1.92\times10^8$ where $n$ is the improvement of the CPI.
$n = 5$ is the solution to that equation, so the CPI of L/S instructions should be improved by 5 times, which is to be reduced to $20\%$.

### 1.14.3

Number of cycles after improvement is
$(50\times0.6+110\times0.6+80\times4\times0.7+16\times2)\times10^6 = 3.52\times10^8$
Time improvement is $\frac{5.12\times10^8}{2\times10^9} - \frac{3.52\times10^8}{2\times10^9} = 0.08$ s, which is about a $31\%$ reduction.