# CSCI 206 Problem Set 1

## Exercise 1.3

### 1.3.1

P1: Seconds per Instruction = 1.5/2 = 0.75 ns

P2: Seconds per Instruction = 1.0/1.5 = 0.666 ns

P3: Seconds per Instruction = 2.5/3 = 0.833 ns

Answer: P2 has the highest performance.

### 1.3.2

P1: Number of Cycles = 10\*2 GHz = 20\*10^9;

Number of Instructions = (20\*10^9)/1.5 = 1.33\*10^10

P2: Number of Cycles = 10\*1.5 GHz = 15\*10^9;

Number of Instructions = (15\*10^9)/1.0 = 15\*10^9

P3: Number of Cycles = 10\*3 GHz = 30\*10^9;

Number of Instructions = (30\*10^9)/2.5 = 1.2\*10^10

### 1.3.3

Time per Instruction = CPI / CR 🡺 CR = CPI / Time per Instruction

CR = 1.2/0.7 = 1.714

The clock rate needs to increase 71.4%

### 1.3.4

P1: IPC = 20\*10^9/(7\*2\*10^9) = 1.429

P2: IPC = 30\*10^9/(10\*1.5\*10^9) = 2

P3: IPC = 90\*10^9/(9\*3\*10^9) = 3.333

### 1.3.5

IPC = No. Instruction / (CR \* Time) 🡺 CR = No. Instruction / (IPC \* Time)

CR = 30\*10^9 / (2000 \* 7) = 2.14 GHz

### 1.3.6

CR = 30\*10^9 / (2000 \* 9) = 1.67 GHz

## Exercise 1.4

### 1.4.1

P1: Time A = 10^6\*0.1\*(1/(1.5\*10^9)) = 0.667 ms

Time B = 10^6\*0.2\*(2/(1.5\*10^9)) = 0.267 ms

Time C = 10^6\*0.5\*(3/(1.5\*10^9)) = 1 ms

Time D = 10^6\*0.2\*(4/(1.5\*10^9)) = 0.533 ms

Time Total = A+B+C+D = 2.467 ms

P2: Time = 10^6\*(2/(2\*10^9)) = 1 ms

Answer: P2 is faster.

### 1.4.2

P1: CPI = 1\*0.1+2\*0.2+3\*0.5+4\*0.2 = 2.8

P2: CPI = 2

### 1.4.3

P1: Number of Cycles = 2.8\*10^6 = 2.8\*10^6

P2: Number of Cycles = 2\*10^6 = 2\*10^6

### 1.4.4

Total Cycles = 500+(50+100)\*5+50\*2 = 1350

Time = 1350/(2\*10^9) = 0.675 ns

### 1.4.5

CPI = 1350 / 700 = 1.929

### 1.4.6

Speed-up = 50\*5/(2\*10^9) = 0.125 ns

CPI = (1350 – 250)/700 = 1.571

## Exercise 1.6

### 1.6.1

a. Number of Cycles = (1+1.4)/(10^-9) = 2.4\*10^9

CPI = No. of Cycles / Instructions = 2.4\*10^9/((1.2+1)\*10^9) = 1.091

b. Number of Cycles = (0.8+0.7)/10^-9 = 1.5\*10^9

CPI = No. of Cycles / Instructions = 1.5\*10^9/(2.2\*10^9) = 0.682

Compiler A: CPI = 1.8 / 2 = 0.9

Compiler B: CPI = 2.1 / 2.4 = 0.875

### 1.6.2

Time = CPI \* No. Instruction / CR

CR­A/CRB = 1.2\*CPI / 1\*CPI = 1.2

### 1.6.3

Time = No. Instruction\*CPI/CR = 0.6\*10^9 \* 1.1/10^9 = 0.66 s

Speed-up for Compiler A = 10^9\*0.9/10^9 – 0.66 = 0.24 s

Speed-up for Compiler B = 1.2\*10^9\*0.875/10^9 – 0.66 = 0.39 s

### 1.6.4

P1: Peak = CR / CPI = 4 GHz

P2: Peak = CR / CPI = 6/2 = 3 GHz

### 1.6.5

Let total number of instructions = L

Class A = 1/3L, B = 1/6L, C = 1/6L, D = 1/6L, E = 1/6L

Time for P1 = (1/3\*1 + 1/6 \* (2+3+4+5))L/CR = 0.667L ns

Time for P2 = (1/3\*2+ 1/6 \* (2+2+4+4))L / CR = 0.444L ns

Ratio of time = P1/P2 = 0.667L / 0.444L = 1.5

### 1.6.6

CR-P2 = 4 GHz

## Exercise 1.14

### 1.14.1

P1: Seconds per Instruction = 1.25/(4\*10^9) = 0.3125 ns

P2: Seconds per Instruction = 0.75/(3\*10^9) = 0.25 ns

Answer: P2 has better performance than P1

### 1.14.2

Time = 10^6\*(0.3125\*10^-9) = 0.03125 s

Number of Instructions P2 = 0.03125/(0.25\*10^-9) = 1.25\*10^6

### 1.14.3

MIPS for P1 = CR/(CPI\*10^6) = 4\*10^9/(1.25\*10^6) = 3200

MIPS for P2 = 3\*10^9/(0.75\*10^6) = 4000

Answer: MIPS is true for P2 and P1

### 1.14.4

a. Execution Time = (0.5\*10^6\*0.75+0.4\*10^6\*1+0.1\*10^6\*1.5)/(3\*10^9) = 0.308 ms

MFLOPS = 0.4\*10^6/(0.000308\*10^6) = 1297

b. Execution Time = (0.4\*1.25+0.4\*0.7+0.2\*1.25)\*(3\*10^6)/(3\*10^9) = 1.03 ms

MFLOPS = 0.4\*3\*10^6/0.00103\*10^6 = 1165

### 1.14.5

a. MIPS = 3\*10^9/(0.925\*10^6) = 3243

b. MIPS = 3\*10^9/(1.03\*10^6) = 2913

### 1.14.6

a. Performance = 1/Execution Time = 1/0.000308 = 3247

b. Performance = 1/Execution Time = 1/0.00103 = 970.9

The performance is consistence with MIPS and MFLOPS in this case.

## Exercise 1.15

### 1.15.1

a. Time reduced = 35\*0.2 = 7 s

7/200 = 3.5%

b. Time reduced = 50\*0.2 = 10 s

10/210 = 4.76%

### 1.15.2

a. Time reduced = 200\*0.2 = 40

INT time reduced ratio = 40/85 = 47.1%

b. Time reduced = 210\*0.2 = 42

INT time reduced ratio = 42/80 = 52.5%

### 1.15.3

The total time can’t be reduced by 20% by just reducing the time for branch instruction.

### 1.15.4

Total Cycles = 560\*10^6+2000\*10^6+1280\*10^6\*4+256\*10^6\*2 = 8.192\*10^9

Cycle reduced = 0.5\*8.192\*10^9 = 4.096\*10^9

CPI reduced = 4.096\*10^9 / (560\*10^6) = 7.3125

Answer: It’s impossible to improve the program this much by just improving CPI of FP

### 1.15.5

CPI reduced = 4.096\*10^9/(1280\*10^6) = 3.2

We need to improve CPI of L/S to 0.8.

### 1.15.6

New total Cycles = 560\*10^6\*0.6+2000\*10^6\*0.6+1280\*10^6\*2.8+256\*10^6\*1.4=5.4784\*10^9

Cycle reduced = (8.192\*10^9 – 5.4784\*10^9)/(8.192\*10^9) = 33.125%

Execution time reduced by 33.123%