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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

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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

CR_A/CR_B = 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

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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

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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%