ECE 485/585 – Computer Organization and Design

HOMEWORK #1 SOLUTION

Solve the following exercises from the textbook (Chapter 1)

1. Exercise 1.2
    a. Performance via Pipelining
    b. Dependability via Redundancy
    c. Performance via Prediction
    d. Make the Common Case Fast
    e. Hierarchy of Memories
    f. Performance via Parallelism
    g. Design for Moore's Law
    h. Use Abstraction to Simplify Design
2. Exercise 1.6

    Class A: 10^5 instr. Class B: $2*10^5$ instr. Class C: $5*10^5$ instr. Class D: $2*10^5$ instr.

$$Global\ CPI = \frac{Total\ Time\ * Clock\ Rate}{No.Inst.}$$

$$Total\ Time = \sum_i \frac{Inst.Count_i * CPI_i}{Clock\ Rate}$$

Clock Cycles = $\sum_{i=1}^{n}(CPI_i * C_i)$

a. Total Time P1 = $(10^5*1 + 2*10^5*2 + 5*10^5*3 + 2*10^5*3)/(2.5*10^9)$ = **$10.4*10^{-4}$ s**

   Total Time P2 = $(10^5*2 + 2*10^5*2 + 5*10^5*2 + 2*10^5*2)/(3*10^9)$ = **$6.66*10^{-4}$ s**

   CPI P1 = $(10.4*10^{-4} * 2.5*10^9)/(10^6)$ = **2.6**

   CPI P2 = $(6.66*10^{-4} * 3*10^9)/(10^6)$ = **2.0**

b. Clock Cycles P1 = $10^5*1 + 2*10^5*2 + 5*10^5*3 + 2*10^5*3$ = **$26*10^5$**

   Clock Cycles P2 = $10^5*2 + 2*10^5*2 + 5*10^5*2 + 2*10^5*2$ = **$20*10^5$**

3. Exercise 1.9
    a.

p	Arith	L/S	B	Cycles	Exec Time	Speedup
1	2.56E+09	1.28E+09	2.56E+08	1.92E+10	9.60 s	1.00
2	1.83E+09	9.14E+08	2.56E+08	1.41E+10	7.04 s	1.36
4	9.14E+08	4.57E+08	2.56E+08	7.68E+09	3.84 s	2.50
8	4.57E+08	2.29E+08	2.56E+08	4.48E+09	2.24 s	4.29

b.

p	Arith	L/S	B	Cycles	Exec Time
1	2.56E+09	1.28E+09	2.56E+08	2.18E+10	10.9
2	1.83E+09	9.14E+08	2.56E+08	1.59E+10	7.95
4	9.14E+08	4.57E+08	2.56E+08	8.59E+09	4.30
8	4.57E+08	2.29E+08	2.56E+08	4.94E+09	2.47

c.

$$\frac{\frac{(\#\,Inst_{Ar}*CPI_A)+(\#\,Inst_L*CPI_L)}{0.7*4}+(\#Instr_B*CPI_B)}{Clock\ Rate}=\frac{(\#\,Inst_{Ar}*CPI_A)+(\#\,Inst_L*CPI_{L,new})+(\#Instr_B*CPI_B)}{Clock\ Rate}$$

$$\frac{(\#\,Inst_{Ar}*CPI_A)+(\#\,Inst_L*CPI_L)}{0.7*4}=(\#\,Inst_{Ar}*CPI_A)+(\#\,Inst_L*CPI_{L,new})$$

$$(2.56E9*1+1.28E9*12)/2.8 = 2.56E9*1 + 1.28E9*CPI_{L/S,\ New}$$

$CPI_{L/S,\ New}$ = **3**

4. Exercise 1.13

T_{total} = 250s, T_{fp} = 70s, $T_{L/S}$ = 85s, T_B = 40s, T_{INT} = 55s

a. $T_{fp,new}$ = 70*0.8 = 56 s

   $T_{new} = T_{fp,new} + T_{L/S} + T_B + T_{INT}$ = 70 + 85 + 40 + 55 = 236s

   Reduction = 1 – T_{new}/T_{old} = 1 – 0.944 = **5.6%**

b. T_{new} = 250*0.8 = 200 s

   $T_{fp} + T_{L/S} + T_B$ = 70 + 85 + 40 = 195 s

   T_{int} = 200 – 195 = 5 s

   Reduction = 1 – 5/55 = **90.9% reduction**

c. T_{new} = 200s

   $T_{fp} + T_{INT} + T_{L/S}$ = 70 + 55 + 85 = 210 s -> **no room for reduction so NO**

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5. Exercise 1.14

$$\text{Clock Cycles} = \sum_{i=1}^{n}(CPI_i * C_i)$$

Initial Clock Cycles = 1*(50E6) + 1*(110E6) + 4*(80E6) + 2*(16E6) = 512E6

a. $CPI_{TP,New}$*50E6 + 1*(110E6) + 4*(80E6) + 2*(16E6) = 256E6

   $CPI_{TP,New}$*50E6 + 462E6 = 256E6

   CPI cannot be negative so not possible

b. 1*(50E6) + 1*(110E6) + $CPI_{L/S,New}$*(80E6) + 2*(16E6) = 256E6

   192E6 + $CPI_{L/S,New}$*(80E6) = 256E6

   $CPI_{L/S,New}$ = 0.8

c. Cycles = 0.6*(50E6) + 0.6*(110E6) + 0.7*4*(80E6) + 0.7*2*(16E6) = 342.4E6

$$Time = \frac{Cycles}{Clock\ Rate}$$

   $Time_{initial}$ = (512E6)/(2E9) = 0.256 s
   $Time_{new}$ = (342.4E6)/(2E9) = 0.1712 s