CSE 140 Lab/HW#2 – Due: see below

1. Name your source file as "cse140_your-first-name_your-last-name_mm.s" and submit it to CatCourse.

   Total instructions executed: 42576

Performance (20pts)

2. Assume a program requires the execution of 50×10^6 floating-point instructions, 110×10^6 integer instructions, 80×10^6 load/store instructions, and 16×10^6 branch instructions. The CPI for each type of instruction is 1, 1, 4, and 2, respectively. Assume that the processor has a 2 GHz clock rate.
   a. By how much do we need to improve the CPI of floating-point instructions if we want the program to run two times faster? If it is impossible to make 2X speedup by improving the CPI of floating-point instruction, explain the reason.
   Each processor clock rate = 2GHz

Execution time = $\sum \frac{(Clock\ cycles)}{clock\ rate}$

Clock cycles = CPI(FP) x No.FP instructions + CPI(INT) x No.INT instructions
+ CPL(L/S) x No.L/S instructions + CPI(branch)x NO. branach instructions

Clock cycles = (50x10^(6) x1)+(110x(10^(6))x1) + (80x10^(6)x4) + (16x10^(6)x2)
= 512x10^(6)

FP(floating point) instructions, initial execution time for 16 processors

Clock cycles = 512x10^(6)

Execution time = $\frac{512x10\wedge(6)}{2x10\wedge(9)}$= 256x10^(-3)sec

Half the number of clock cycles to improve the CPI of FP instructions,

$\frac{Clock\ cycles}{2}$ = CPI(FPimproved)x NO.FP instruction + CPI(INT) x NO.INT instructions +
CPI(L/S) X NO.L/S instructions + CPI(branch)x NO.branch instruction

CPI(FPimproved) =

$$\frac{\frac{Clock\ cycles}{2} - (CPI(INT)XNO.INT\ instructions + CPI(L\backslash S)X\ NO.L\backslash S\ instructions + CPI(branch)xNO.branch\ instructions}{NO.FP\ instructions}$$

$$CPI(FPimproved) = \frac{\frac{512x10^6}{2} - ((110x10^{(6)}\ x\ 1) + (80\ x\ 10^6\ x\ 4) + (16x10^6x2)}{50x10^6} = \frac{\frac{512x10^6}{2} - (462x10^6)}{50x10^6}$$

$$= \frac{-206x10^6}{50x10^6} = -4.12 < 0$$

The CPI of FP instructions cannot be improved when we run the program 2 times faster because the CPI of FP instructions would be negative; you cannot have negative instructions.

   b. By how much do we need to improve the CPI of load/store instructions if we want the program to run two times faster? If it is impossible to make 2X speedup by improving the CPI of load/store instruction, explain the reason.
   To improve the CPI of load/store instruction 2X -> half the number of clock cycles to improve the CPI of LS instructions

$\frac{Clock\ cycles}{2}$ = CPI(FPimproved)x NO.FP instruction + CPI(INT) x NO.INT instructions +
CPI(L/S) X NO.L/S instructions + CPI(branch)x NO.branch instruction

CPI(LSimproved) =

$$\frac{\frac{Clock\ cycles}{2} - (CPI(FP)X\ NO.FP\ instructions + CPI(INT)XNO.INT\ instructions + CPI(branch)xNO.branch\ instructions}{NO.LS\ instructions}$$

CPI(LSimproved) = $\frac{\frac{512x10^6}{2}-((50\ x\ 10^6\ x\ 1)+(110x10^{(6)}\ x\ 1\ )+(16x10^6x2)}{80x10^6} = \frac{256X10^6-(192x10^6)}{80x10^6}$

$= \frac{64X10^6}{80x10^6} = 0.8 > 0$

Since, there are 4 NO.LS instructions and the CPI of LS instructions are more than 0.

$\frac{4}{0.8}=5$

CPI of LS instructions must be improved by 5 times for the program to run 2 times faster.

c. By how much is the execution time of the program improved (with the original configuration that the results of the above a and b are not applied) if the CPI of integer and floating-point instructions is reduced by 40%, the CPI of load/store is reduced by 30%, and that of branch is reduced by 25%?

Reduce 40% on Floating point,

CPI(FP) = 1-1(0.4)

= 0.6

Reduce 40% on INT

CPI(INT) = 1-1(0.4)

= 0.6

Reduce 30% on Load/Store,

CPI(LS) = 4-4(0.3)

= 2.8

Reduce 25% on Branch

CPI(branch) = 2-2(0.25)

=1.5

Clock cycles = (50x10^(6) x0.6)+(110x(10^(6))x0.6) + (80x10^(6)x2.8) + (16x10^(6)x1.5)

= 344x10^(6)

Initial Execution time is

$\frac{344x10\text{^}(6)}{2x10\text{^}(9)}$= 172 x10^(-3)sec

The performance for 16 processors are

Clock cycles = 344x10^(6)

Execution time = 172x10^(-3) sec

Improving execution time of program is

= $\frac{0.256\ sec}{0.172\ sec}$= 1.488 times

Submission Guideline

- Submit the matrix multiply code in an assembly file namely "cse140_your-first-name_your-last-name_mm.s", and your solution for the performance calculation problem in a separate MS Word or a pdf format to the CatCourse.
- Deadline: **Before the next lab** (If your lab time is 2/8 at 7:30 AM, the deadline is 2/15 7:30 AM)