Keegan Smith

Computer Architecture and Design

HW1

10/10/2023

1. The results of the benchmark named P running on CPU A has an IC (instruction count) of 2.389\*10^12 and an execution time of 750 seconds.
   1. Find the CPI if the clock cycle time is 0.333 ns.

* 1. Find the increase in CPU time if the number of instructions of the benchmark is increased 2% without affecting the CPI.

So, the increase in the number of instructions resulted in a 103% increase in CPU time.

* 1. Find the increase in the CPU time if the number of instructions of the benchmark is increased by 10% and the CPI is increased by 20%.

The increase in instructions and CPI generated a 133% increase in the CPU time from the initial benchmark.

* 1. Suppose that we are developing a CPU B with a 4GHz clock rate. We have also added some additional instructions to the instruction set so that the number of instructions has been increased by 5%. The execution time is reduced to 725ns. Find the new CPI.

* 1. This CPI value is larger than obtained in 1.a as the clock rate was increased from 3GHz to 4GHz. Determine whether the increase in the CPI is similar to that of the clock rate. If they are dissimilar, why?

The increase in CPI is similar to that of the clock rate because of the linearity of the CPI equation when a single variable is changing. If more than one variable was being adjusted, then the relationship may not be so similar.

* 1. By how much has the CPU time been reduced?

The CPU time can be reduced by reducing the instruction count, cycles per instruction, or decreasing the clock rate. Since CPU Time = (IC \* CPI) / clock rate, making IC or CPI smaller would result in a smaller number. Once could also slow down the CPU speed. This may seem backwards, but the CPU time formula, the clock rate in seconds is given so, the larger the clock frequency, the smaller the clock rate will be and the larger the CPU time will be because of the larger denominator.

1. Translation between C statements and MIPS assembly instructions.
   1. Assuming variables f, g, h and I are given as 32-bit integers, what are the corresponding MIPS assembly instructions for the following C program? Use a minimal number of instructions.

A group of letters and numbers on a black background

Description automatically generated

* 1. What is the corresponding C statement for the following MIPS assembly instructions?

Add f, g, h

Add f, i, f

A black background with white letters and symbols

Description automatically generated

* 1. What is the corresponding MIPS assembly code for the C statement below? Assume that the variables f, g, h, i, and j are assigned to registers $s0, $s1, …, $s4, respectively. Assume also that the base address of the array A and B are stored in registers $s6 and $s7, respectively. B[6] = A[i-j];

A screenshot of a computer program

Description automatically generated

* 1. What is the corresponding C statement for the following MIPS assembly instructions? Assume that the variables and base address of the arrays are the same as 2.c.

sll $t0, $s0, 2 # $t0 = f \*4

add $t0, $s6, $t0 # $t0 = &A[f]

sll $t1, $s1, 2 # $t1 = g\*4

add $t1, $s7, $t1 # $t1 = &B[g]

lw $s0, 0($t0) # f = A[f]

addi $t2, $t0, 4

lw $t0, 0($t2)

add $t0, $t0, $s0

sw $t0, 0($t1)

A black background with white text and colorful symbols

Description automatically generated with medium confidence

1. The table below shows 32-bit values of an array stored in memory.

A white rectangular table with black text and numbers

Description automatically generated

* 1. For the memory location in the table above, write C code to sort the data from lowest to highest; in other words, placing the lowest value in the smallest memory location.

A screen shot of a computer program

Description automatically generated

* 1. A screenshot of a computer

     Description automatically generatedWrite the same sort code using MIPS instructions. Use a minimum number of MIPS instructions. Assume that the base address of Array is stored in register $s6.