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CS M151B HW 2

2.16 Expand MIPS register to 128 registers
    4 times as many instructions

1) Each of the register fields (rs, rt, rd) would need to be
increased to 7 bits as $2^7 = 128$. The funct field may
need to increase as well to encapsulate the new instructions
However, this depends on how many instructions there
were to begin with. The instruction no longer fits in 32 bits.

2) Each of the register fields (rs, rt) would need to be increased
to 7 bits as well. This would increase the total number
of bits needed to 36, unless some are taken from
the immediate.

3) Decrease — Now that there are more instructions, its possible
that multiple small instructions could have been combined
into one. This would decrease the size of the program.
Larger registers can combat spilling, which decreases
overall program size.

Increase — Now that the instructions themselves are larger
(no longer 32 bits), this may increase the size of a 'word',
effectively increasing program size.

2.39   CPI : Arith : 1   Load/Store : 10   Branch : 3   3800
             500M   300M   100M

1) Arith : 400   Load/Store : $(300 \times 11) = 3300$ Branch : $(100 \times 3.3) = 330$ 4030
This is not a good design choice. Reducing arithmetic instructions
is nice, but they required few cycles to begin with. Increasing
the clock cycle time adversely affects the other more costly
instructions to a greater degree. The new design will actually
cause the program to take longer to execute.

2) Original : $(1 \times 500) + (10 \times 300) + (3 \times 100) = 3800$
New #1 : $(0.5 \times 500) + (10 \times 300) + (3 \times 100) = 3550$ 1.07× speedup
New #2 : $(0.1 \times 500) + (10 \times 300) + (3 \times 100) = 3350$ 1.13× speedup

2.40   70% arithmetic   10% Load/Store   20% branch

1) 2 CPI   6 CPI   3 CPI

$(0.7 \times 2) + (0.1 \times 6) + (0.2 \times 3) = 2.6$ average CPI

2) 25% improvement in overall performance

Performance can be defined by IPC (instructions per cycle)

$IPC = \frac{1}{CPI}$ $IPC = \frac{1}{2.6} = 0.3846$

If we increase this by 25% → $0.3846 \times 1.25 = 0.481$ IPC

$CPI = \frac{1}{IPC}$ $CPI = \frac{1}{0.481} = 2.08$

We are aiming for a CPI of 2.08.

$(0.7 \times ?) + (0.1 \times 6) + (0.2 \times 3) = 2.08$

$(0.7 \times ?) = 0.88$

$? = 1.257$

Arithmetic instructions should take, on average, 1.257 CPI.

3) 50% improvement in overall performance

$IPC = 0.3846$

Increase this by 50% → $0.3846 \times 1.5 = 0.577$ IPC

$CPI = \frac{1}{0.577} = 1.733$

We are aiming for a CPI of 1.733

$(0.7 \times ?) + (0.1 \times 6) + (0.2 \times 3) = 1.733$

$(0.7 \times ?) = 0.533$

$? = 0.7614$

Arithmetic instructions should take, on average, 0.7614 CPI.