CS M151B - Homework 2

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Problem 2.24

Let us first consider the Jump **(j)** instruction. Because this is a *j-type* equation, we have 26 bits for the immediate, with a left shift of 2 bits because of word alignment. Thus initially we have **0x3FFFFFF** which after a left shift becomes **0xFFFFFFC**. The upper four bits of the PC is fixed to **0x2**, and so upon concatenation, our final maximum addressable space with the jump instruction is **0x2FFFFFFC**. We notice that $0x40000000 > 0x2FFFFFFC$ and so we **cannot** jump to the given address based on the jump instruction.

With Branch if Equal **(beq)** instruction, we only have 16 bits for the immediate with a left shift of 2 bits giving us a jump distance range of $[-2^{15}, 2^{15} - 1]$. Therefore, the beq instruction cannot jump by $0x40000000 - 0x20000000$ as it does not fall in the aforementioned range.

Problem 2.26.1

We see that the initial value of of **$t1** is 10, and we essentially loop until the value of **$t1** is 0. Upon each iteration of the loop, we decrement the value of **$t1** and the value of **$s2** is incremented by 2. Thus the loop runs a total of **10 iterations** thus leading

$$\$s2 = 2 \cdot 10 = \mathbf{20}$$

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Problem 2.26.3

We see that there are a total of **5** instructions per iteration of the loop. We see that the terminating condition of the loop is upon **$t1** reaching 0, with a decrement by 1 per loop cycle. Thus if **$t1** starts out as **N** then the loop with terminate after **N** cycles, thus leading to a total of **5N** MIPS instructions along with the last two instructions to end the loop, thus leading to a final of **5N** + **2**.

Problem 2.46.1

To compare whether the tradeoff between the more powerful arithmetic instructions and increased cycle time overall, we have to look at the execution times before and after.

$$ET_{before} = CT \cdot ((500 \cdot 10^6 \cdot 1) + (300 \cdot 10^6 \cdot 10) + (100 \cdot 10^6 \cdot 3)) = 3800 \cdot 10^6 \cdot CT$$

$$ET_{after} = (1.1 \cdot CT) \cdot ((0.75 \cdot 500 \cdot 10^6 \cdot 1) + (300 \cdot 10^6 \cdot 10) + (100 \cdot 10^6 \cdot 3)) = 4042.5 \cdot 10^6 \cdot CT$$

Thus we see that with the new arithmetic instructions we have an increased execution time as $4042.5 \cdot 10^6 CT > 3800 \cdot 10^6 CT$ and thus this is **not a good design decision** as the old set of instructions lead to a faster execution time.