CSEE W3827

Fundamentals of Computer Systems

Homework Assignment 5

Solutions

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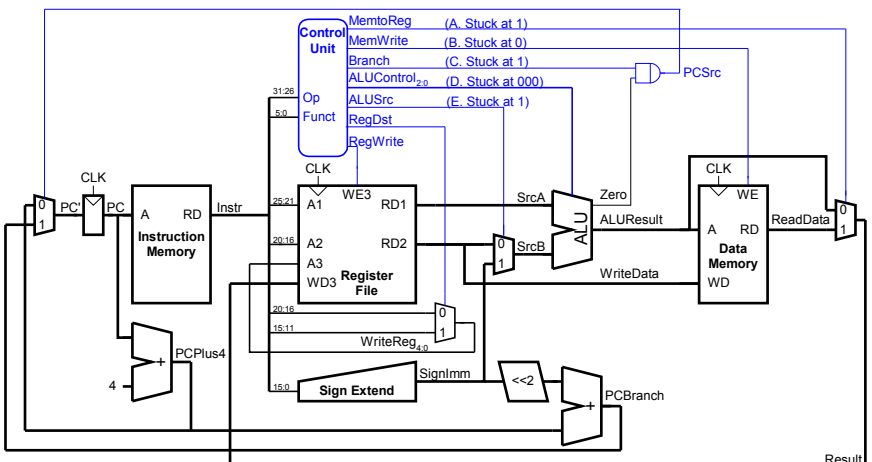
Due April 18, 2012 at 1:10 PM

Write your name **and UNI** on your solutions

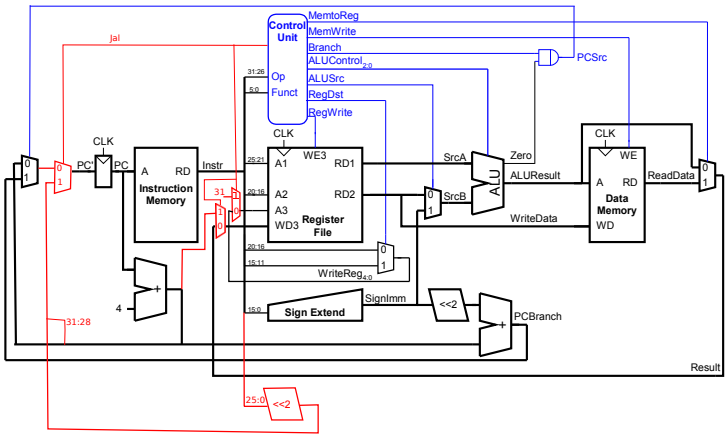
Show your work for each problem; we are more interested in how you get the answer than whether you get the right answer.

1. (25 pts.) Imagine each of the five control wires (A - E) in the above processor are stuck at a particular value. For each fault, provide an instruction that will still work and a second that will not. You should assume in each of the five cases, that all other wires are operating properly. Opcodes alone are sufficient, unless the operands are required to specify the scenario.



Fault	Working Instruction	Broken Instruction
A	lw	any R-Type, e.g., add
B	anything that does not write memory, e.g., lw	sw
C	beq	any instr where ALUResult=0 that should not branch, e.g., add $t0, $0, $0
D	and	any non-and instr that uses the ALU, e.g., beq, lw, sw, other R-types
E	any instr that feeds immediate into ALU, e.g., lw or sw	any instr that doesn't, e.g., beq, R-type

2. (25 pts.) Extend the single-cycle MIPS processor to support `jal` (j-format, opcode=000011).



Inst.	OP	RegWrite	RegDst	ALUSrc	Branch	MemWrite	MemToReg	ALUOp	Jal
R-type	000000	1	1	0	0	0	0	1-	0
lw	100011	1	0	1	0	0	1	00	0
sw	101011	0	-	1	0	1	-	00	0
beq	000100	0	-	0	1	0	-	01	0
jal	000011	1	-	-	-	0	-	–	1

3. (25 pts.) Consider a program, P, with 1 billion dynamic instructions, 50% R-Rype, 10% each of loads and stores, and 30% branches.

(a) How long would P take to execute on a single cycle processor with a 100MHz clock?

$$\frac{10^9 instructions}{P} \cdot \frac{1 cycle}{instruction} \cdot \frac{10 \times 10^{-9} seconds}{cycle} = 10 seconds$$

(b) Assuming a multicycle processor where R-type instructions take 4 cycles, loads and stores 5 cycles, and branches 3 cycles, what is the CPI of P?

$$CPI = 0.5 \cdot 4 + 0.1 \cdot 5 + 0.1 \cdot 5 + 0.3 \cdot 3 = 3.9$$

(c) Assuming the multicycle processor operated at 400MHz, how long would it take to execute P?

$$\frac{10^9 instructions}{P} \cdot \frac{3.9 cycle}{instruction} \cdot \frac{2.5 \times 10^{-9} seconds}{cycle} = 9.75 seconds$$

4. (25 pts.) Consider a new MIPS instruction “conditional move” or `cmov`. The instruction `cmov $1, $2, $3` means “copy the value in register 2 into register 1 if register 3 is nonzero”.

   If a processor does not support the `cmov` instruction, the function of the `cmov` instruction can be executed via software:

```
beq $3, $0, DONE
add $1, $2, $0
DONE
```

   Imagine two single-cycle MIPS processors, P and P_{cmov}. P runs at 100MHz and does not implement the `cmov` instruction. P_{cmov} runs at 90MHz does.

   (a) Consider a 1 billion instruction application, called A_{cmov}, of which 5% of the instructions are `cmov` instructions. How long would it take to execute A_{cmov} on P_{cmov}?
   $\frac{1\times10^{9}instructions}{program} \times \frac{1cycle}{instruciton} \times \frac{11.11\times10^{-9}s}{cycle} = 11.11s$

   (b) If A_{cmov} were modified to remove all instances of `cmov`, creating A, how many dynamic instructions would A have? Assume that the condition was true for all dynamic `cmov`s in A_{cmov}. $0.95 \times 10^9 + (2 \times 0.05 \times 10^9) = 1.05 \times 10^9$

   (c) How long would

i. A take to execute on P?
$$\frac{1.05\times10^{9} instructions}{program} \times \frac{1 cycle}{instruciton} \times \frac{10\times10^{-9} s}{cycle} = 10.5s$$

ii. A take to execute on P_{cmov}?
$$\frac{1.05\times10^{9} instructions}{program} \times \frac{1 cycle}{instruciton} \times \frac{11.11\times10^{-9} s}{cycle} = 11.66s$$