Computer Organization, Spring 2017

Lab 3: Single Cycle CPU

Due: 2017/5/11

1. Goal

In this Lab, we add memory unit to the CPU you created in Lab2 to implement a complete single cycle CPU which is able to run R-type, I-type and jump instructions,

2. HW Requirement

(1) Please use Xilinx ISE as your HDL simulator.

(2) Please attach your names and student IDs as comment at the top of each file.

(3) Please use the Testbench we provide you.

(4) PLEASE FOLLOW THE FOLLOWING RULE!

1. Zip your folder and submit *.zip file.
2. Name the *.zip file with your student IDs (e.g., 0416001_0416002.zip). Other filenames and formats such as *.rar and *.7z are NOT accepted!
3. A team's submissions must be uploaded by the same person.
4. If one violates the rules above, score will be deducted.

(5) Reg_File[29] represents stack point initialized to 128, others are 0.

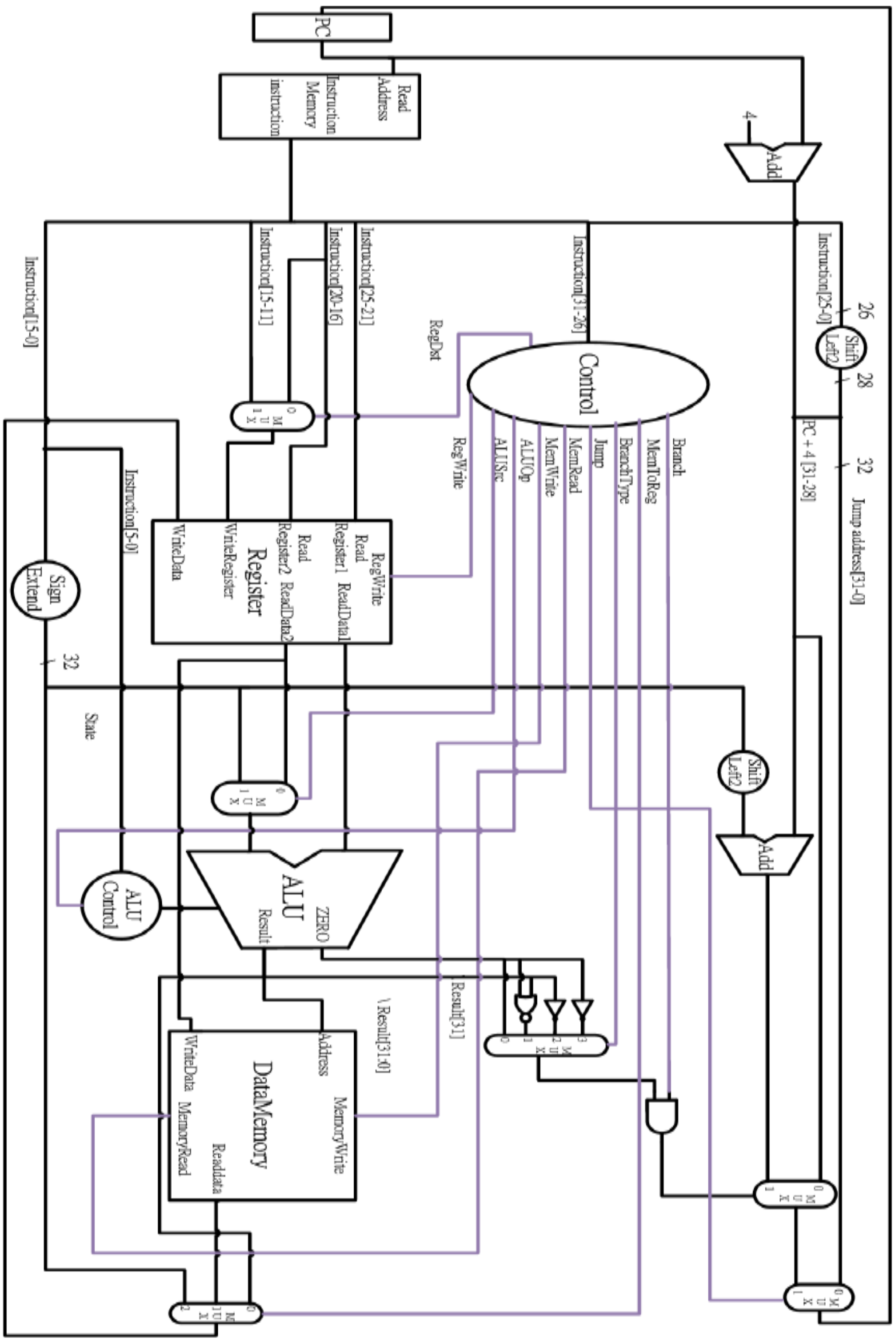
You may add these control signals to decoder: Branch_o, Jump_o, MemRead_o, MemWrite_o, MemtoReg_o

(6) Basic instruction set (50%)

All instructions in Lab2 and the following should be implemented.

Instruction	Example	Meaning	Op field	Function field
LW(Load Word)	lw r1, 12(r2)	r1=MEM[r2+12]	35	-
SW(Save Word)	sw r1, 12(r2)	MEM[r2+12]=r1	43	-
J(Jump)	j target	PC={PC[31:28], target<<2}	2	-
MUL(Multiply)	mul r1, r2, r3	r1=r2*r3	0	24(0x18)

3. Architecture diagram



4. Advanced Instructions 1 (10 pts)

Instruction	Example	Meaning	Op field	Function field
JAL(Jump and Link)	jal target	see below	3	-
JR(Jump register	jr r1	see below	0	8(0x8)

JAL:

3	address

In MIPS, the 31st register is used to save return address for function call. When perform jal, Reg[31] saves PC+4 and jump.

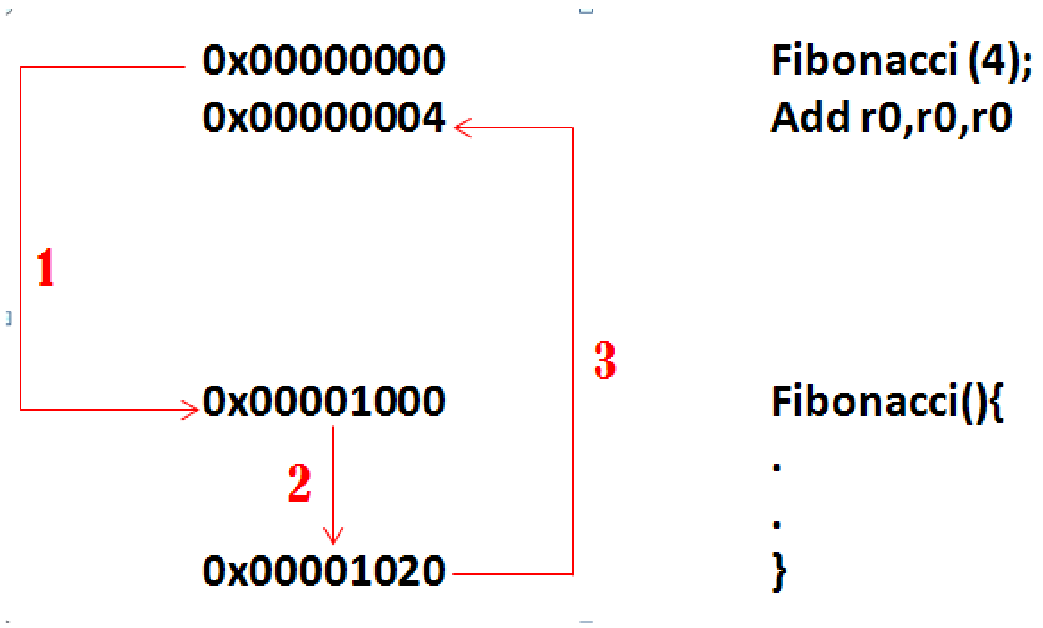
i.e., Reg[31]=PC+4; PC={PC[31:28], target<<2}

JR:

0	-	-	-	-	8

In MIPS, return can be implemented by jr r31.

e.g., When CPU executes function call



If you want to execute recursive function, you can use the stack point (Reg[29]). Store the register to memory and load back after the function call is finished.

5. Advanced Instructions 2 (20 pts)

Instruction	Example	Meaning	Op field	Function field
BLE (Branch Less Than Equal)	ble r1, r2, 25	if(r1<=r2) goto PC+100	7	-
BLT (Branch Less Than)	blt r1, r2, 25	if(r1<r2) goto PC+100	6	-
BNEZ (Branch Not Equal Zero)	bnez r1, 25	if(r1!=0) goto PC+100	5	-
LI (Load Immediate)	li r1, 1	r1 = 1	15	-

BLE:

7	Rs	Rt	offset

BLT:

6	Rs	Rt	offset

BNEZ:

5	Rs	0	offset

LI:

15	0	Rd	immediate

6. Grade

(1) Total: 100 points (plagiarism will get 0 point)

(2) Document: 20 points

(3) Late submission: 10 points off per day

7. Hand in

Please follow the rules! Zip your folder and name it as "ID1_ID2.zip" (e.g., 0416001_0416002.zip) before uploading to e3. Multiple submissions are accepted, and the version with the latest time stamp will be graded.

8. How to test

```
        add     $t0, $0,  $0
        addi    $t1, $0,  10
        addi    $t2, $0,  13
        mul     $t3, $t1, $t1
        j       Jump
bubble:
        li      $t0, 10
        li      $t1, 4
        mul     $t4, $t0, $t1
outer:
        addi    $t6, $t0, 8
        sub     $t0, $t4, $t6
        li      $t1, 0
inner:
        lw      $t2, 4($t0)
        lw      $t3, 0($t0)
        ble     $t2, $t3, no_swap
        sw      $t2, 0($t0)
        sw      $t3, 4($t0)
        li      $t1, 1
no_swap:
        addi    $t5, $0,  4
        sub     $t0, $t0, $t5
        blt     $t0, $0, next_turn
        j       inner
next_turn:
        bnez    $t1, outer
        j       End
Jump:
        sub     $t2, $t2, $t1
Loop:
        add     $t4, $t3, $t2
        beq     $t1, $t2, Loop
        j       bubble
End:
```

CO_P2_test_data1.txt is for basic instruction and CO_P2_test_data2.txt is for advanced set 1. As for advanced set 2, please translate the bubble sort above to machine code, and test it on your CPU.

9. Q&A

For any questions regarding Lab 3, please contact 林湑晨 (miz1205@gmail.com) and 曾天鴻 (eric830303@gmail.com)