Computer Organization, Spring, 2015

Lab3: Single Cycle CPU

1.Goal:

Based on Lab 2 (simple single-cycle CPU), add a memory unit to implement a complete single-cycle CPU which can run R-type, I-type and jump instructions.

2.HW requirement:

Deadline: 5/11 11:59 pm

1. Xinlinx as simulation platform

2. Please attach your names and student IDs as comments at the top of each file. PLEASE FOLLOW THE FOLLOWING RULE! Zip your folder and name it as "ID.zip" (e.g., 0216001.zip) before uploading to e3. Multiple submissions are accepted, and the version with the latest time stamp will be graded.

3. Do not copy, or you will get 0.

4. Refer to Lab 2 for top module's name and IO ports.

Initialize the stack pointer (i.e., Reg_File[29]) to 128, and all of the other registers to 0

Decoder may add control signals:

-Branch_o

-Jump_o

-MemRead_o

-MemWrite_o

-MemtoReg_o

3.Requirement description:

lw instruction ：

memwrite is 0，memread is 1，regwrite is 1

Reg[rt]， Mem[rs+imm]

sw instruction :

Memwrite is 1，memread is 0

Mem[rs+imm]， Reg[rt]

Branch instruction ：

Branch is 1，and decide branch or not by do AND with the zero signal from ALU

PC=PC+4+ (sign_Imm<<2)

Jump instruction :

jump is 1

PC={PC[31:28]，address<<2}

1. Code: (80%)

Basic instruction: (50%)

Lab 2 instruction + mul、lw、sw、j

R-type

Op[31:26]	Rs[25:21]	Rt[20:16]	Rd[15:11]	Shamt[10:6]	Func[5:0]

I-type

Op[31:26]	Rs[25:21]	Rt[20:16]	Immediate[15:0]

Jump

Op[31:26]	Address[25:0]

instruction	Op[31:26]			
lw	6’b100011	Rs[25:21]	Rt[20:16]	Immediate[15:0]
sw	6'b101011	Rs[25:21]	Rt[20:16]	Immediate[15:0]
jump	6'b000010	Address[25:0]		

Mul is R-type instruction

0	rs	rt	rd	0	24

Advance set 1: (10%)

instruction	op	rs	rt	rd	shamt	Func
jal	6’b000011	Address[25:0]				
jr	6’b000000	rs	0	0	0	6’b001000

Jal: jump and link

In MIPS，31th register is used to save return address for function call

Reg[31] save PC+4 and perform jump

Reg[31]=PC+4

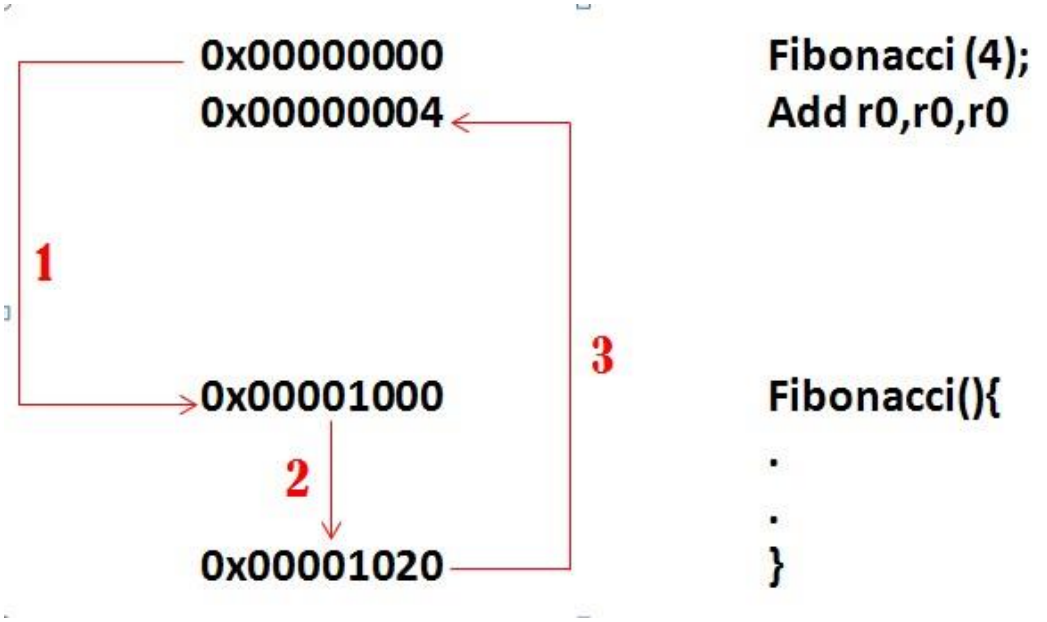
PC={PC[31:28],address[25:0]<<2}

Jr: jump to the address in the register rs

PC=reg[rs];

e.g.：In MIPS，return could be used by jr r31 to jump to return address from **JAL**

Example: when CPU executes function call,



If you want to execute recursive function, you must use the stack point (Reg_File[29]).

First, store the register to memory and load back after function call has been finished.

The second testbench CO_P3_test_data2.txt is the Fibonacci function. After it is done, r2 stores the final answer. Please refer to test2.txt

Advance set 2: (20%)

blt (branch on less than) • if(rs<rt) then branch

6	rs	rt	offset

bnez (branch non equal zero) • if(rs!=0) then branch (it is same as bne)

5	rs	0	offset

bgez (branch greater equal zero) if(rs>=0) then branch

1	rs	1	offset

li (load immediate)

You don't have to implement it, because it is similar to (and thus can be replaced by) addi.

0xf	0	rd	immediate

2. Testbench

CO_P3_test_data1.txt tests the basic instructions (50%) and CO_P3_test_data2.txt tests the advanced set 1 (10%). Please refer to test1.txt and test2.txt for details. The following MIPS code is bubble sort. Please transform the MIPS code to machine

code, store the machine code in CO_P3_test_data3.txt and run it (for testing advance set 2 (20%)).

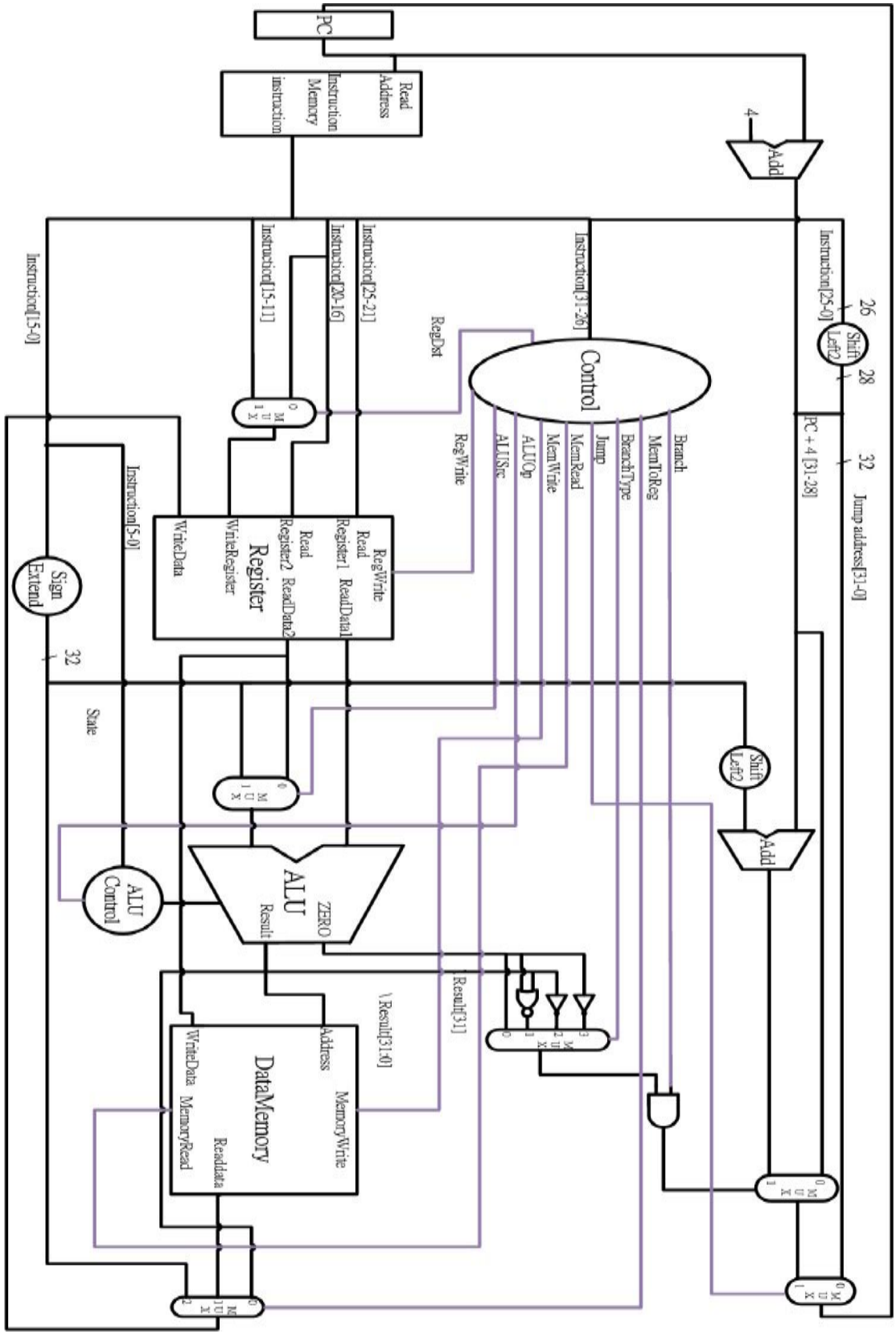
```
    add     $t0, $0, $0
    addi    $t1, $0, 10
    addi    $t2, $0, 13
    mul     $t3, $t1, $t1
    j       Jump
bubble:
    li      $t0, 10
    li      $t1, 4
    mul     $t4, $t0, $t1
outer:
    addi    $t6, $0, 8
    sub     $t0, $t4, $t6
    li      $t1, 0
inner:
    lw      $t2, 4($t0)
  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

3. Report (20%)

Please refer to CO_document.docx

4. Reference architecture

This lab might use extra signal(s) to control. Please draw the architecture you designed in your report.



5. Hand in your assignment:

Put all of *.v source files and report into the same folder. Please zip your folder and submit only one *.zip file. Name the *.zip file with your student ID (e.g., 0216001.zip). Other formats such as *.rar and *.7z are NOT accepted.