**ECEN 323 – Winter 2020**

Lab 9: Forwarding

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Section 1

Preliminary

**Forwarding**

Include your commented code in your laboratory report.

addi x1, x0, 1 # No forwarding

add x2, x1, x1 # x1 is forwarded from the MEM stage to A input of EX stage

# x1 is forwarded from the MEM stage to B input of EX stage

sub x3, x2, x1 # x2 is forwarded from the MEM stage to A input of the EX stage

# x1 is forwarded from the WB stage to B input of the EX stage

slt x4, x1, x2 # x2 is forwarded from the WB stage to B input of the EX stage

addi x5, x2, -3 # No forwarding

andi x5, x5, 0x7f0 # x5 is forwarded from the MEM stage to A input of the EX stage

ori x5, x5, 0xf # x5 is forwarded from the MEM stage to A input of the EX stage

add x5, x5, x5 # x5 is forwarded from the MEM stage to A input of the EX stage

# x5 is forwarded from the MEM stage to B input of the EX stage

addi x6, x0, 1024 # No forwarding

lw x7, 0(x6) # x6 is forwarded from the MEM stage to A input of the EX stage

add x8, x7, x2 # x7 is forwarded from the MEM stage to A input of the EX stage

sw x8, 4(x6) # No forwarding

slt x9, x2, x1 # No forwarding

or x10, x5, x8 # x8 is forwarded from the WB stage to B input of the EX stage

xor x11, x6, x2 # No forwarding

ori x12, x0, 0 # No forwarding

ori x13, x0, 2 # No forwarding

**EX Stage Forwarding**

For each of the five cycles below, determine the values of ForwardA and ForwardB.

|  | **Cycle** | | | | |
| --- | --- | --- | --- | --- | --- |
| **Stage** | **1** | **2** | **3** | **4** | **5** |
| IF | or | add | sd |  |  |
| ID | and | or | add | sd |  |
| EX | sub | and | or | add | sd |
| MEM |  | sub | and | or | add |
| WB |  |  | sub | and | or |
| **ForwardA** | 00 | 10 | 00 | 00 | 00 |
| **ForwardB** | 00 | 00 | 01 | 00 | 00 |

**Forwarding with Immediate Data**

Summarize the changes in the logic used for the ForwardB logic on page 301 in the textbook to accommodate the use of immediate data for the second operand.

The changes to be accommodated are that the forwarding logic must take place before the mux that determines whether the immediate or the rs2 value is used. The ForwardA logic needs no adjustment.

**Pipeline Hazards**

Provide your annotated assembly code.

lw x2,20(x1)

add x4,x2,x5 # Load use hazard!

lw x5,14(x4)

sw x6,-4(x5) # Load use hazard!

sub x4,x2,x6

lw x7,-12(x4)

xori x7,x4,0x1ff

lw x8,256(x7)

lw x9,0(x8) # Load use hazard!

and x10,x9,x8 # Load use hazard!

lw x11,-8(x10)

andi x12,x10,0xff

Emulate the execution of this instruction sequence by completing the pipeline table shown below.

| Cycle # => |
| --- |
| **Stage** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** |
| IF | ori | beq | addi | subi | beq | andi | ori | xori | sub | add | beq | andi | xori | ori |
| ID |  | ori | beq | addi | subi | beq | andi | ori | xori | sub | add | beq | andi | xori |
| EX |  |  | ori | beq | addi | subi | beq | andi | nop | nop | sub | add | beq | andi |
| MEM |  |  |  | ori | beq | addi | subi | beq | nop | nop | nop | sub | add | beq |
| WB |  |  |  |  | ori | beq | addi | subi | beq | nop | nop | nop | sub | add |

| **15** | **16** | **17** | **18** |
| --- | --- | --- | --- |
| sub | add | beq | andi |
| ori | sub | add | beq |
| nop | nop | sub | add |
| nop | nop | nop | sub |
| beq | nop | nop | nop |

Exercise #1

**Hazard Detection Logic**

**Instruction Fetch (IF)**

**Instruction Decode (ID)**

**Execute (EX)**

**Memory Access (MEM)**

**Write-Back (WB)**

Exercise #2

Include the last 15 lines of the console output in your laboratory report.

Include a copy of your Forwarding pipeline code in your laboratory report.

Exercise #3

Include a copy of the testbench console output in your laboratory report

Exercise #4

Summarize and justify any warnings you had during synthesis. If you did not have any warnings, say such in your laboratory report.

Summarize the estimated resources for your synthesized logic in the table below.

|  |
| --- |
|  |
| **Resource** | **Estimation** |
| LUT |  |
| LUTRAM |  |
| FF |  |
| IO |  |
| BUFG |  |

How many hours did you work on the lab?

- hours

Please provide any suggestions for improving this lab in the future:

None. Great stuff.