JOINT INSTITUTE
交大密西根学院

ECE3700J Introduction to Computer Organization

Homework 5

Assigned: October 24, 2023

Due: 11:59pm on Saturday, October 28, 2023

Submit a PDF file on Canvas

1. (50 points) Given the following instructions:

```
L1: add  x8,x9,x10
L2: lw   x3,8(x8)
L3: sw   x3,-12(x8)
L4: lb   x6,1(x3)
L5: or   x8,x9,x6
```

   a) Assume there is no forwarding in this pipelined processor. Indicate hazards and add "nop" instructions to eliminate them. How many clock cycles will it take to execute the instructions? (15 points)
   b) Assume there is ALU-ALU forwarding (from ALU output to ALU input) but not MEMORY-ALU forwarding (from data memory output to ALU input). Indicate hazards and add NOP instructions to eliminate them. How many clock cycles will it take to execute the instructions? (10 points)
   c) Assume there are both ALU-ALU and MEMORY-ALU forwarding paths. Indicate hazards and add NOP instructions to eliminate them. How many clock cycles will it take to execute the instructions? (10 points)
   d) What could potentially be the smallest number of clock cycles to execute the instructions correctly? What would you do to achieve that? (15 points)

NOTE: the following problems are optional and won't be graded.

2. Assume that x11 is initialized to 11, x12 is initialized to 12, and x13 is initialized to 13. Suppose you executed the code below on a pipelined processor that does not handle data hazards at all.

```
L1: addi x12, x11, 5
L2: add x13, x12, x11
L3: add x14, x12, x13
```

   e) Indicate data dependencies, if any, in above instruction sequence. (which register between which instructions)
   f) What would the final values of registers x13 and x14 be?
   g) Insert "nop" instructions to resolve the data hazards.

3. Given this assembly instruction sequence executed by the pipelined processor:

```
L1: sub x6, x2, x1
L2: lw  x3, 8(x6)
L3: lw  x2, 0(x6)
L4: or  x3, x3, x2
L5: sw  x3, 0(x5)
```

a) Identify all the data hazards.
b) If the processor has forwarding, but we forgot to implement the “hazard detection unit”, what happens when this code executes?
c) If there is forwarding as shown in above pipeline diagram, for the first five cycles during the execution of this code, specify which signals are asserted in each cycle by the “hazard detection” and “forwarding units”.
d) If there is no forwarding, what new inputs and output signals do we need for the hazard detection unit? Using this instruction sequence as an example, explain why each signal is needed.