EGC442 **HW#5** **Dr. Izadi**

First Name: _____ Last Name: _____

Question 1 (25 Points)

For the code below,

```
lw      $t0, 0($s1)
add     $t1, $s1, $a2
sub     $t0, $t0, $s2
sw      $t1, 0($s1)
addi    $s1, $s1,–4
```

a. On the diagram, mark and identify all the data dependencies in the code given below and identify which dependencies will cause data hazards without forwarding hardware.
b. Assuming there is no special hardware that is added for forwarding, add "nop" instructions to the code to avoid the data hazards.
c. Assume that the hardware supports forwarding and stalling. Show from which pipe the data is taken from and where it is forwarded. How many cycles will it take to execute this code (no need for nops)? Indicate what each stage will do during the 6^{th} clock cycle.
d. How many cycles will it take to execute this code in parts b. and c.?

Question 2 (25 Points)

For the code below,

```
lw      $1, 0($1)
lw      $1, 0($1)
add     $1, $1, $2
lw      $1, 0($1)
sw      $2, 12($1)
```

a. On the diagram, mark and identify all the data dependencies in the code given below and identify which dependencies will cause data hazards without forwarding hardware.
b. Assuming there is no special hardware that is added for forwarding, add "nop" instructions to the code to avoid the data hazards.
c. Assume that the hardware supports forwarding and stalling. Show from which pipe the data is taken from and where it is forwarded. How many cycles will it take to execute this code (no need for nops)? Indicate what each stage will do during the 6^{th} clock cycle.
d. How many cycles will it take to execute this code in parts b. and c.?

Question 3 (25 Points)

In this exercise, we examine how data dependences affect execution in the basic 5-stage pipeline described in the text (An overview of pipelining). Problems in this exercise refer to the following sequence of instructions:

or r1, r2, r3

or r2, r1, r4

or r1, r1, r2

Also, assume the following cycle times for each of the options related to forwarding:

Without Forwarding	With Full Forwarding	With ALU-ALU Forwarding Only
250ps	300ps	290ps

a.Indicate dependences and their type.

b. Assume there is no forwarding in this pipelined processor. Indicate hazards and add nop instructions to eliminate them.

c. Assume there is full forwarding. Indicate hazards and add NOP instructions to eliminate them.

d What is the total execution time of this instruction sequence without forwarding and with full forwarding? What is the speedup achieved by adding full forwarding to a pipeline that had no forwarding?

e. Add nop instructions to this code to eliminate hazards if there is ALU-ALU forwarding only (no forwarding from the MEM to the EX stage).

f What is the total execution time of this instruction sequence with only ALU-ALU forwarding? What is the speedup over a no-forwarding pipeline?

Note: With full forwarding, an ALU instruction can forward a value to EX stage of the next instruction without a hazard, With ALU-ALU-only forwarding, an ALU instruction can forward to the next instruction

Question 4 (25 Points)

This exercise is intended to help you understand the relationship between forwarding, hazard detection, and ISA design. Problems in this exercise refer to the following sequence of instructions, and assume that it is executed on a 5-stage pipelined datapath:

add r5, r2, r1

lw r3, 4(r5)

lw r2, 0(r2)

or r3, r5, r3

sw r3, 0(r5)

a.If there is no forwarding or hazard detection, insert nops to ensure correct execution.

b. repeat a but now use nops only when a hazard cannot be avoided by changing or rearranging these instructions. You can assume register R7 can be used to hold temporary values in your modified code.

c. If the processor has forwarding, but we forgot to implement the hazard detection unit, what happens when this code executes?

d. If there is forwarding, for the first five cycles during the execution of this code, specify which signals are asserted in each cycle by hazard detection and forwarding units in text (Pipelined control overview, showing the two multiplexor for forwarding …).

e. If there is no forwarding, what new inputs and output signals do we need for the hazard detection unit in text (Pipelined control overview, showing the two multiplexor for forwarding …)? Using this instruction sequence as an example, explain why each signal is needed.

f. For the new hazard detection unit from e., specify which output signals it asserts in each of the first five cycles during the execution of this code.

Due: 4/14/2023