CS 2200 Homework 6

Spring 2019

- Please print a copy of the assignment and hand write your answers. No electronic submissions are allowed. **Please print as one double-sided page. Do NOT staple multiple sheets together. There will be a 60 point penalty if you do this improperly.**
- This is an individual assignment. You may discuss concepts but not the answers.
- Due Date: **6th March 2019 – 6:15 PM** in recitation. Bring your BuzzCard. Show up on time.

Name:_____ **GT Username:**_____ **Section:**_____

1. The RAMA-2200 processor uses a 5-stage pipeline of stages:

   IF ID/RR EX MEM WB

   You can assume the following about the processor:
   - All registers are initialized to 0
   - There is data forwarding from EX, MEM, and WB to ID/RR
   - Branches are resolved in **EX**
   - Branches are handled conservatively (Branch Not Taken)
   - CPI = 1 in the event of no hazards

   The assembly code in the diagram below is run to completion. Show the first 12 cycles of code execution with the following waterfall diagram. We have filled in the first instruction (A)'s path for you.

```
I1. ADDI   $t0, $t0, 1
I2. ADDI   $t1, $t1, 1
I3. BEQ    $t1, $t0, I2
I4. LW     $t2, 0($s0)
I5. NAND   $s1, $t2, $t2
I6. HALT
```

Cycle	IF	ID/RR	EX	MEM	WB
0	I1				
1	I2	I1			
2	I3	I2	I1		
3	I4	I3	I2	I1	
4	I4	NOP	I3	I2	I1
5					
6					
7					
8					
9					
10					
11					

2.

a. Fill in the table below with the number of NOPs (bubbles) each situation will produce. In the case of the RAW hazard, assume that there are no other instructions in between the write instruction and read instruction.

	No data forwarding	Data forwarding
RAW Hazard		
Load-to-Use RAW Hazard		
	When the branch does not occur	When the branch does occur
Conservative Branching		
Branching with Branch Prediction		

b. Explain how you calculated the number of NOPs produced by a load instruction with data forwarding in the previous question.

3. For each instruction below, state what type of hazard(Structural, Data, or Control) the instruction can cause, if any. If the instruction causes a data hazard, then state what type of data hazard it is.

		Class of Hazard (If any)	Type of Data Hazard (If applicable)
I1.	`ADDI $t0, $t0, 1`	_____	_____
I2.	`ADDI $t1, $t0, 1`	_____	_____
I3.	`NAND $t1, $t1, $t1`	_____	_____
I4.	`BLT $t0, $t1, END`	_____	_____

3. When we consider branch prediction, why is flushing necessary? What may happen if we do not implement flushing?

4. What is the branch target buffer? How does it help us, and what does it store?