CSCE 692 HW Set 3 – Exercises

(Appendix C)

(100 Points)

Due: NLT 1100 Thursday, 31 January 2019

**Problems: C.1 – a** [**10**]**, b** [**20**]**, c** [**20**]**, d** [**20**]

**C.3 – a** [**7**]**, b** [**7**]**, c** [**7**]**, d** [**9**]

**Instructions:**

* Put your name at the top, and number each page (last name-pg)
* State the complete problem
* Show your work
* Clearly indicate your answer

**Notes:**

**C.1 a. Not all data dependencies result in hazards. Find ALL data dependencies.**

* **Do not list “transitive” dependencies (that cross instructions).**

**C.1 (b, c, d)**

* **Assume branch target is known in ID, but that branch outcome is not decided until the EX stage.**
* **When computing how many cycles the loop requires, it is asking for all iterations of the loop, beginning at the first instruction, and continuing until the next valid instruction following the loop is able to begin.**
* **When you have to draw a multi-cycle diagram, consider using or printing out copies of the blank template (pipeline\_matrix.xlsx) (on CANVAS, and printed below).**

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| Instruction | Operands | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| ld | x1, 0(x2) | IF | ID | EX | M | WB |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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C.1 [10/20/2/20/] <C.2> Using the following code fragment, answer the following questions:

Loop: ld x1,0(x2) ; load x1 from address 0+x2

addi x1,x1, 1 ; x1=x1+1

sd x1,0(x2) ; store x1 at address 0+x2

addi x2,x2, 4 ; x2=x2+4

sub x4,x3,x2 ; x4=x3-x2

bnez x4,Loop ; branch to Loop if x4!=0

(Assume that the initial value of x3 is x2 + 396.)

99 Loops 🡪 x2 is increasing by 4 each iteration of the loop

1. [10] <C.2> Data hazards are caused by data dependences in the code. Whether a dependency causes a hazard depends on the machine implementation (i.e., number of pipeline stages). List all of the data dependences in the code above. Record the register, source instruction, and destination instruction; for example, there is a data dependency for register x1 from the ld to the addi.

|  |  |  |
| --- | --- | --- |
| **Register** | **Source Instruction** | **Destination Instruction** |
| x1 | ld | addi |
| x1 | addi | sd |
| x2 | sd | addi |
| x2 | sub | addi |
| x4 | sub | bnez |

1. [20] <C.2> Show the timing of this instruction sequence for the 5-stage RISC pipeline without any forwarding or bypassing hardware but assuming that a register read and a write in the same clock cycle “forwards” through the register file, as shown in Figure C.5. Use a pipeline timing chart like that in Figure C.8. Assume that the branch is handled by flushing the pipeline. If all memory references take 1 cycle, how many cycles does this loop take to execute?

c. [20] <C.2> Show the timing of this instruction sequence for the 5-stage RISC pipeline with full forwarding and bypassing hardware. Use a pipeline timing chart like that shown in Figure C.8. Assume that the branch is handled by predicting it as not taken. If all memory references take 1 cycle, how many cycles does this loop take to execute?

d. [20] <C.2> Show the timing of this instruction sequence for the 5-stage RISC pipeline with full forwarding and bypassing hardware. Use a pipeline timing chart like that shown in Figure C.8. Assume that the branch is handled by predicting it as taken. If all memory references take 1 cycle, how many cycles does this loop take to execute?

C.3 [7/7/7/9] <C.2> We begin with a computer implemented in single-cycle implementation. When the stages are split by functionality, the stages do not require exactly the same amount of time. The original machine had a clock cycle time of 7 ns. After the stages were split, the measured times were IF, 1 ns; ID, 1.5 ns; EX, 1 ns; MEM, 2 ns; and WB, 1.5 ns. The pipeline register delay is 0.1 ns.

a. [7] What is the clock cycle time of the 5-stage pipelined machine?

Clock cycle time = longest stage + register delay = 2 + .1 = 2.1 ns

b. [7] If there is a stall every 4 instructions, what is the CPI of the new machine?

CPI = 1

c. [7] What is the speedup of the pipelined machine over the single- cycle machine?

d. [9] If the pipelined machine had an infinite number of stages, what would its speedup be over the single-cycle machine?