

CSCI 516 - Fundamental Concepts in Computing and Machine Organization

Homework Assignment 6

Due on 11/22/2022 (Tuesday), 11:55PM

Requirement

- You need to do your assignment independently.
- You need to submit “.pdf” file which contains your solutions to D2L

Questions

Given the following assembly instructions, answer the questions.

loop:

```
LDUR X9, [X0, #0]
LSL X9, X9, #2
STUR X9, [X0, #0]
ADD X10, X10, #8
CMP X1, X10
B.GT loop
```

X0 stores the base address of an array, X1 indicate the number of iterations for this loop.

Questions:

1. Assume there is no forwarding or branch prediction. How many stalls are in the pipeline in the previous code (one iteration). List all the stalls between the execution of the instructions.
2. Assume there is forwarding, no branch prediction.
 - a. Unroll the loop two times.
 - b. Reorder the code and see how many cycles are needed to complete the unrolled code.

1. There are 5 stalls in the pipeline

- the LDUR instruction takes 1 clock cycle to execute so it stalls the pipeline for 1 clock cycle.
- the LSL instruction takes 1 clock cycle to execute so it stalls the pipeline for 1 clock cycle.

- the STUR instruction takes 1 clock cycle to execute so it stalls the Pipeline for 1 clock cycle.
- the ADD instruction takes 1 clock cycle to execute so it stalls the pipeline for 1 clock cycle.
- the CMP instruction takes 1 clock cycle to execute so it stalls the pipeline for 1 clock cycle.

2. If the loop is unrolled 2 times it will take 10 cycles to complete the unrolled code.

The first instruction, LDUR $x9, [x0, \#0]$, loads the value at memory address $x0$ into register $x9$.

The second instruction, LSL $x9, x9, \#2$, shifts the value in register $x9$ to the left by 2 bits.

The third instruction, STUR $x9, [x0, \#0]$, stores the value in register $x9$ back into memory at address $x0$.

The fourth instruction, ADD $x10, x10, \#8$, adds to the value in register $x10$.

The fifth instruction, CMP $x1, x10$, compares the value in register $x1$ to the value in register $x10$.