05.03.2020

Istanbul Technical University
Department of Computer Engineering

BLG 322E – Computer Architecture
Assignment 2

Due Date: 18.03.2020, **Wednesday,** 23.59.

QUESTION: A RISC CPU has an instruction pipeline with the following 5 stages:

- IF: Instruction fetch
- DR: Instruction Decode, Read registers
- EX: Execute
- ME: Memory
- WB: Write back

The CPU does not have any forwarding (bypass) connections. The CPU writes data to registers in the first half of the cycle (rising edge) and reads data from registers in the second half of the cycle (falling edge). The branch target address is calculated in the EX stage, and the result is sent directly to the IF stage.

```
        LDL  $00(R3), R1
        LDL  $04(R3), R2
        ADD R1, R2, R1
        LDL  $08(R3), R4
        SUB  R1, R4, R1
        BRU LAST_OP
        LDL  $14(R3), R2
        SUB  R1, R2, R1
        STL  $104(R3), R1
LAST_OP:  LDL   $10(R3), R2
        ADD R1, R2, R1
        STL  $104(R3), R1
```

a) Draw the space-time diagram for the execution of the given program, in the given instruction pipeline. Solve all data and branch conflicts using NOOP instructions. For the given piece of code, what is the total amount of penalty in clock cycles caused by conflicts?

b) To minimize the amount of penalty, apply optimized software-based solutions to the conflicts, if possible. Keep in mind that the results generated by the program cannot be changed. What is the total amount of penalty in clock cycles with the new solutions?

INSTRUCTION SET:

LDL	X(Rs), Rd	Rd ← M[Rs + X]	Load
STL	X(Rs), Rm	M[Rs + X] ← Rm	Store
ADD	Ri, Rj, Rd	Rd ← Ri + Rj	Add
SUB	Ri, Rj, Rd	Rd ← Ri - Rj	Subtract
BRU	Y	PC ← PC + Y	Branch relative

Submission: Draw the diagrams using a computer program. You should type your name and student ID at the top of the paper. You must submit your homework in PDF format through the Ninova system before the due date.

Late submissions will not be accepted.

Assignments have to be done individually. If any plagiarism is detected, disciplinary regulations of the University will be applied.

Note: If you have a problem about the homework, you may contact the research assistants of the course (ozcelikfu@itu.edu.tr).