Exercise sheet 7 – Processor architecture

Goals:

- Pipelining
- Instruction Scheduling

Exercise 7.1: Pipelining

(a) Given is a sequence of instructions and a 5-stage-pipeline. State the procedure and be careful, the instructions are not ordered perfectly to fully utilise the pipeline.

Instruction sequence:

Nr.	Instruction	Comment
(1)	ADD R2, R1, R1	*; R1 = R1 + R2*
(2)	ADD R1, R3, R3	*; R3 = R1 + R3*
(3)	ADD R4, R5, R5	*; R5 = R4 + R5*
(4)	CMP R5, #0, R6	*; R6 = cmp(R5, 0)*
(5)	BNE R6, M	*; Jump to M if result != 0 BNE = branch not equal*
(6)	INST1	*; some random instruction 1*
(7)	INST2	*; some random instruction 2*
	...	
(8)	M: INST100	*; some random instruction 100*
	...	

Five-stage-pipeline:

Stage	Operation
1.	Fetch instruction
2.	Load operands
3.	Execute instruction
4.	Memory access
5.	Save result into register

(b) Suggest ideas for a better pipeline utilisation of *exercise 7.1a.*
Assume there are additional instructions before the given program excerpt.

Exercise 7.2: Pipeline-Simulator

The pipeline simulator is taken from *http://euler.vcsu.edu/curt.hill/mips.html.*

(a) Update the `CA_exercises` repository with `git pull`.

(b) Change into the `CA_exercises/sheet_07_pipelining/PipelineSimulator` directory.

(c) To compile the pipeline-simulator run `javac GUI.java` from a terminal, or use the `Makefile`.
Hint: Make sure that you have properly installed the JDK and JRE. Within the VM it is already installed.

(d) Start the simulator with: `java GUI`

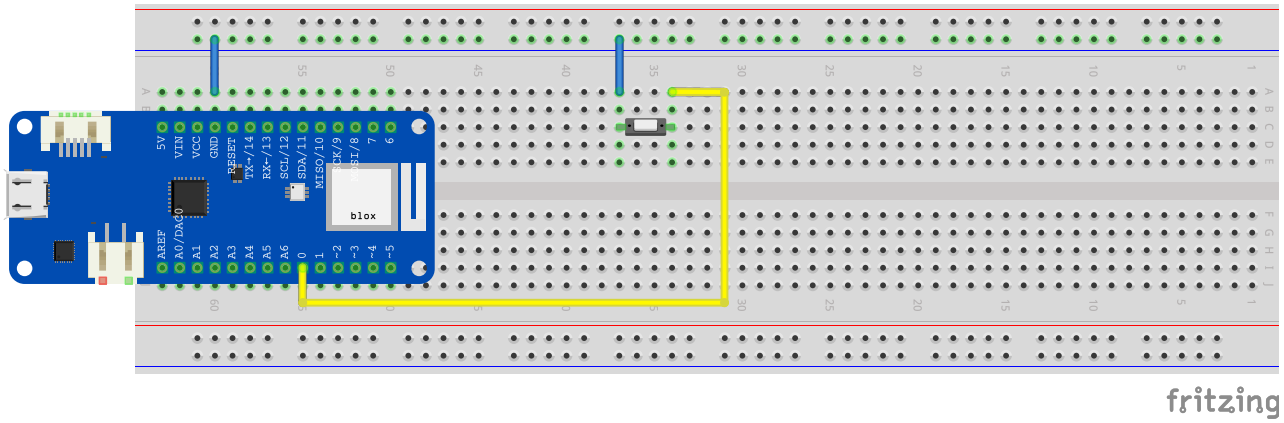
(e) In *mips.html* you can find some information on how to work with the simulator.

(f) Create a little assembly program, based on *exercise 7.1a* and run the simulator. *Hint: There is no one-to-one mapping possible, because not all required instructions are available.*

Exercise 7.3: Instruction scheduling (coding)

We want to write an Arduino sketch which counts the number of button presses. If the button is pressed, an interrupt occurs which calls an ISR.

(a) Prepare the wiring with the Arduino MKR WiFi 1010 as follows:



(b) Please double check your wiring with the lecturer, before you connect the Arduino MKR WiFi 1010.

(c) Make sure that you have installed the Arduino IDE (`https://www.arduino.cc/en/software`).

(d) Make sure you have installed the board SDK:

- `Tools -> Board: -> Boards Manager...`
- Install (latest version): `Arduino SAMD Boards (32-bits ARM Cortex-M0+)`

(e) Open the skeleton file from
`CA_exercises/sheet_07_pipelining/io_interrupt/io_interrupt.ino`
with the Arduino IDE.

(f) Follow the TODOs in the code. Some configuration depends on your wiring of the I/O pins. *Hint: The Arduino reference contains descriptions of the used functions:* ***`https://www.arduino.cc/reference/en`****.*

(g) Configure the board within the Arduino IDE: `Tools -> Board: -> Arduino MKR WiFi 1010`.

(h) Compile (verify) your sketch within the Arduino IDE. If it compiles then upload it your sketch.

(i) Open the 'Serial Monitor' to see the printed strings and do some debugging with the text based logging.

(j) Press the button to test your sketch. Does it work as expected?