

BLG 322E – Computer Architecture Assignment 2

There are 2 important conditions for setting the timing of processes:

- While reading data from the register, it is enough to run the DR step of the instruction that will read data from the record and the WB step of the instruction that will write data to the registry at the same time. Because the CPU writes data to registers in the first half of the cycle and reads data from registers in the second half of the cycle.
- In branching operation, IF step of the process to be followed must come after the EX step of the branch instruction. Because the branch target address is calculated in the EX stage, and the result is sent directly to the IF stage.

In the chart below, light steps are a prerequisite for dark steps.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
LDL \$00(R3), R1	IF	DR	EX	ME	WB											
LDL \$04(R3), R2		IF	DR	EX	ME	WB										
ADD R1, R2, R1			IF	DR	EX	ME	WB									
LDL \$08(R3), R4				IF	DR	EX	ME	WB								
SUB R1, R4, R1					IF	DR	EX	ME	WB							
BRU LAST_OP						IF	DR	EX	ME	WB						
LDL \$14(R3), R2							IF	DR	EX	ME	WB					
SUB R1, R2, R1								IF	DR	EX	ME	WB				
STL \$104(R3), R1									IF	DR	EX	ME	WB			
LAST_OP: LDL \$10(R3), R2										IF	DR	EX	ME	WB		
ADD R1, R2, R1											IF	DR	EX	ME	WB	
STL \$104(R3), R1												IF	DR	EX	ME	WB

- a) First of all, we put NOOP instruction between instructions to set the timing. And let's exclude instructions that could not enter the pipeline from the scheme.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
LDL \$00(R3), R1	IF	DR	EX	ME	WB																		
LDL \$04(R3), R2		IF	DR	EX	ME	WB																	
NOOP			IF	DR	EX	ME	WB																
NOOP				IF	DR	EX	ME	WB															
ADD R1, R2, R1				IF	DR	EX	ME	WB															
LDL \$08(R3), R4					IF	DR	EX	ME	WB														
NOOP						IF	DR	EX	ME	WB													
NOOP							IF	DR	EX	ME	WB												
SUB R1, R4, R1							IF	DR	EX	ME	WB												
BRU LAST_OP								IF	DR	EX	ME	WB											
NOOP									IF	DR	EX	ME	WB										
NOOP										IF	DR	EX	ME	WB									
LAST_OP: LDL \$10(R3), R2											IF	DR	EX	ME	WB								
NOOP												IF	DR	EX	ME	WB							
NOOP													IF	DR	EX	ME	WB						
ADD R1, R2, R1														IF	DR	EX	ME	WB					
NOOP															IF	DR	EX	ME	WB				
NOOP																IF	DR	EX	ME	WB			
STL \$104(R3), R1																	IF	DR	EX	ME	WB		

Total amount of penalty is 10 clock cycles.

- b) To minimize the amount of penalty, let's move the locations of instructions as a software-based solution.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LDL \$00(R3), R1	IF	DR	EX	ME	WB													
LDL \$04(R3), R2		IF	DR	EX	ME	WB												
LDL \$08(R3), R4			IF	DR	EX	ME	WB											
BRU LAST_OP				IF	DR	EX	ME	WB										
ADD R1, R2, R1					IF	DR	EX	ME	WB									
NOOP						IF	DR	EX	ME	WB								
LAST_OP: LDL \$10(R3), R2							IF	DR	EX	ME	WB							
SUB R1, R4, R1								IF	DR	EX	ME	WB						
NOOP									IF	DR	EX	ME	WB					
NOOP										IF	DR	EX	ME	WB				
ADD R1, R2, R1											IF	DR	EX	ME	WB			
NOOP												IF	DR	EX	ME	WB		
NOOP													IF	DR	EX	ME	WB	
STL \$104(R3), R1														IF	DR	EX	ME	WB

Total amount of penalty is 5 clock cycles.