Lab 6: PUnC

Team Members

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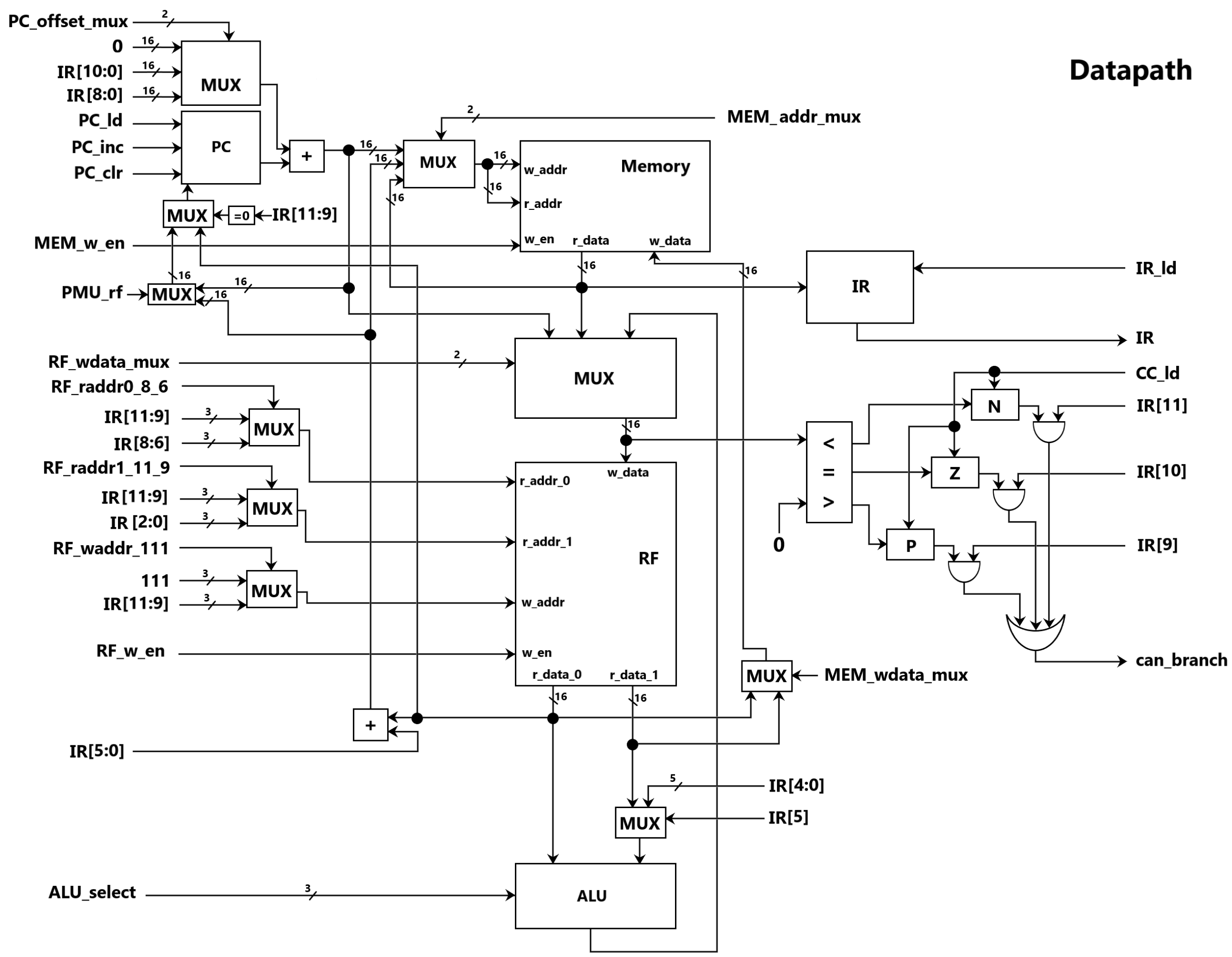
Datapath



Control Signal Table

CTRL SIG	FETCH	DECODE	ADD+	AND+	BR1	BR2	JMP/RET	JSR1	JSR2	LD+	LDI1+	LDI2+	LDR+	LEA+	NOT+	ST	STI1	STI2	STR	HALT
MEM_w_en																1		1	1	
IR_ld	1																			
RF_addr0_8_6			1	1			1		1				1		1			1	1	
RF_addr1_11_9																			1	
RF_waddr_111								1												
RF_w_en			1	1				1		1		1	1	1	1					
PC_ld						1	1		1											
PC_clr																				
PC_offset_mux	00	00	00	00	00	01	00	00	10	01	01	00	00	01	00	01	01	00	00	
PC_inc		1																		
CC_ld			1	1						1	1	1	1	1	1					
RF_wdata_mux			10	10				00		01		01	01	00	10					
ALU_select			00	01											10					
MEM_addr_mux	00									00	00	10	01			00	00	10	01	
MEM_wdata_mux																0		0	1	
PMU_rf							1													

Assembly Program

```
\*0 *\ LD R0, #29           // Loads base into R0
\*1 *\ LD R1, #29           // Loads index into R1

// If the index is 0, stores 1 as the resulting power.
// Otherwise, calculates the power.
\*2 *\ BRp #3               // If index is positive, branches
\*3 *\ ADD R1, R1, #1       // Sets value of R1 to be 1
\*4 *\ ST R1, #27           // Stores value of R1 at memory address 32
\*5 *\ BRnzp #13            // Unconditionally branches to HALT

// Initializes the registers for exponent calculations
\*6 *\ ADD R2, R1, #-1      // R2 = R1 - 1
\*7 *\ LD R3, #22           // Loads base into R3
\*8 *\ LEA R6, #11          // Loads location of multiplication function
in R6

// The exponentiation loop
\*9 *\ JSRR R6              // Jumps to Multiplication function
\*10 *\ ADD R2, R2, #-1     // R2 = R2 - 1
\*11 *\ BRp #-3             // If R2 > 0, continue looping
```

```
// If base is negative and index is positive, stores the absolute value of
the resulting power.
// Otherwise, stores the resulting power.
\*12 *\ AND R1, R1, #1      // If R1 is odd, R1 = 1. Otherwise, R1 = 0.
\*13 *\ BRp #4              // If R1 is odd, branch to store instruction
\*14 *\ ADD R0, R0, #0      // Sets condition codes based on value of R0
\*15 *\ BRzp #2             // If R0 >= 0, branch to store instruction
\*16 *\ NOT R3, R3          // Otherwise, calculate the twos complement of
R3
\*17 *\ ADD R3, R3, #1
\*18 *\ ST R3, #13          // Store R3 at memory address 32
\*19 *\ HALT

// Multiplication function: base * base
\*20 *\ LD R4, #11          // R4 = 0
\*21 *\ LD R5, #8           // Loads the base into R5
\*22 *\ BRzp #2             // If the base is positive, branch to address
25
// If the base is negative, takes the two's complement of R5
\*23 *\ NOT R5, R5
\*24 *\ ADD R5, R5, #1
\*25 *\ ADD R4, R4, R3      // Adds the current power to R4
\*26 *\ ADD R5, R5, #-1     // R5 = R5 - 1
\*27 *\BRp #-3              // If R5 > 0, continue looping

\*28 *\ ADD R3, R4, #0      // R3 = R4
\*29 *\ RET

\*30 *\ FFFD                // The base of the exponent
\*31 *\ 0004                // The index of the exponent
```

Explanation

Our assembly program takes two arguments, a base and an index (i.e. the exponent), and finds the corresponding power. This program allows for the base to be negative, but does not support negative indices. The program first loads in the base and index arguments from memory into registers. If the index given is equal to zero, the program will not perform any computation and will instead store the value 1 as the power (following the multiplicative identity). The actual computation is performed using two nested loops. The first tracks the current power; the second uses repeated addition to perform the multiplication for that power. The final power is then stored in memory.

Feedback

Overall we really enjoyed this lab. We spent a substantial amount of time trying to fix all of its bugs, but we felt that the challenges we faced were fair. We would have appreciated if the LC3 assembler would allow the size of the left-hand window to be adjusted. Additionally, computing the offsets manually for long programs is also extremely tedious. It would be great if labels were supported in the assembler to avoid this.