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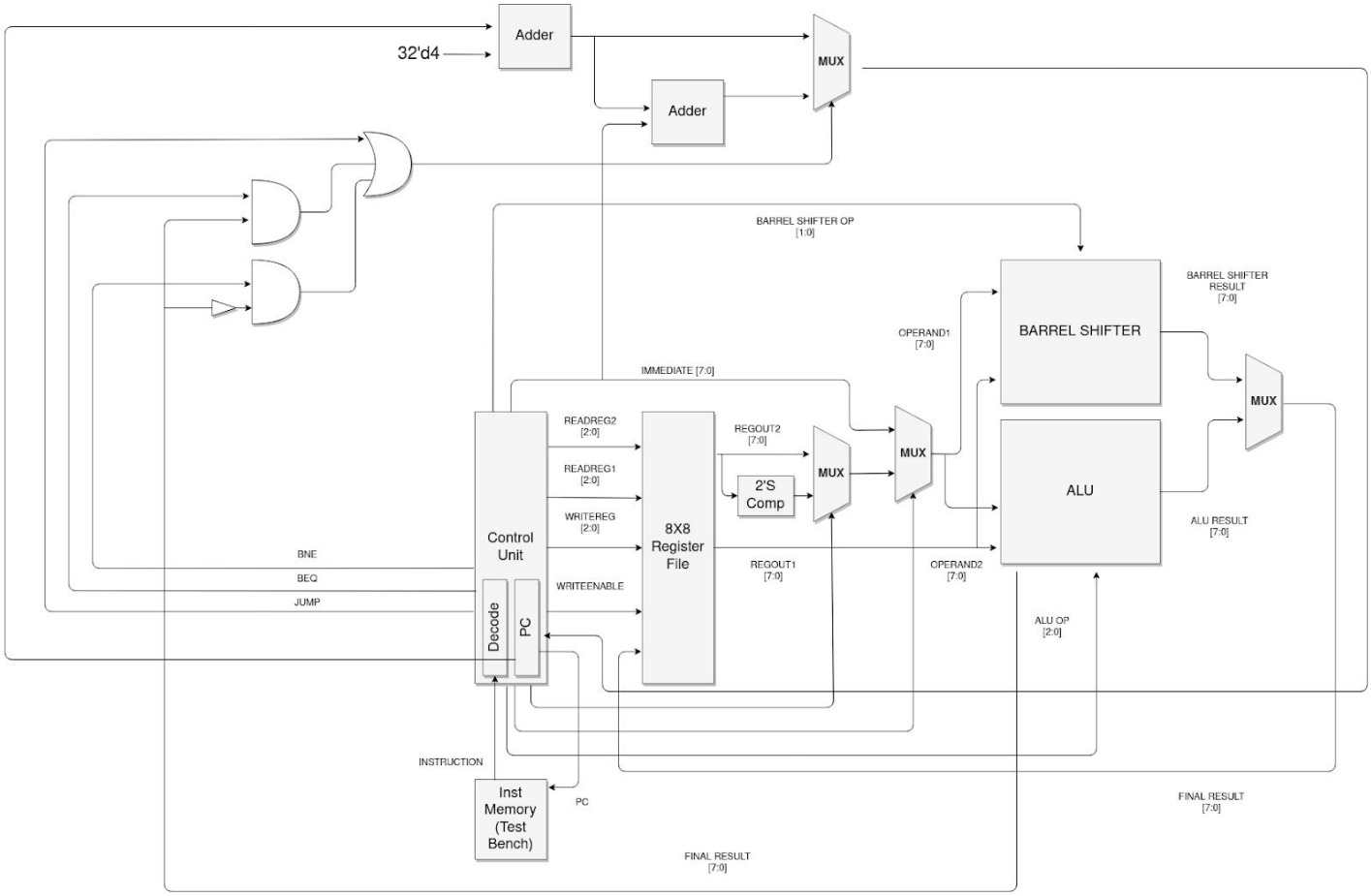
CO224 - Lab05 (Designing a CPU) Part05 (bonus)

In this part, we have given to implement, Two or more instructions from the following instruction set,

1. mult (Multiply)
2. sll (Logical Left Shift)
3. srl (Logical Right Shift)
4. ror (Rotate Right)
5. bne (Branch if negative)

I have implemented all of the above commands the whole structure of the CPU looks as follows.



The whole CPU has created according to the following OPCode format.

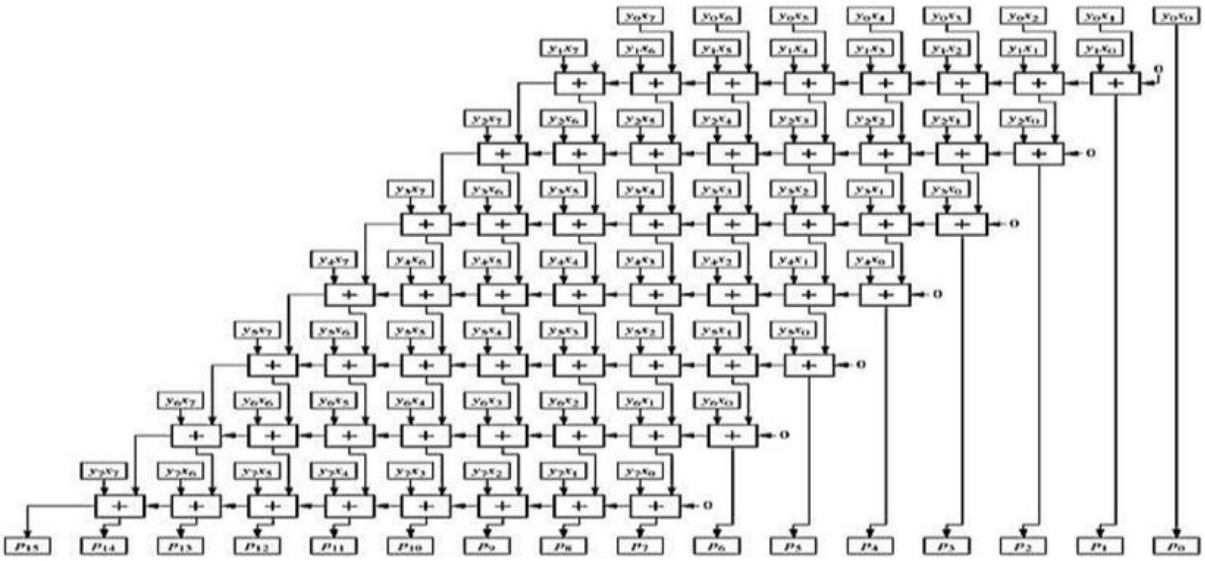
Operation	**Code**	**OpCode**
Addition	ADD	8'h00
Subtraction	SUB	8'h01
Bitwise AND	AND	8'h02
Bitwise OR	OR	8'h03
Move from one reg to another	MOV	8'h04
Load Immediate	LOADI	8'h05
Jump	J	8'h06
Branch if Equal	BEQ	8'h07
Branch if Not Equal	BNE	8'h08
Logical Shift Left	SLL	8'h09
Logical Shift Right	SRL	8'h0A
Arithmetic Shift Right	SRA	8'h0B
Rotate	ROR	8'h0C
Multiply	MUL	8'h0D

ALU OP Codes

Operation	**Code**	**OpCode**
Forward data 2 to the result	FORWARD	3'b000
Add the two operands	ADD	3'b001
Bitwise and the operands	AND	3'b010
Bitwise or the operands	OR	3'b011
Multiply the operands	MUL	3'b100

1) MUL Instruction

For this operation, I used an 8-bit array multiplier because this process should be done within a clock cycle time.



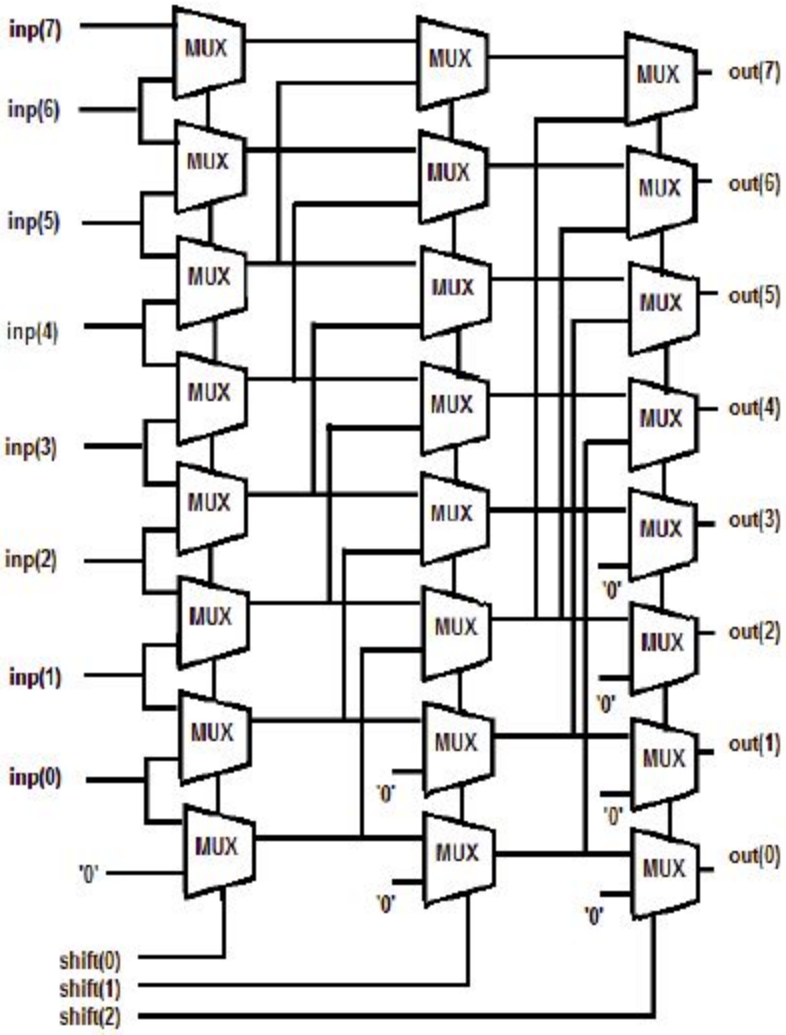
I used an arrangement like shown in the picture. The eight adding layers can be reduced to three layers by doing some additions in parallel.

#2 add(layer1, layer2); add(layer3, layer4); add(layer5, layer6); add(layer7, layer8)
#2 add(2_layer1, 2_layer2); add(2_layer3, 2_layer4)
#2 add(3_layer1, 3_layer2);

When we take the adder gets #2 time unit delay then the multiplication process takes 6 time units.

2) Barrel Shifter

I used a barrel shifter module in parallel to the ALU to do the shift operations. I used this method because in our CPU we don't do shifting operations in combination with the arithmetic operations. In our instruction encoding format, we can't do such complicated operations. So I fixed the barrel shifter parallel to the CPU. the below figure shows the left shift barrel shifter, but I cave change that a little bit to accomplish the four types of shifts. I have used an additional 7 MUXs to the point where the below diagram gives static 0 inputs. By using that I have made **Logical Right Shift, Arithmetic Right Shift, Rotate Right**. And I have added two 2 to 1 8bit MUXs in order to do the **Left Shift Logical** operation.



I have generated a separate opcode to the barrel shifter.

Barrel Shifter OP Codes

Operation	**Code**	**OpCode**
Logical Right Shift	SRL	2'b00
Arithmetic Right Shift	SRA	2'b01
Rotate Right	ROR	2'b10
Logical Left Shift	OR	2'b11

3) BNE Operation

BNE operation data path is shown in the above data path figure. I inverted the ALU comparator signal and feed that to a and gate along with the BNE control signal. After that, I feed that signal to the or gate which I previously used to do the jump and BEQ operations.