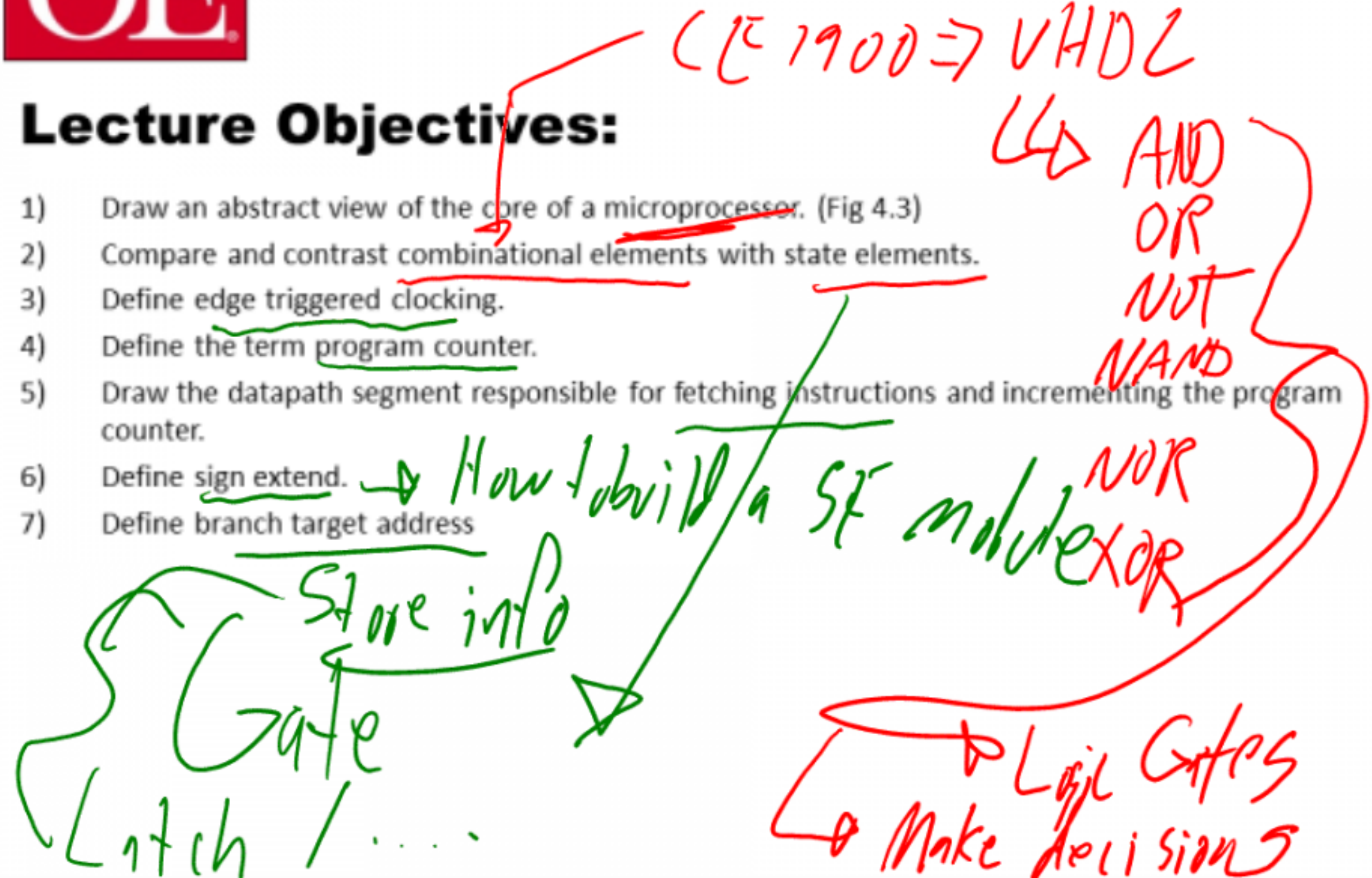
The Processor

Lecture Objectives:

1) Draw an abstract view of the core of a microprocessor. (Fig 4.3)
2) Compare and contrast combinational elements with state elements.
3) Define edge triggered clocking.
4) Define the term program counter.
5) Draw the datapath segment responsible for fetching instructions and incrementing the program counter.
6) Define sign extend.
7) Define branch target address

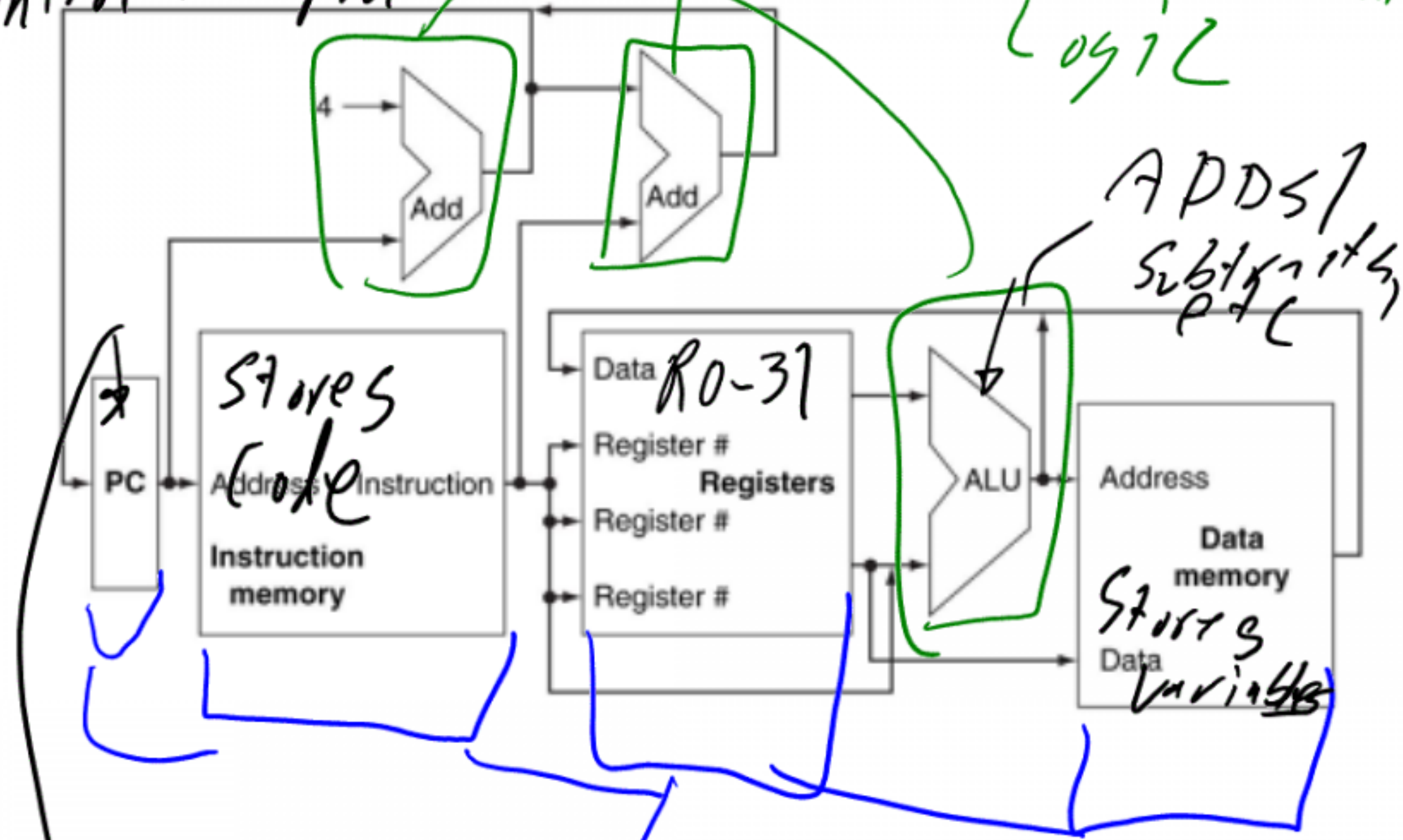


Instructions
=> Control the processor

Combinatorial
Logic

ADDS/
Subtracts
etc

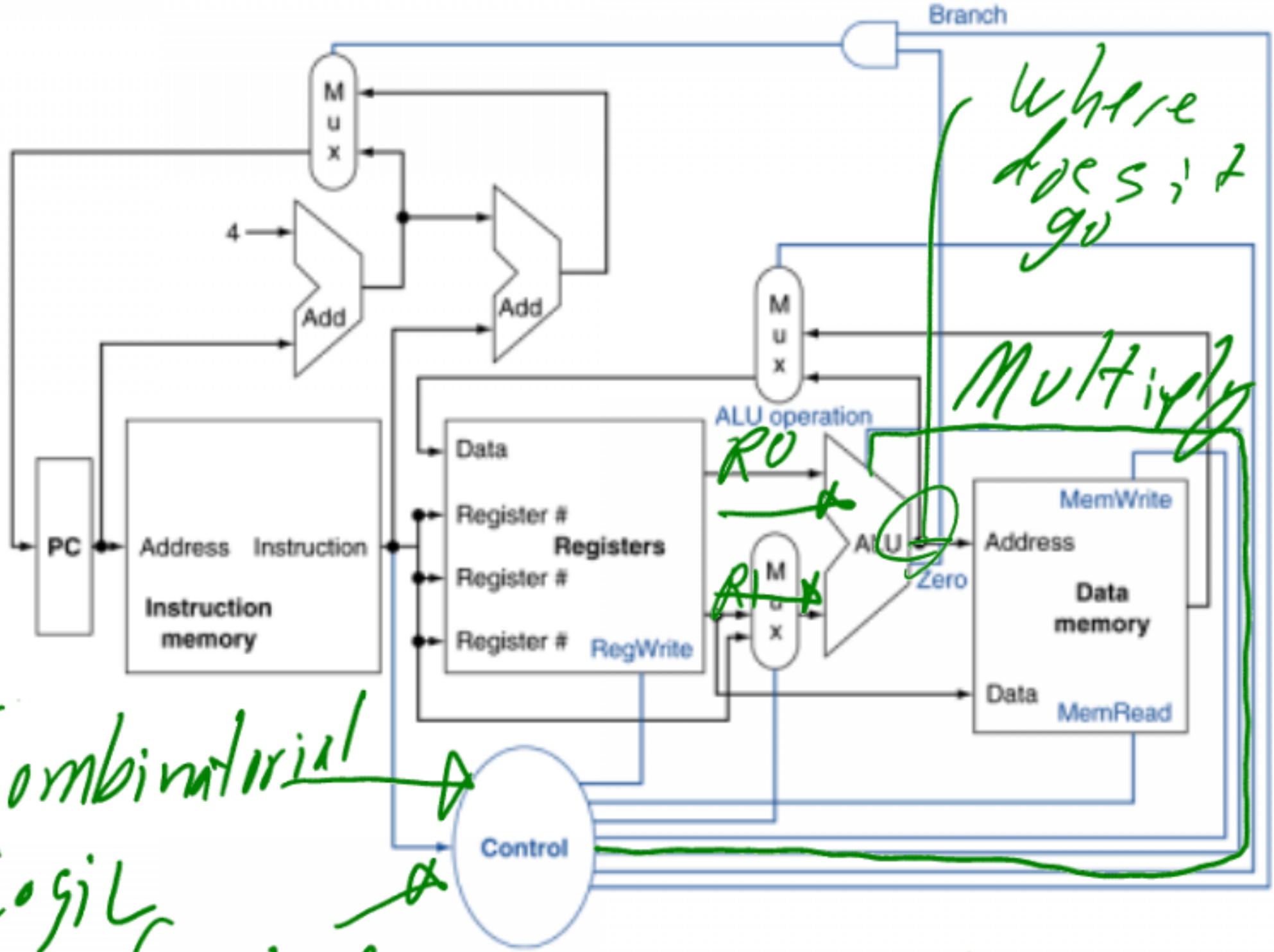
The MIPS Processor

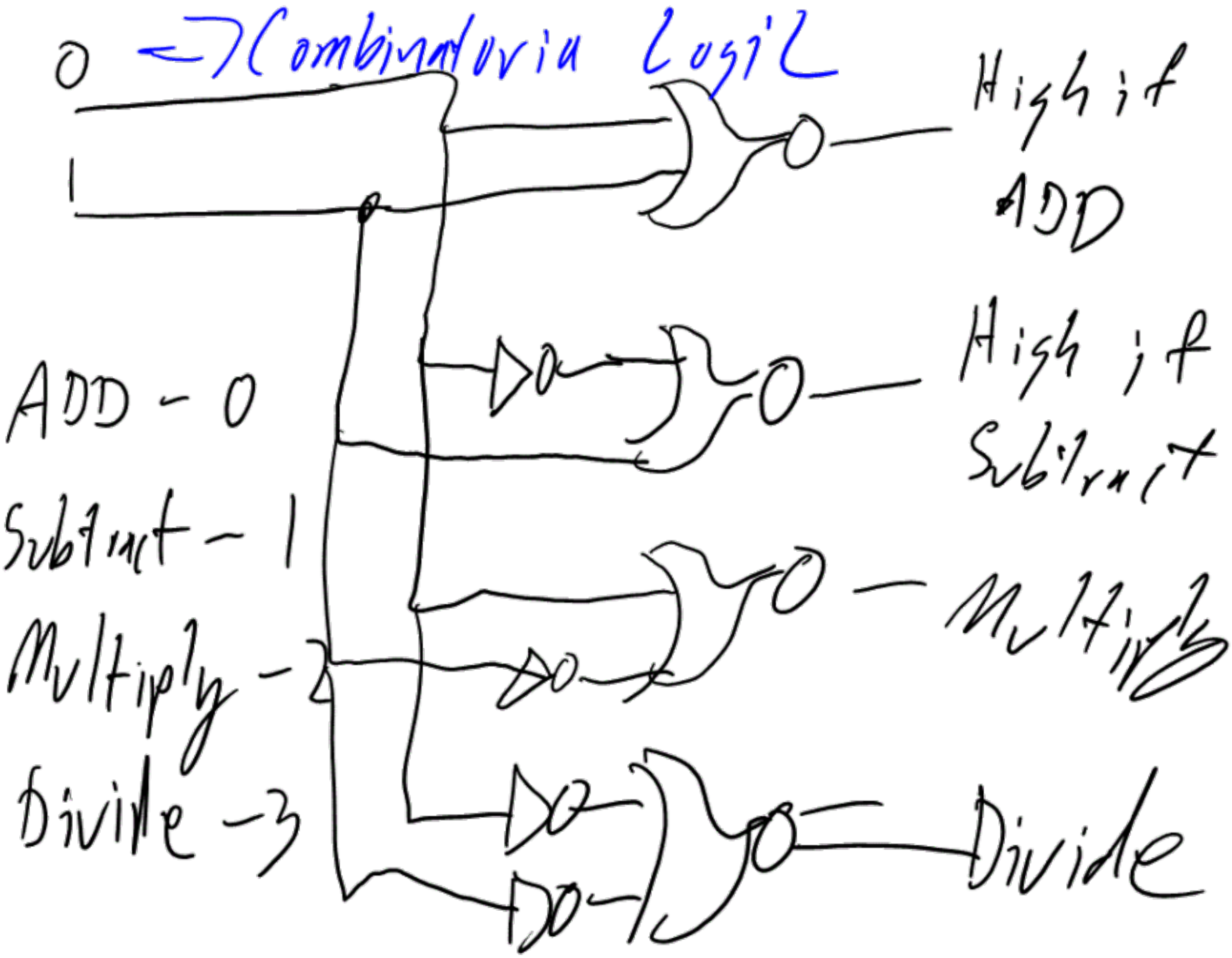


Determines Current instruction

Stores elements

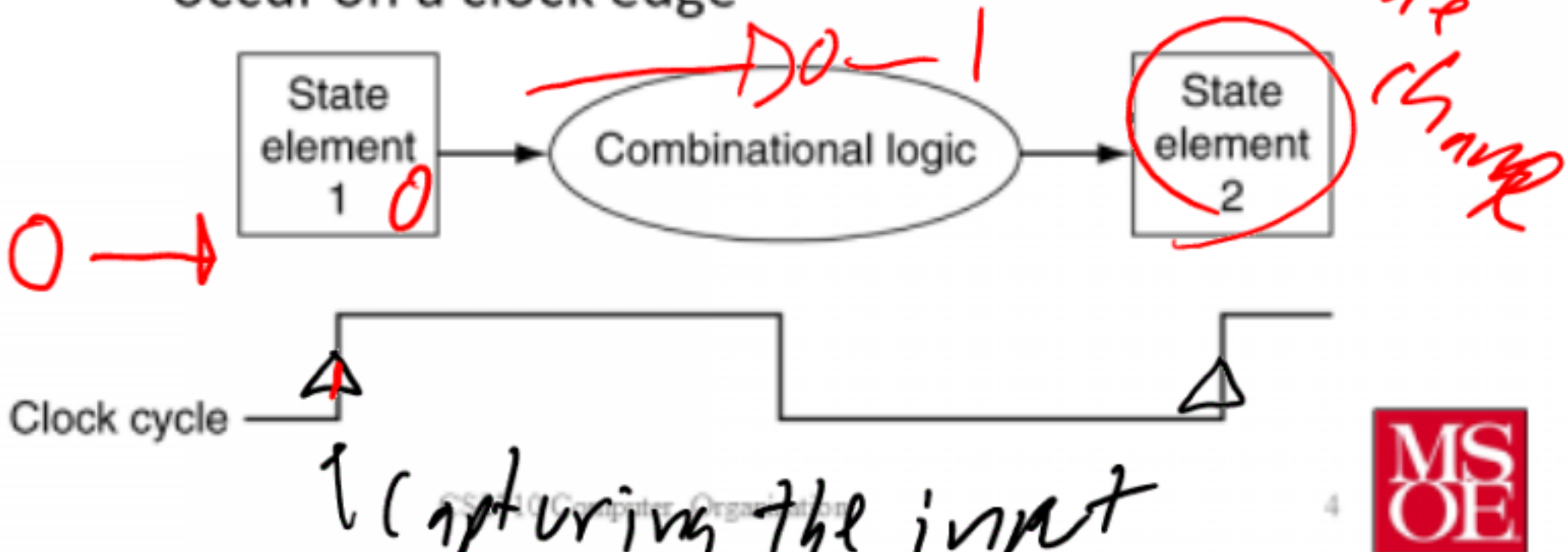
A Basic MIPS Processor




0 → Combinatorial Logic
1
ADD - 0
Subtract - 1
Multiply - 2
Divide - 3
High if ADD
High if Subtract
Multiply
Divide

Definitions

- State Element
  - A memory element, such as a register or memory
- Asserted
  - A signal is logically high
- Deasserted
  - A signal is logically low
- Edge Triggered Clocking
  - A clocking scheme in which all state changes occur on a clock edge

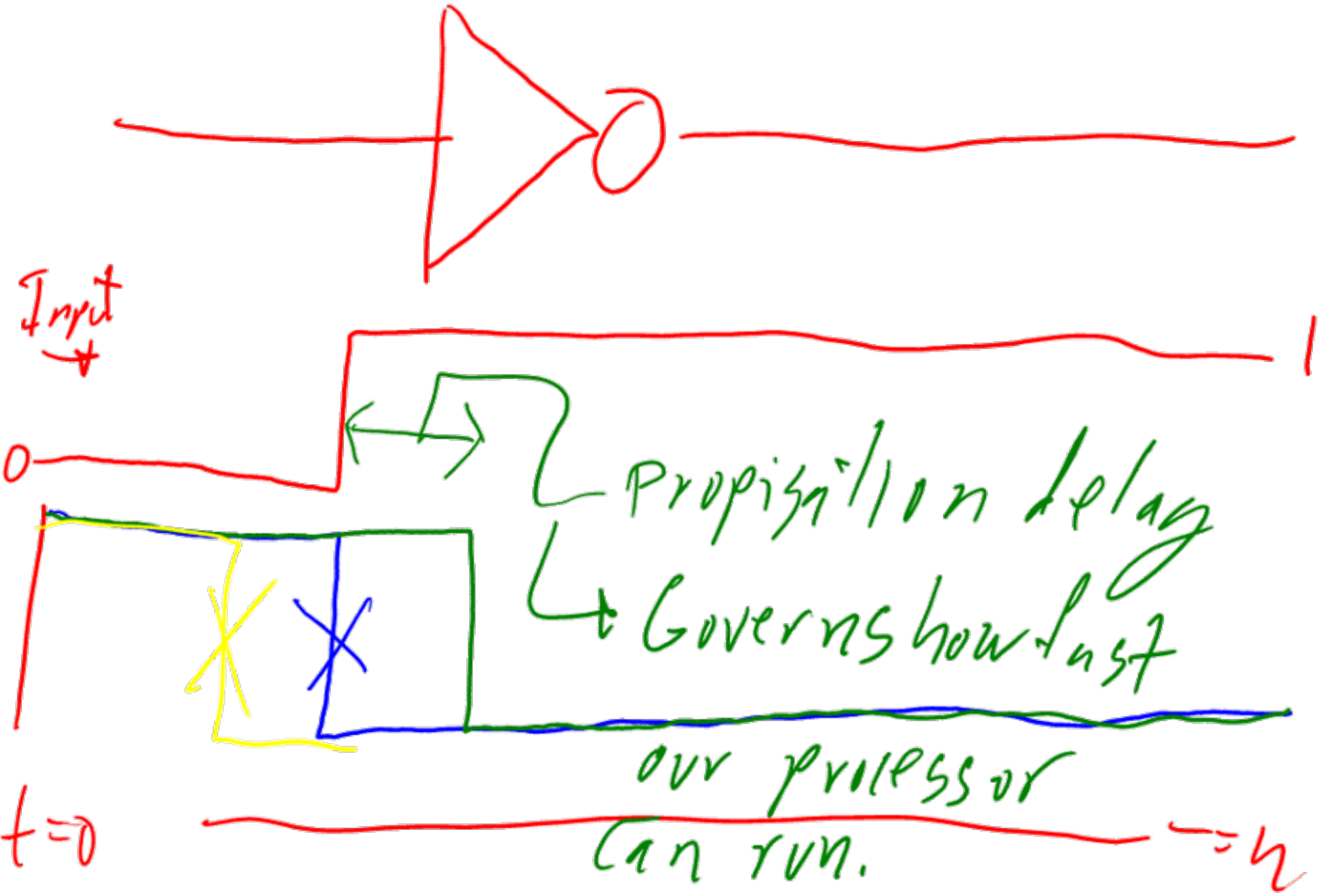


Clock

2.0 GHz

Rising edge

Count only changes when the
risesses.


Input
1
0
Propisation delay
Governs how fast
our processor
can run.
t=0
t=h

Definitions

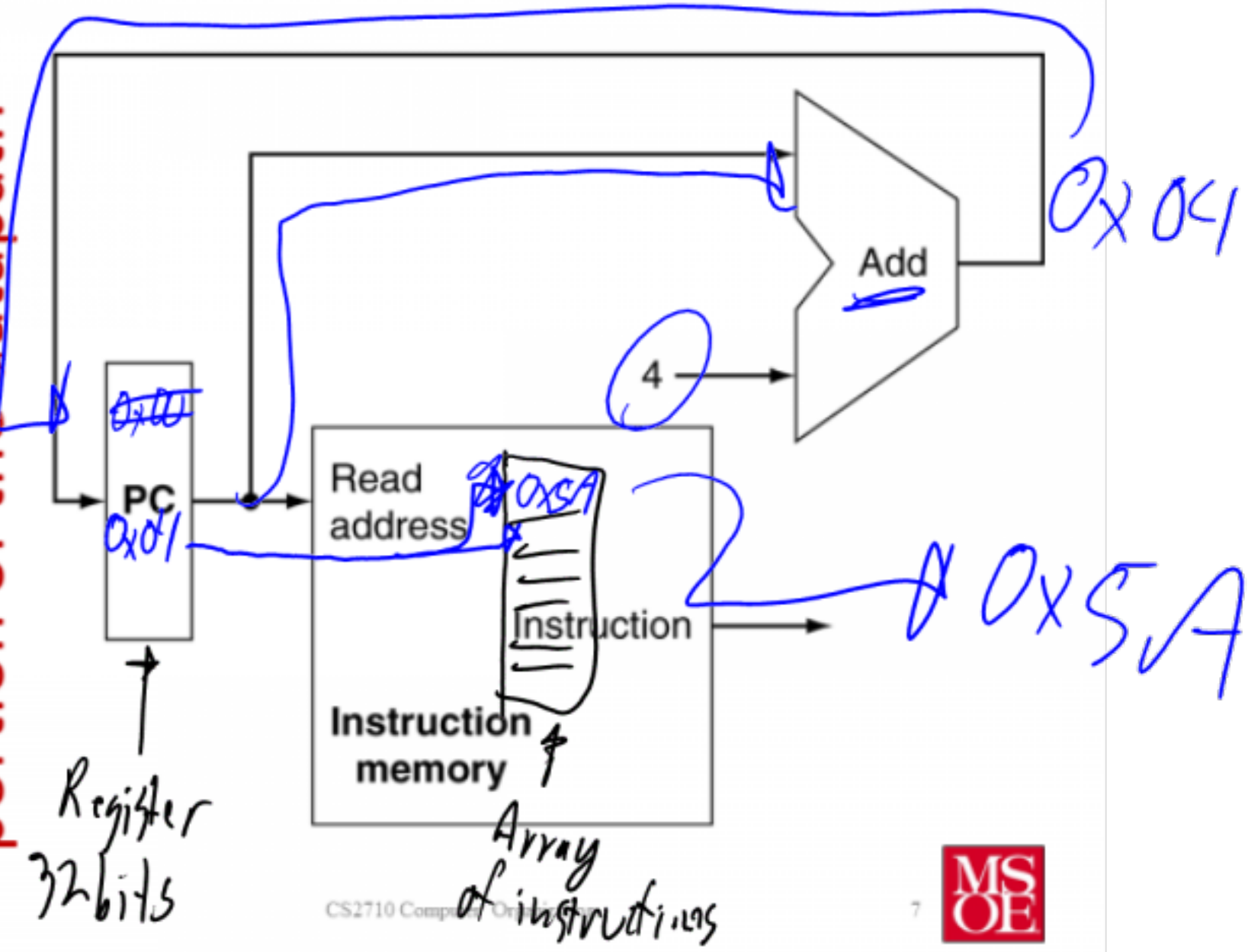
- Datapath Element
  - A unit used to operate on or hold data within a processor
- Program counter (PC)
  - The register containing the address of the instruction in the program being executed
- Sign extend
  - To increase the size of a data item by replicating the high order sign bit of the original data item to the high order bits of the larger destination data item
- Branch target address
  - The address, specified in a branch which the PC is set to if the branch is taken.

How do we determine what the next instruction is to execute?

How do we obtain an instruction?

⇒ Program counter Management block.

The PC Management portion of the datapath



Clock edge comes in => Fetch the instruction

D:\My Dropbox\Administrative\summer_projects\CS2710\demos\SimplePCDemo - MARS 4.2

File Edit Run Settings Tools Help

Off

Run speed

Edit Execute

DegreesToRadiansDemo.asm SimplePCDemo

```
1  # In Class Project Number 1
2  # Instructor's solution
3  # By: Walter W. Schilling, Jr. July 5, 2012
4  #
5  # This program will demonstrate a few simple PC operations.
6
7  .text
8  main:
9          li $t0, 3
10
11 loop:
12         addi $t0, $t0, -1
13         bnez $t0, loop
14
15         # Exit the program
16         li $v0, 10
17         syscall
18
```

=> ADDI $t0, $zero, 3

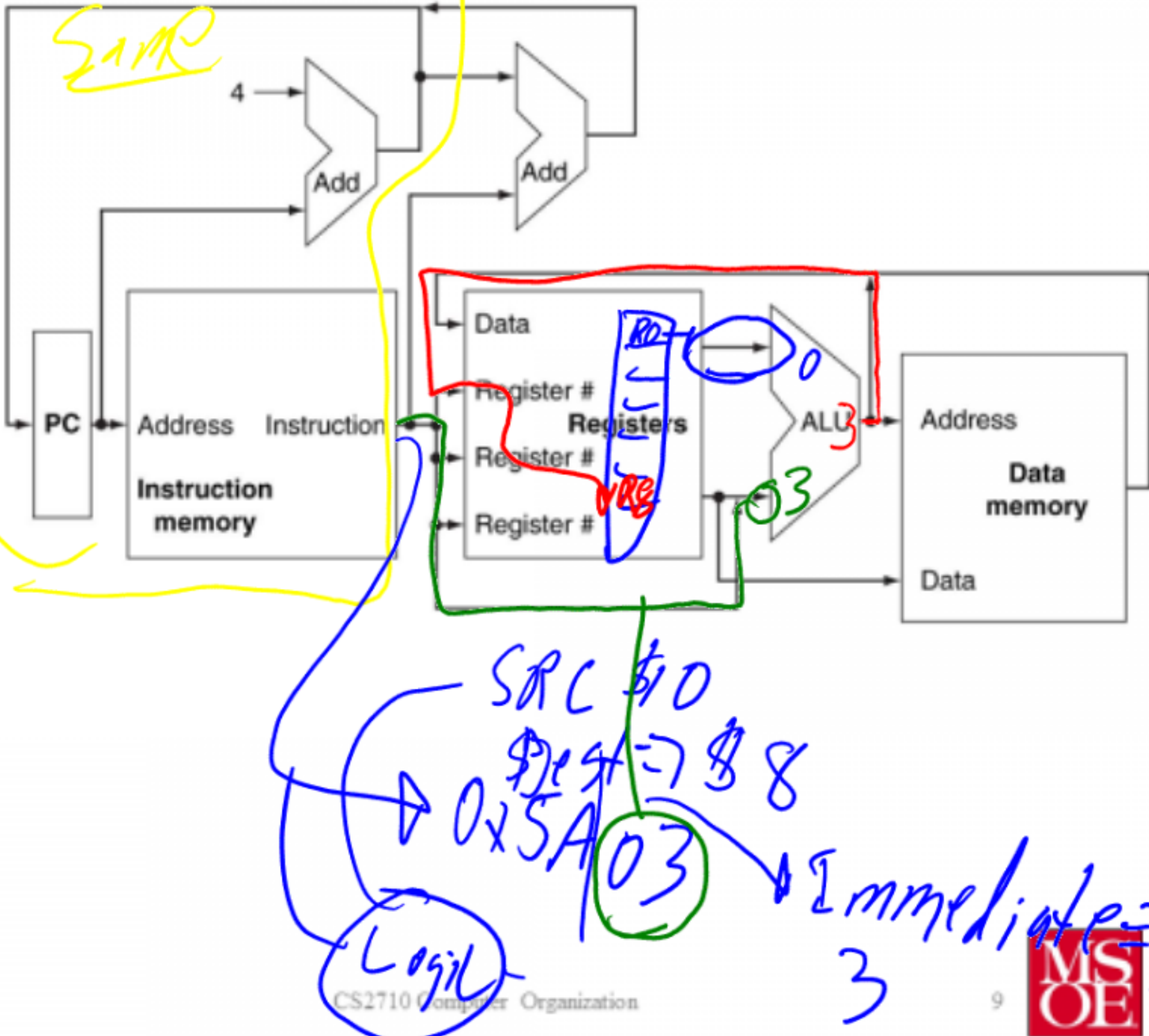
Line: 9 Column: 3 Show Line Numbers

Mars Messages Run I/O

Registers Coproc 1 Coproc 0

Name	Number	Value
$zero	0	0x00000000
$at	1	0x00000000
$v0	2	0x00000000
$v1	3	0x00000000
$a0	4	0x00000000
$a1	5	0x00000000
$a2	6	0x00000000
$a3	7	0x00000000
$t0	8	0x00000000
$t1	9	0x00000000
$t2	10	0x00000000
$t3	11	0x00000000
$t4	12	0x00000000
$t5	13	0x00000000
$t6	14	0x00000000
$t7	15	0x00000000
$s0	16	0x00000000
$s1	17	0x00000000
$s2	18	0x00000000
$s3	19	0x00000000
$s4	20	0x00000000
$s5	21	0x00000000
$s6	22	0x00000000
$s7	23	0x00000000
$t8	24	0x00000000
$t9	25	0x00000000
$k0	26	0x00000000
$k1	27	0x00000000
$gp	28	0x10008000
$sp	29	0x7fffeffc
$fp	30	0x00000000
$ra	31	0x00000000
pc		0x00400000
hi		0x00000000
lo		0x00000000

How do we manage to load the immediate value in?



R-Format Instructions

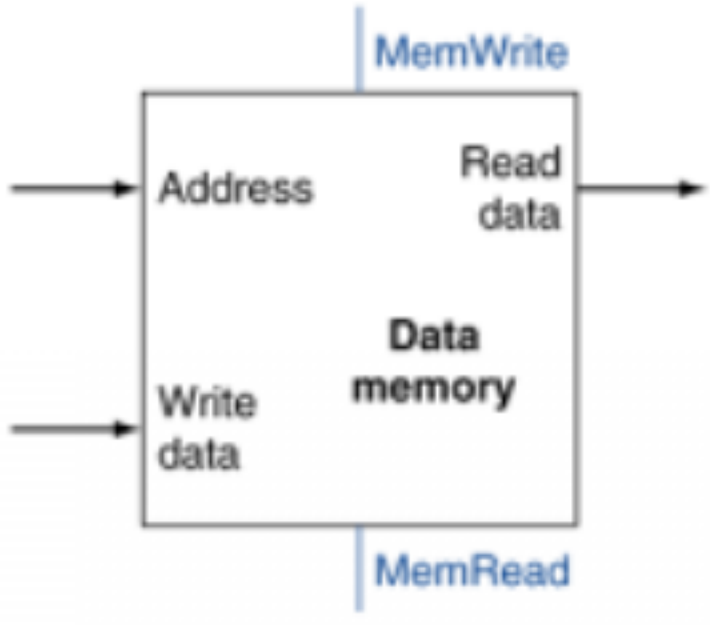
- Read two register operands
- Perform arithmetic/logical operation
- Write register result

a. Registers

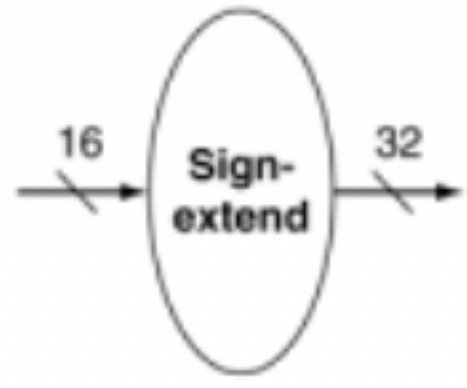
b. ALU

Load/Store Instructions

- Read register operands
- Calculate address using 16-bit offset
  - Use ALU, but sign-extend offset
- Load: Read memory and update register
- Store: Write register value to memory

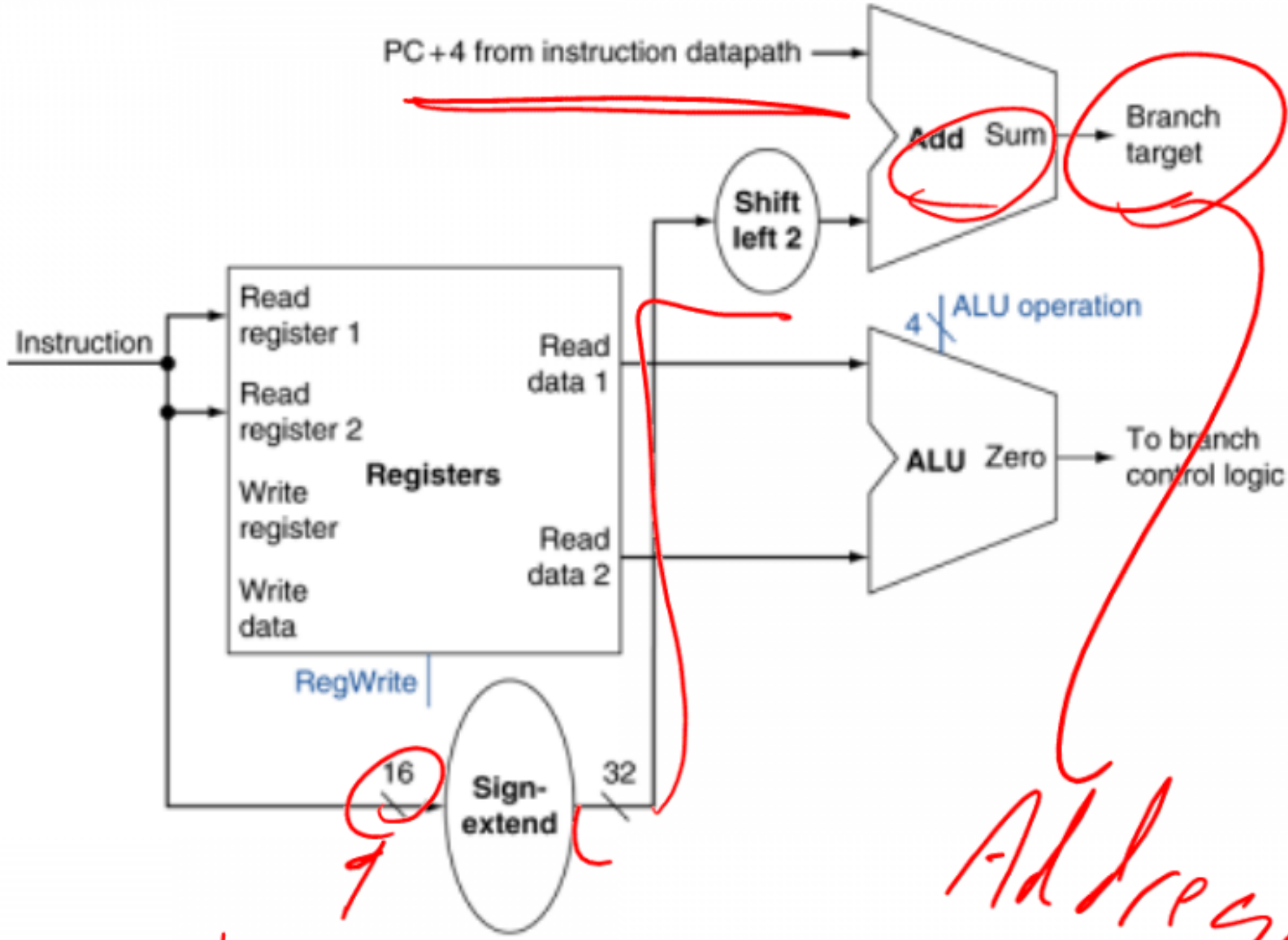


a. Data memory unit



b. Sign extension unit

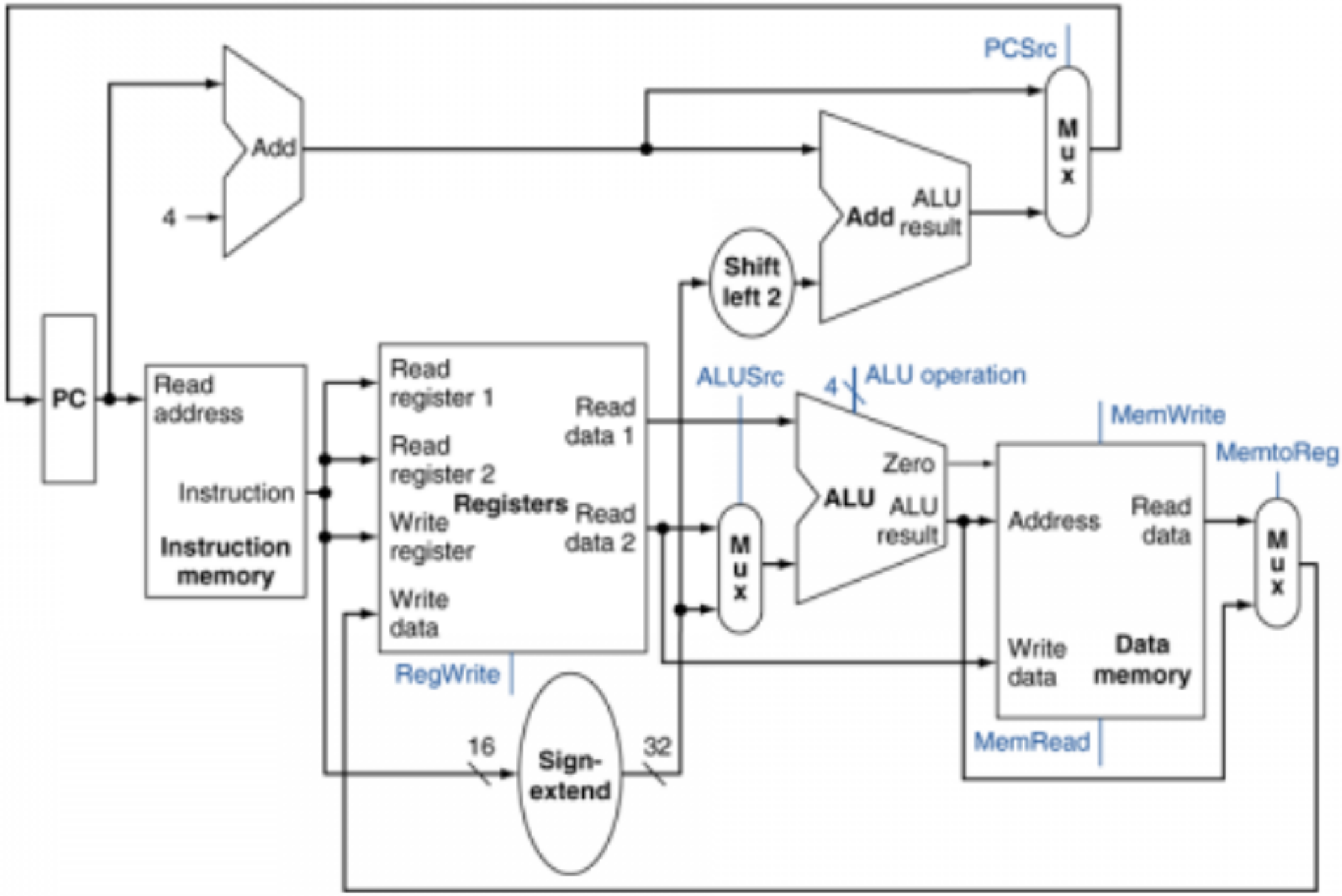
How do we manage a jump?



Branch Instructions

- Read register operands
- Compare operands
  - Use ALU, subtract and check Zero output
- Calculate target address
  - Sign-extend displacement
  - Shift left 2 places (word displacement)
  - Add to PC + 4
    - Already calculated by instruction fetch

Full Datapath



Datapath With Control