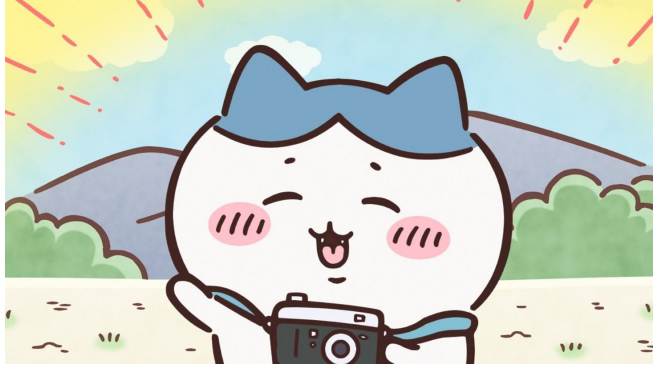


Computer Organization

Lab 4 - Pipelined CPU

教授：蔡文錦

TAs：單宇晟 吳年茵 曾偉杰

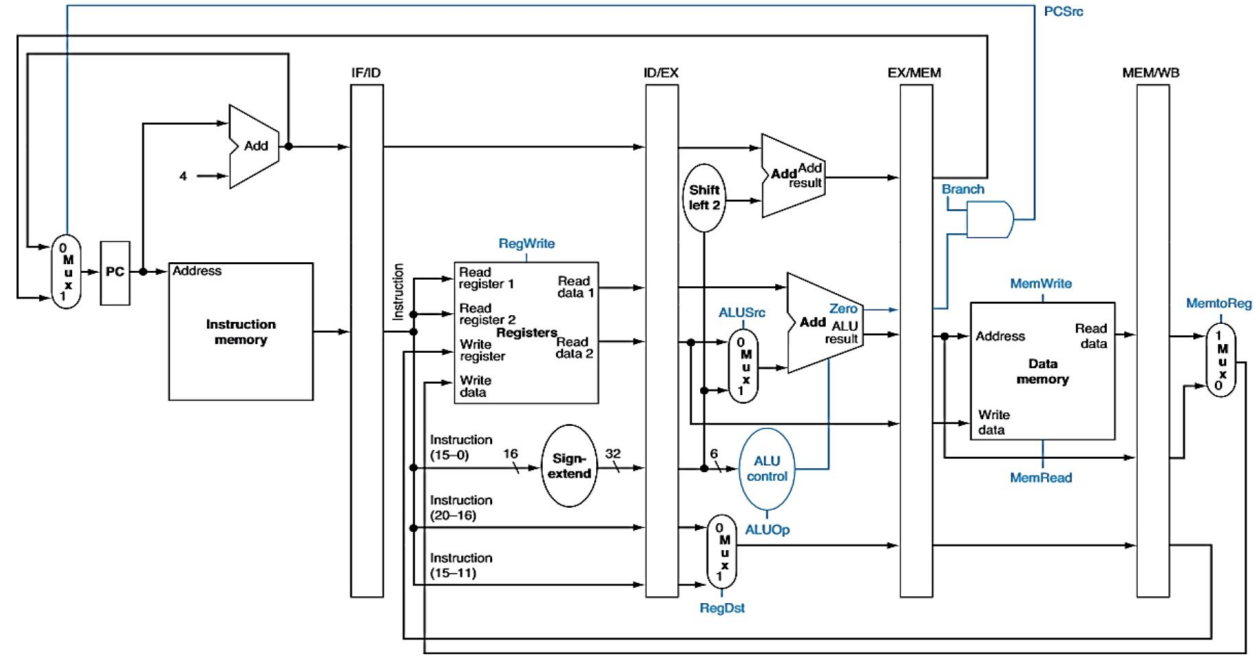
Objectives

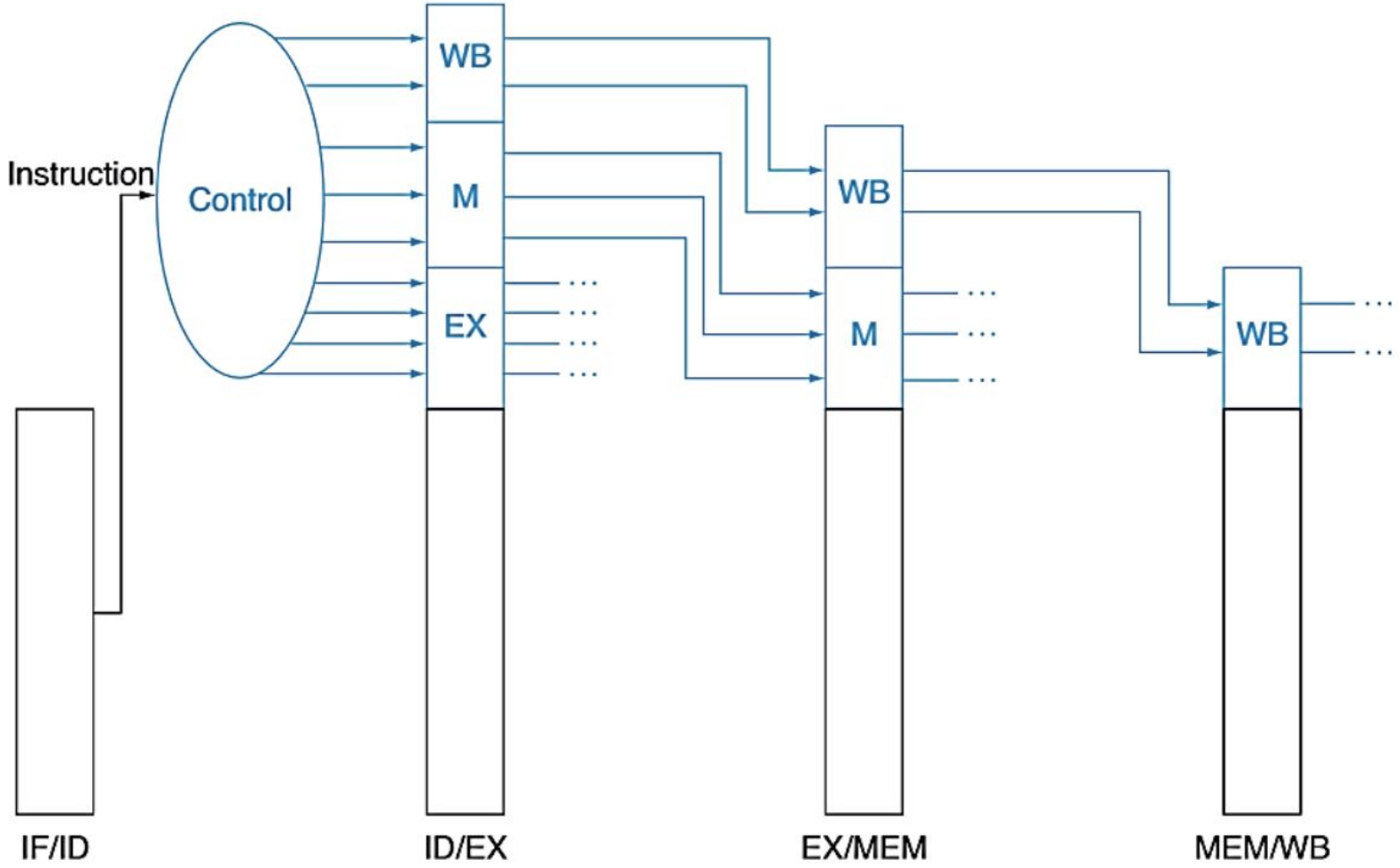
In this lab, you are going to implement a **Pipelined CPU** with memory unit, which can run **R-type** and **I-type** instructions.

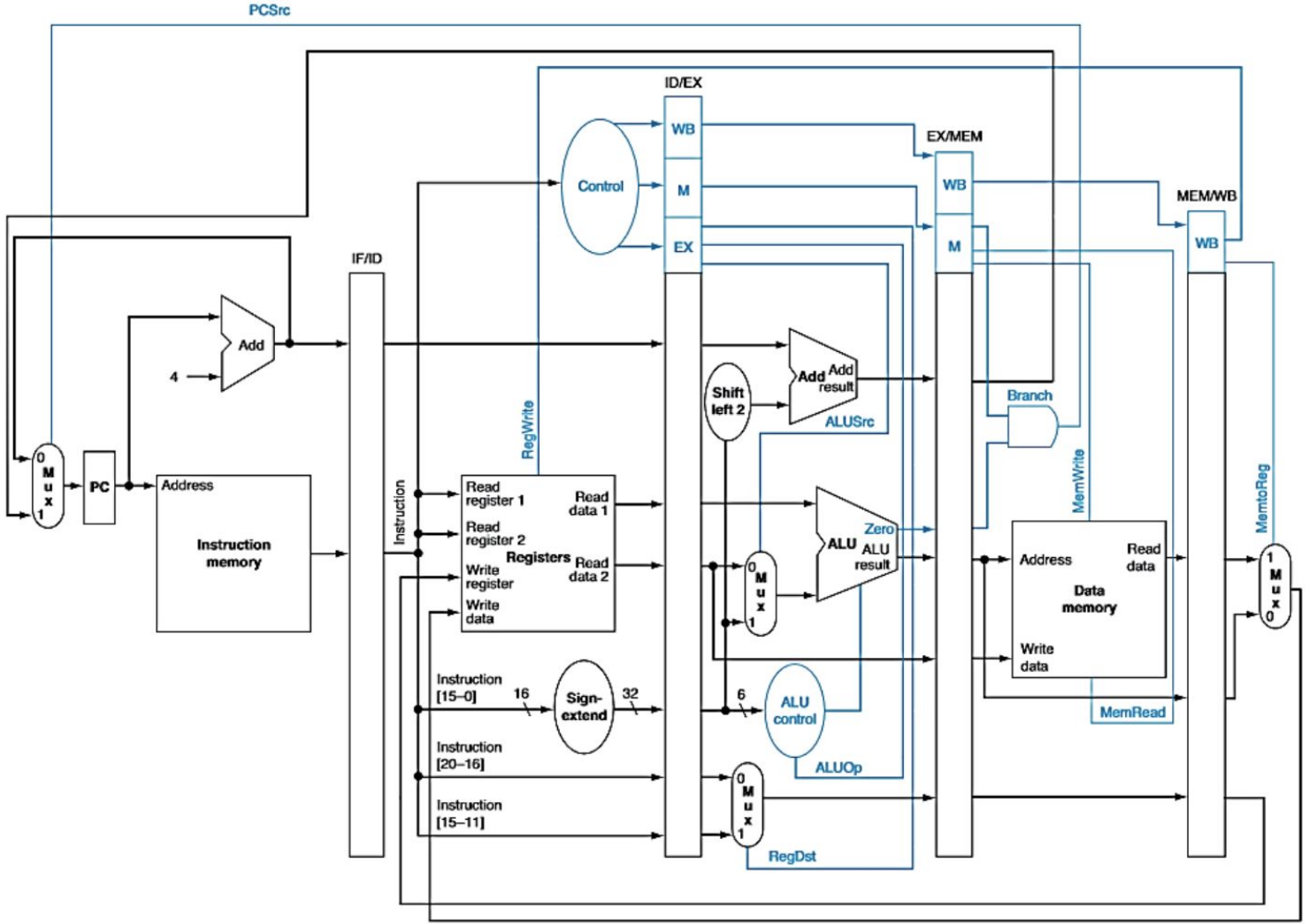
- To realize how to set the control signal in different instruction type.
- To learn how to follow the datapath to form a pipelined CPU

Overview

- Implement the datapath of pipelined CPU as belows




Instruction
Control
WB
M
EX
WB
M
WB
IF/ID
ID/EX
EX/MEM
MEM/WB


PCSrc
ID/EX
EX/MEM
MEM/WB
WB
M
EX
Control
IF/ID
Add
4
0
M
u
x
1
PC
Address
Instruction memory
Instruction
RegWrite
Read register 1
Read register 2
Registers
Write register
Write data
Read data 1
Read data 2
Shift left 2
Add
Add result
ALUSrc
Branch
MemWrite
MemtoReg
ALU
Zero
ALU result
Address
Read data
Data memory
Write data
MemRead
Instruction [15–0]
16
Sign-extend
32
6
ALU control
ALUOp
Instruction [20–16]
Instruction [15–11]
RegDst
1
M
u
x
0

Attached Files

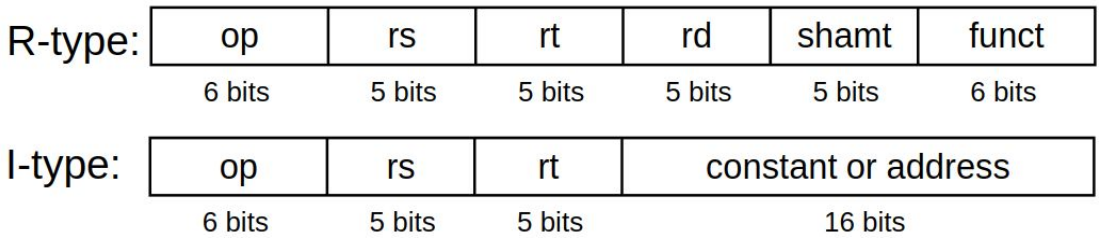
- **TO DO**
  - Adder.v
  - ALU_Ctrl.v
  - ALU.v
  - Decoder.v
  - MUX_2to1.v
  - Pipe_CPU.v
  - Shift_Left_Two_32.v
  - Sign_Extend.v
- **DO NOT modify**
  - Data_Memory.v
  - Instruction_Memory.v
  - Pipe_Reg.v
  - ProgramCounter.v
  - Reg_File.v
- **For validation - DO NOT modify**
  - testbench.v
- **Testcase - YOU CAN modify the instructions in it.**
  - *.txt

Instruction Set

You are going to implement these instructions :

- **R-type :** add, sub, AND, OR, NOR, slt
- **I-type :** lw, sw, beq, bne, addi

Instruction Format:



Instruction Set

R-type		
Function	**Op Field**	**Function Field**
add	000000	100010
sub	000000	100000
AND	000000	100101
OR	000000	100100
NOR	000000	101010
slt	000000	100111

I-type	
Function	**Op Field**
addi	001000
lw	101011
sw	100011
beq	000101
bne	000100

Compile & Run

- **Compile**
  - $ iverilog -o lab4 testbench.v
- **Run**
  - $ ./lab4

Wrong results:

```
************************************************
* Register Error! [Register 31]                *
* Correct result: 00000050                     *
* Your result:    00000000                     *
************************************************
************************************************
*               You have 19 error !            *
************************************************
```

Correct results:

```
************************************************
*          Congratulation. ALL PASS !          *
************************************************
```

Grading Policy

- There are **3 hidden cases with serial several instructions**, and you will get **33** points for each correct testcase, with **an additional point** for submitting, totally **100** points.
- **Any assignment work by fraud will get a zero point！**
- **No late submission！**

Submission

- **Please attach student IDs as comments at the top of each TO DO file.**
- The files you should hand in include:
  - **all *.v files excluding testbench.v**
- Compress all file ***.v** into one zip file **without any extra folder layer**, and **make sure do not add unnecessary files or folders** (like .DS_Store, __MACOSX).
- Name your zip file as **HW4_{studentID}.zip**
  - **e.g.**
    - **HW4_123456789.zip**
      - **{*.v}**
- **Wrong format will have 20% penalty !**
- **Deadline: 2025/5/18 23:55 (No late submission) !**