State element \rightarrow \text{Combinational logic}
a. Instruction memory

b. Program counter

c. Adder
a. Registers

- Read register 1
- Read register 2
- Write register

b. ALU

- ALU control
- ALU result
- Zero
Instruction

Read register 1
Read register 2
Write register
Write data

Read data 1
Read data 2

ALU operation
3

RegWrite

ALU

Zero

ALU result

Zero

RegWrite
a. Data memory unit

b. Sign-extension unit
### Instruction Processing

1. **Instruction**: Input
2. **Read register 1**: Read the first register
3. **Read register 2**: Read the second register
4. **Read data 1**: Read data from first source
5. **Read data 2**: Read data from second source
6. **Write register**: Write the result to register
7. **Write data**: Write the result to data
8. **ALU operation**: Perform the ALU operation
9. **ALU Zero**: Check if the result is zero
10. **Shift left 2**: Shift the result left by 2
11. **Add Sum**: Add the shifted result to the branch target
12. **Branch target**: Output

### ALU Operations
- **Addition**: `Add Sum`
- **Branch Logic**: `Branch target`
- **PC + 4 from instruction datapath**: `To branch control logic`
PC
Instruction memory
Read address
Instruction [31-0]

Instruction [31-26] Control
RegDst Branch MemRead MemtoReg ALUOp MemWrite ALUSrc RegWrite

Instruction [25-21]

Instruction [20-16]

Instruction [15-11]

Instruction [15-0]

ALU control

ALU Address

Read register 1 Read register 2 Registers Read data 1 Read data 2

Write register Write data

ALU result
Zero

Shift left 2

Add

Add result

0 Mux 1

1 Mux 0

ALU result

Address
Write data

Data memory

Read data
PC

Instruction memory

Read address

Instruction [31-0]

Instruction [31-26]

Control

RegDst

Branch

MemRead

MemtoReg

ALUOp

MemWrite

ALUSrc

RegWrite

Instruction [25-21]

Instruction [20-16]

Instruction [15-11]

Instruction [15-0]

Instruction [5-0]

Add

ALU control

Shift left 2

Add

ALU result

0 Mux 1

Read register 1

Read register 2

Read register

Write data

Write register

ALU result

Zero

ALU

Result

ALU control

Write data

Read data

Write memory

Address

Data memory

Read data

1 Mux 0

Sign extend

32

16