Control

- Selecting the operations to perform (ALU, read/write, etc.)
- Controlling the flow of data (multiplexor inputs)
- Information comes from the 32 bits of the instruction
- Example:

add $8, $17, $18 Instruction Format:

000000	10001	10010	01000	00000	100000
op	rs	rt	rd	shamt	funct

- ALU's operation based on instruction type and function code

Control

- e.g., what should the ALU do with this instruction
- Example: lw $1, 100($2)

35	2	1	100
op	rs	rt	16 bit offset

- ALU control input

```
000   AND
001   OR
010   add
110   subtract
111   set-on-less-than
```

- Multi-level control is common: main control unit generates ALUop (load/store, branch, arithmetic) bits, which are then used as input to the ALU control that generates the actual signals (3 bits shown above) to control the ALU unit

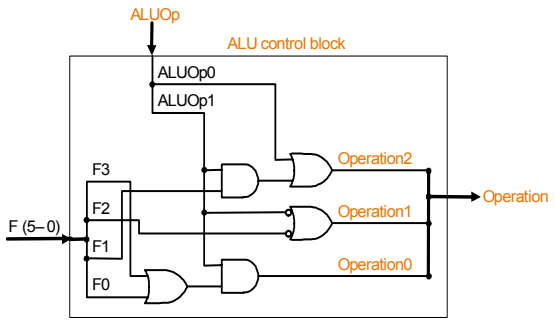
Control

- Must describe hardware to compute 3-bit ALU control input
  - given instruction type
    - 00 = lw, sw
    - 01 = beq,
    - 10 = arithmetic

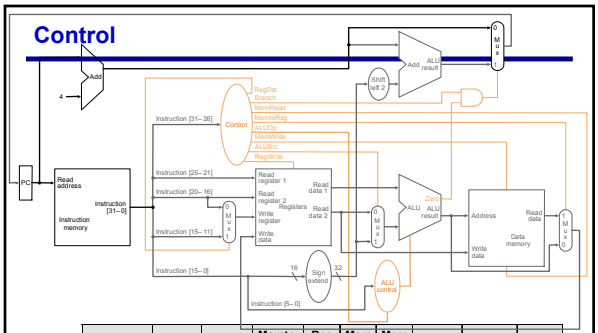
    → ALUOp computed from instruction type
  - function code for arithmetic
- Describe it using a truth table (can turn into gates):

ALUOp		Funct field						Operation
ALUOp1	ALUOp0	F5	F4	F3	F2	F1	F0	
0	0	X	X	X	X	X	X	010
X	1	X	X	X	X	X	X	110
1	X	X	X	0	0	0	0	010
1	X	X	X	0	0	1	0	110
1	X	X	X	0	1	0	0	000
1	X	X	X	0	1	0	1	001
1	X	X	X	1	0	1	0	111

ALU Control Schematic Diagram



Control



Instruction	RegDst	ALUSrc	Memto-Reg	Reg Write	Mem Read	Mem Write	Branch	ALUOp1	ALUp0
R-format	1	0	0	1	0	0	0	1	0
lw	0	1	1	1	1	0	0	0	0
sw	X	1	X	0	0	1	0	0	0
beq	X	0	X	0	0	0	1	0	1

Recall Instruction Format

R	op	rs	rt	rd	shamt	funct
	31-26	25-21	20-16	15-11	10-6	5-0
I	op	rs	rt	16 bit address		
	31-26	25-21	20-16	15-0		
J	op	26 bit address				
	31-26	25-0				

Main Control Schematic Diagram