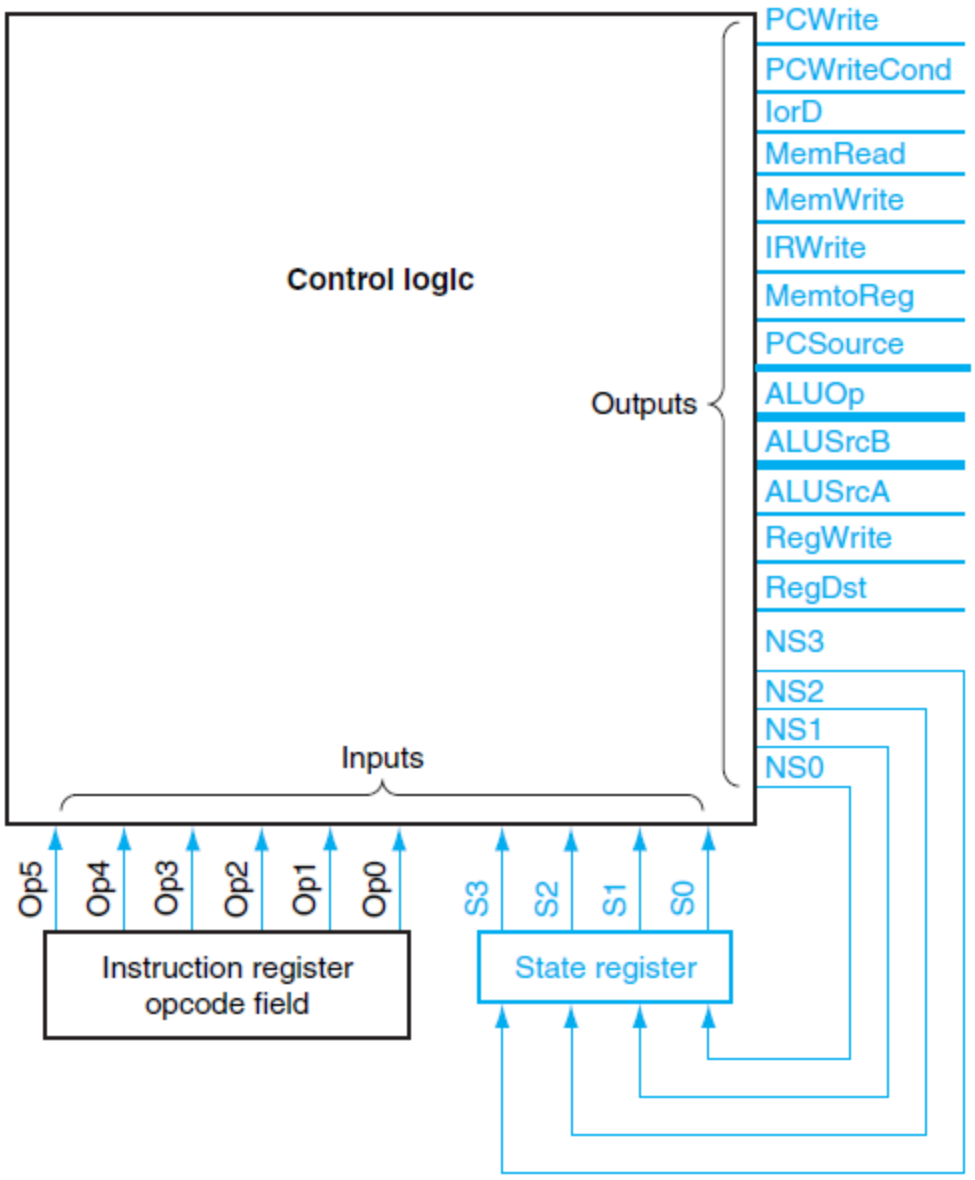
Acknowledgment: Almost all of these slides are based on Dave Patterson's CS152 Lecture Slides at UC, Berkeley.

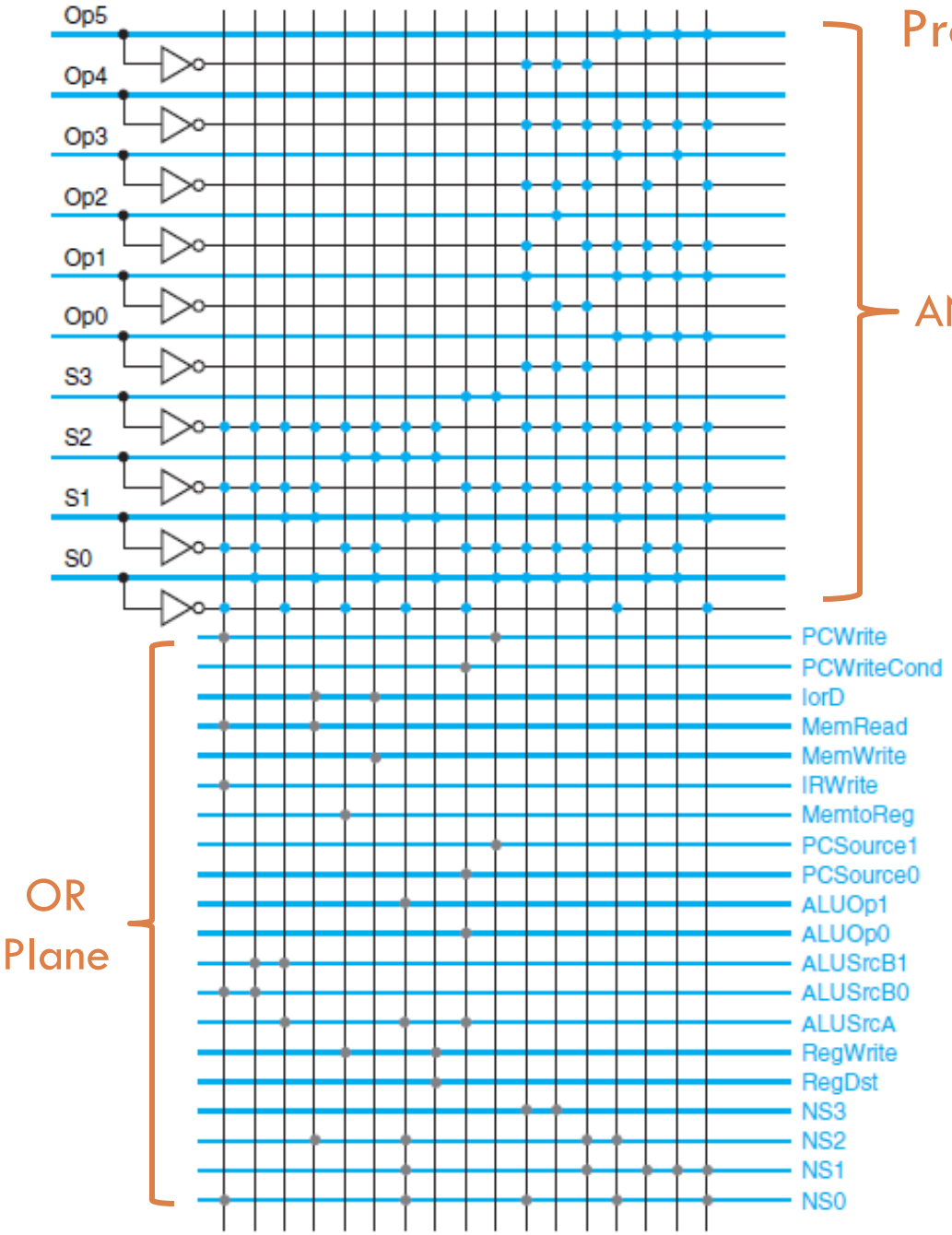
COMPUTER SYSTEMS ORGANIZATION

Multi Cycle CPU Control Logic Design -- Spring 2010 -- IIIT-H -- Suresh Purini


Control logic
Outputs
PCWrite
PCWriteCond
IorD
MemRead
MemWrite
IRWrite
MemtoReg
PCSource
ALUOp
ALUSrcB
ALUSrcA
RegWrite
RegDst
NS3
NS2
NS1
NS0
Inputs
Op5
Op4
Op3
Op2
Op1
Op0
S3
S2
S1
S0
Instruction register
opcode field
State register

Programmable Logic Arrays (PLAs)

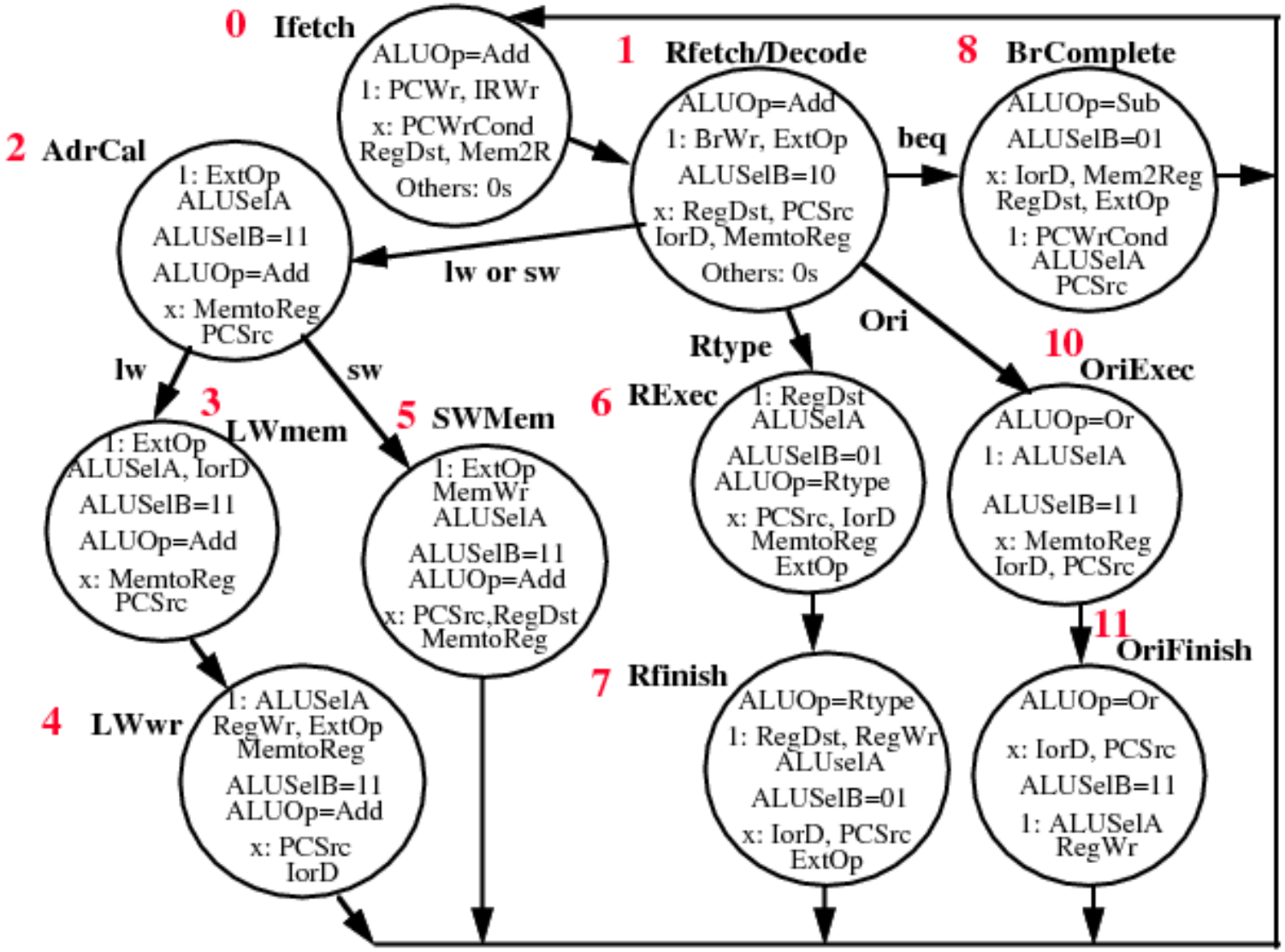
(Hardwired Control)



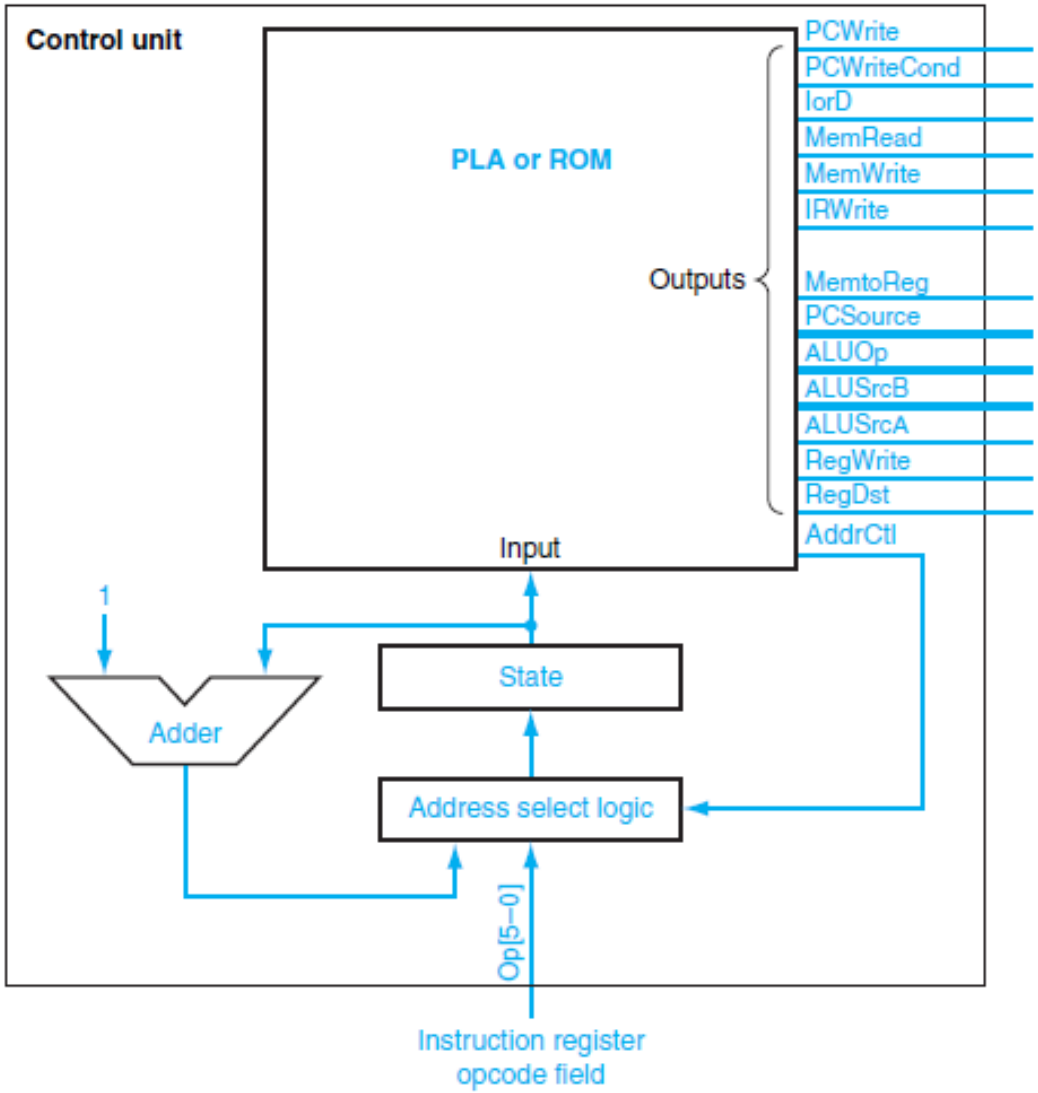
ROM Implementation

- Data Path Control Signals and Next State Signals are a function of the Opcode and the Current State
- Total of 20 output signals (Data Path + Next State) are a function of 10 input signals (Opcode + Current State)
- Store the entire truth table in ROM
  - ROM has 1024 entries each of 20 bits length
  - 20 Kbits overall

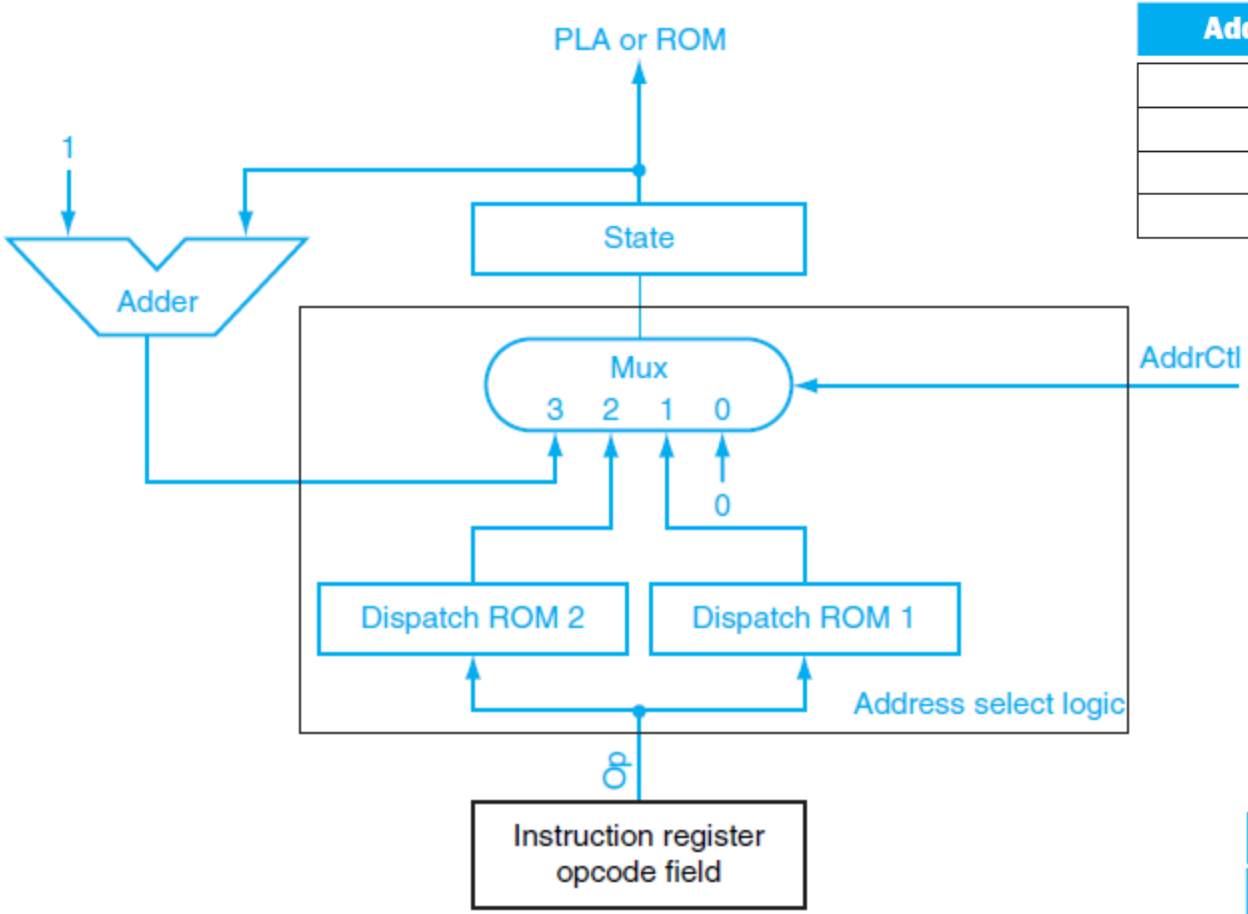
Control Logic in the Form of Finite State Diagram



Control Logic With a Sequencer



Address Select Logic



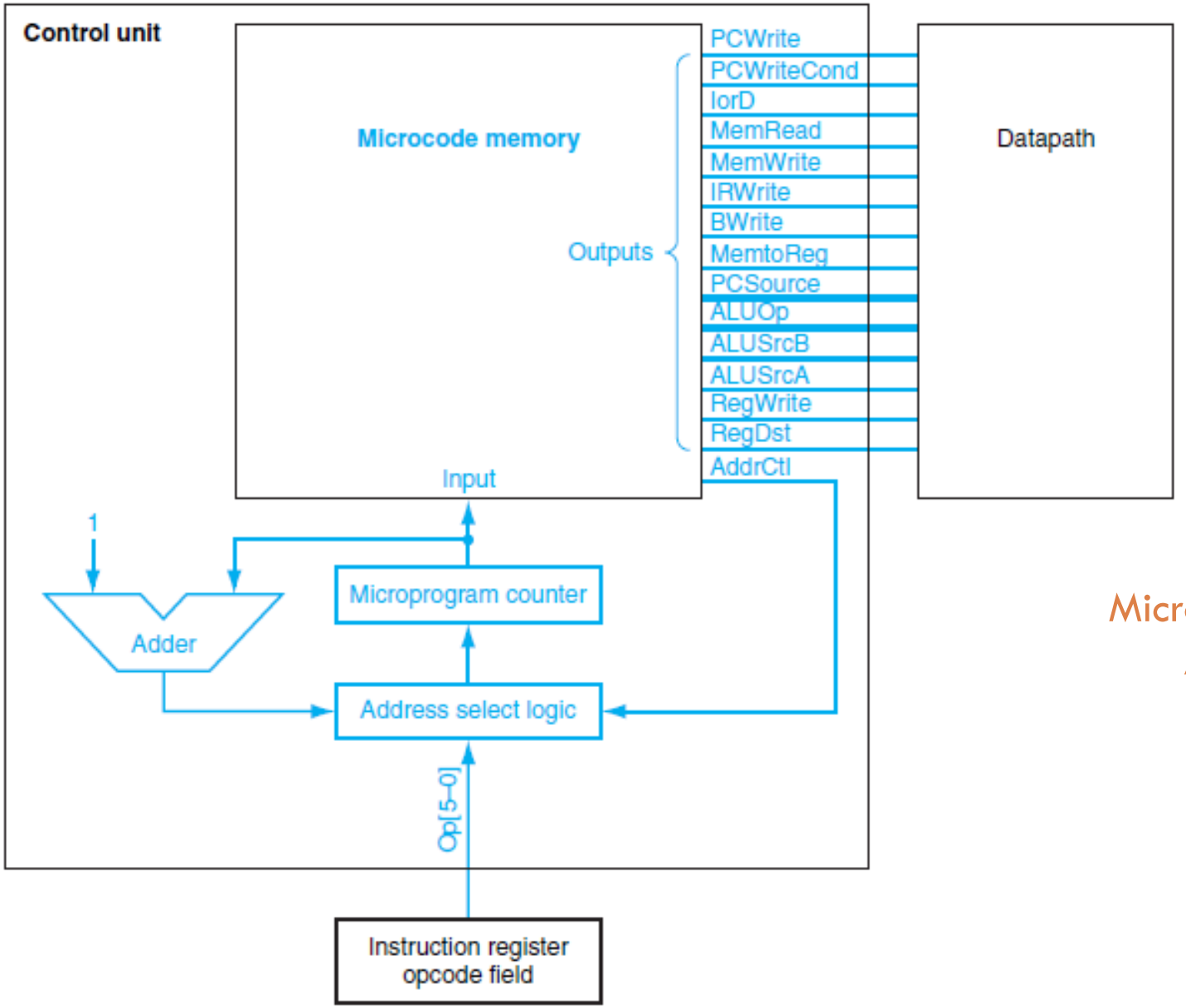
AddrCtl value	Action
0	Set state to 0
1	Dispatch with ROM 1
2	Dispatch with ROM 2
3	Use the incremented state

Dispatch ROM 1		
Op	**Opcode name**	**Value**
000000	R-format	0110
000010	jmp	1001
000100	beq	1000
100011	lw	0010
101011	sw	0010

Dispatch ROM 2		
Op	**Opcode name**	**Value**
100011	lw	0011
101011	sw	0101

Address Control Lines

State number	Address-control action	Value of AddrCtl
0	Use incremented state	3
1	Use dispatch ROM 1	1
2	Use dispatch ROM 2	2
3	Use incremented state	3
4	Replace state number by 0	0
5	Replace state number by 0	0
6	Use incremented state	3
7	Replace state number by 0	0
8	Replace state number by 0	0
9	Replace state number by 0	0



Microprogrammed Approach

Horizontal and Vertical Microprogramming

- Horizontal Microprogramming
  - More control over the potential parallelism of operations in the datapath
  - Uses up lot of control store
- Vertical Microprogramming
  - Saves control due to relatively compact encoding
  - Extra level of decoding may slow down the machine

Microprogramming Pros and Cons

- Ease of design
- Flexibility
  - Easy to adapt to changes in organization, timing, technology
  - Can make changes late in design cycle, or even in the field
- Can implement very powerful instruction sets (just more control memory)
- Generality
  - Can implement multiple instruction sets on same machine. (Emulation)
  - Can tailor instruction set to application.
- Compatibility
  - Many organizations, same instruction set
- Costly to implement
- Slow