

# Computer Science CSCI 355

## Digital Logic and Computer Organization

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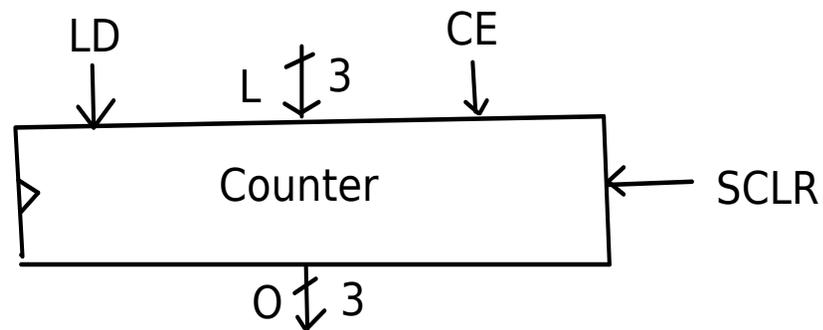
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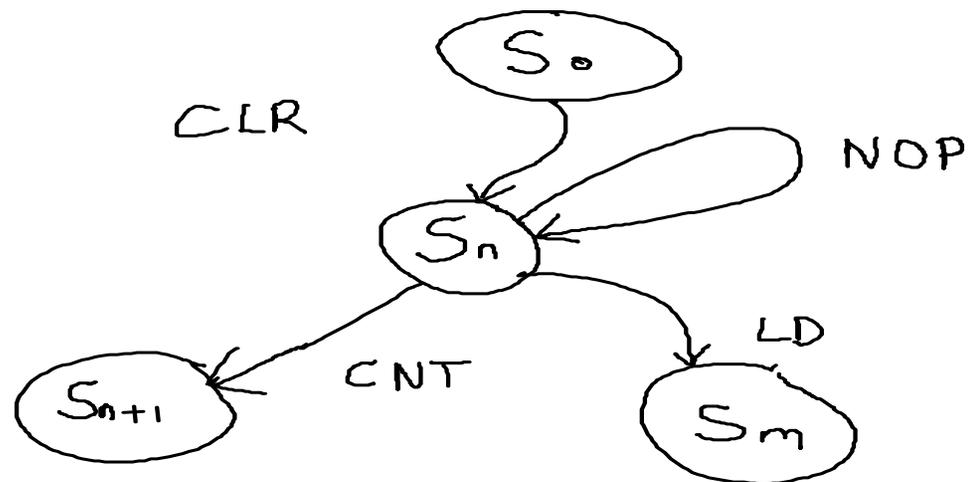
# Counters

LD	CE	SCLR	L[2:0]	Operation	Priority
1	-	-	value	load value LD	0
0	1	0	-	count up CNT	1
0	0	1	-	clear CLR	2
0	0	0	-	nop NOP	3

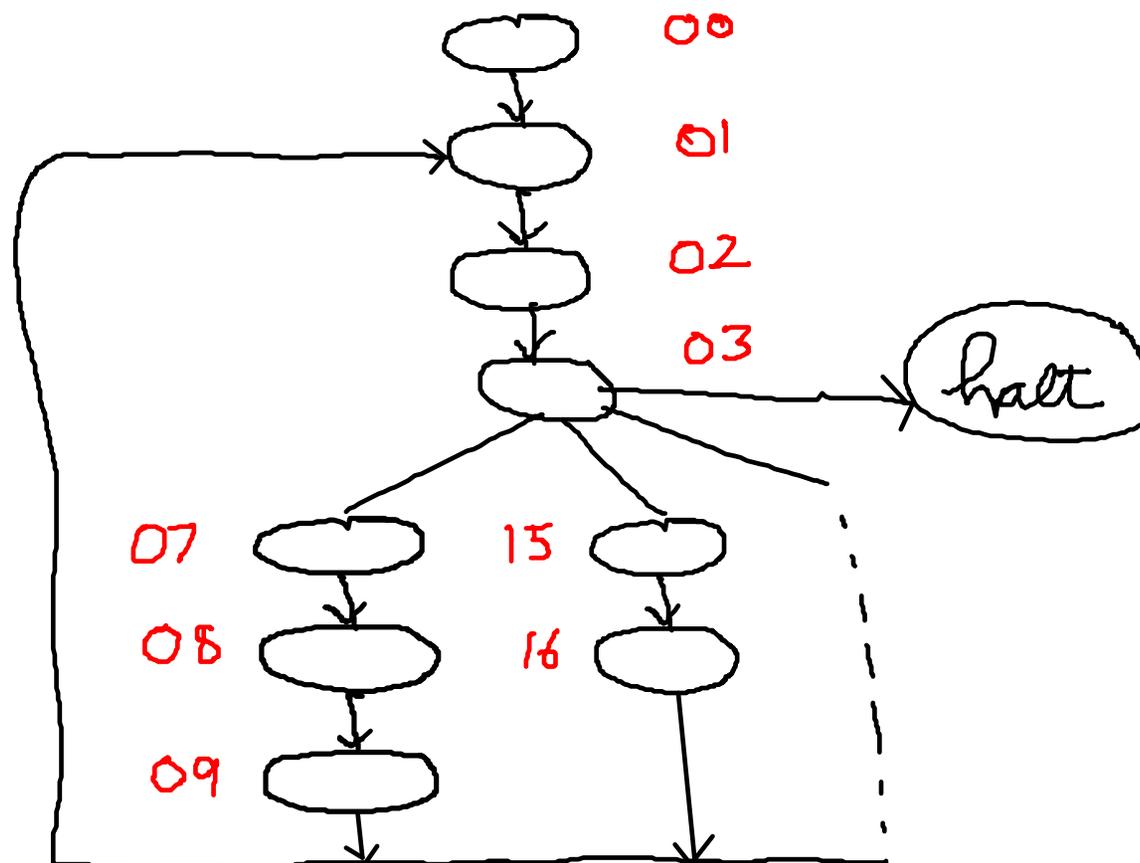


## FSMs Using Counters

- use the counter to store state

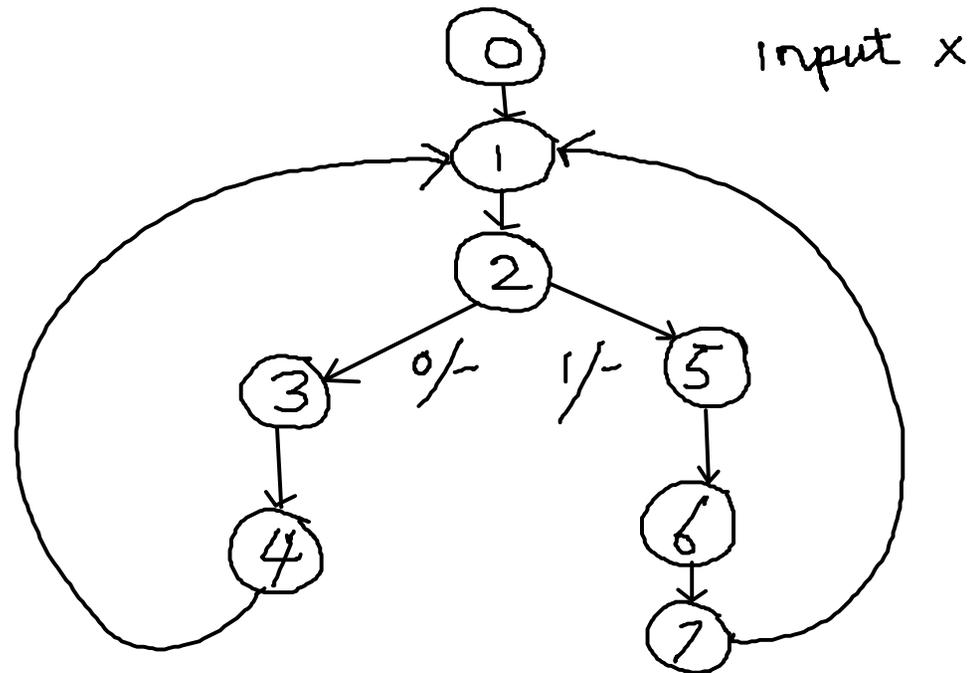


# SSBC Control Unit

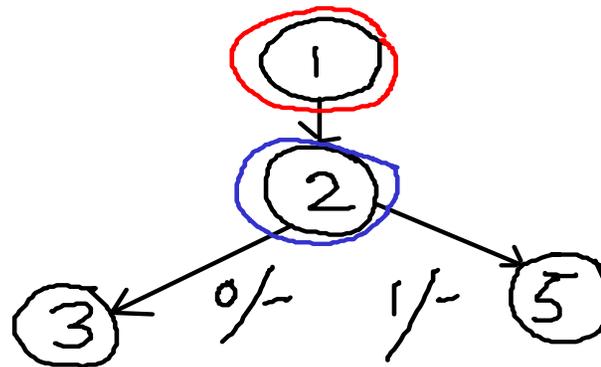


## FSM Implementation Example

- implement state transition using a 3-bit counter



# FSM Implementation Example cont.



Q

Q2	Q1	Q0	X	LD	CE	SCLR	L2	L1	L0
0	0	1	0	0	1	0	-	-	-
0	0	1	1	0	1	0	-	-	-
0	1	0	0	0	1	0	-	-	-
0	1	0	1	1	-	-	1	0	1

# FSM Implementation Example cont.

Q2	Q1	Q0	X	LD	CE	SCLR	L2	L1	L0	<u>State</u>
0	0	0	0	0	1	0	-	-	-	0
0	0	0	1	0	1	0	-	-	-	1
0	0	1	0	0	1	0	-	-	-	2
0	0	1	1	0	1	0	-	-	-	3
0	1	0	0	0	1	0	-	-	-	4
0	1	0	1	1	-	-	1	0	1	5
0	1	1	0	0	1	0	-	-	-	6
0	1	1	1	0	1	0	-	-	-	7
1	0	0	0	1	-	-	0	0	1	
1	0	0	1	1	-	-	0	0	1	
1	0	1	0	0	1	0	-	-	-	
1	0	1	1	0	1	0	-	-	-	
1	1	0	0	0	1	0	-	-	-	
1	1	0	1	0	1	0	-	-	-	
1	1	1	0	1	-	-	0	0	1	
1	1	1	1	1	-	-	0	0	1	

## State Minimization

- Equivalent States
  - two states are equivalent if they have the same next state and output
  
- Minimization Techniques
  - Row Comparison
  - Implication Table

## Row Comparison)

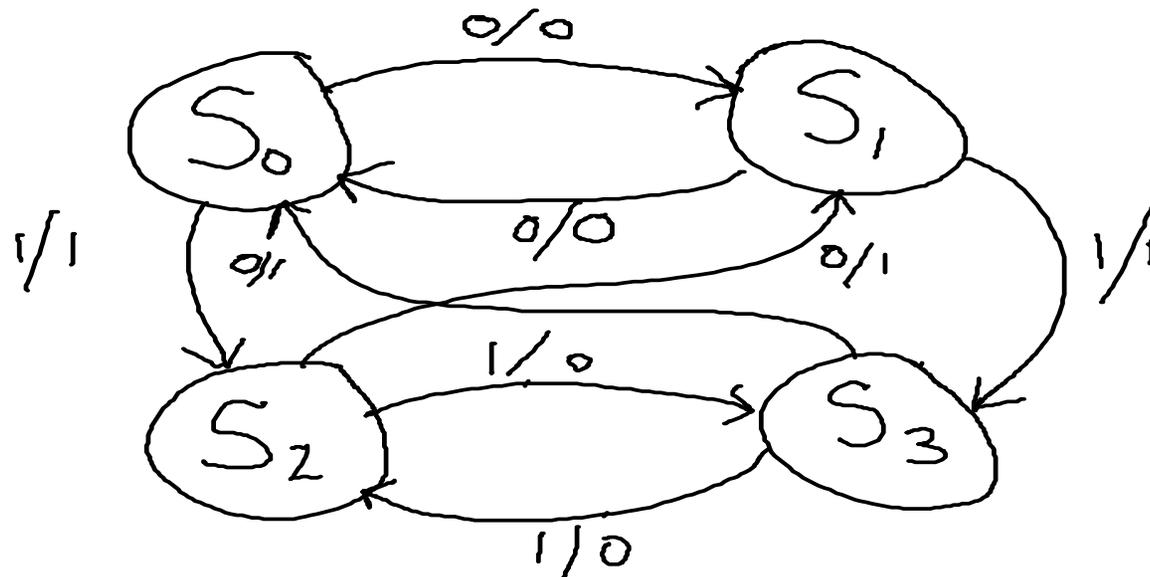
Current State	Next State		Output
	X=0	X=1	
S0	S1	S0	0
S1	S2	S0	0
S2	S3	S6	0
S3	S0	S4	0
S4	S5	S0	0
S5	S0	S0	1
S6	S7	S0	0
S7	S8	S0	0
S8	S0	S0	1

Replace S8 with S5

Replace S7 with S4

## Implication Table

- contrived example

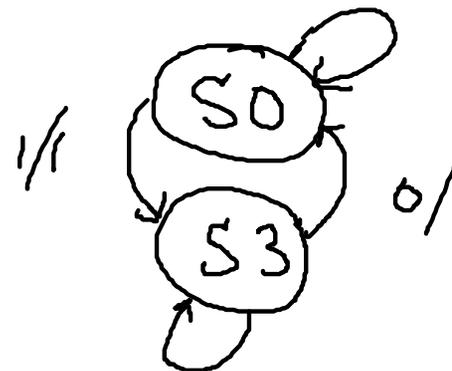


## Implication Table cont.

Current State	Next State		Output	
	X=0	X=1	X=0	X=1
S0	S1	S2	0	1
S1	S0	S3	0	1
S2	S1	S3	1	0
S3	S0	S2	1	0

S1	2=3		
S2	X	X	
S3	X	X	0=1
	S0	S1	S2

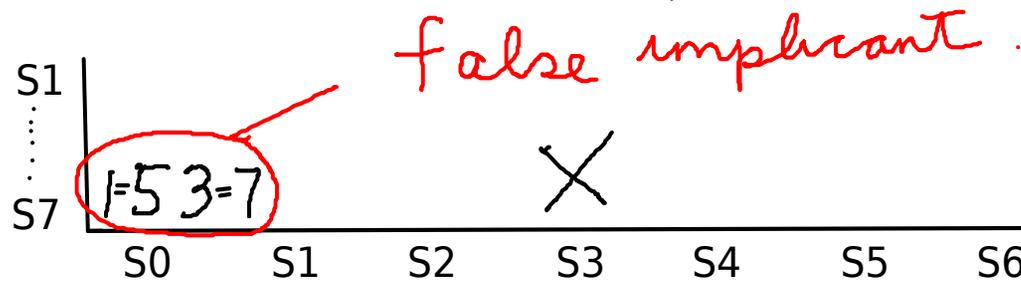
S2 ≡ S3  
S0 ≡ S1



# Implication Table

- a second example

Current State	Next State		Output
	X=0	X=1	
S0	S1	S3	0
S1	S2	S4	0
S2	S0	S3	0
S3	S4	S5	1
S4	S3	S6	1
S5	S7	S6	1
S6	S7	S5	1
S7	S5	S7	0



# Implication Table cont.

S1	$1=2$ $3=4$							
S2	$0=1$	$0=2$ $3=4$						
S3	X	X	X					
S4	X	X	X	$3=4$ $5=6$				
S5	X	X	X	$4=7$ $5=6$	$3=7$			
S6	X	X	X	$4=7$	$6=7$ $3=7$	$5=6$		
S7	$1=5$ $3=7$	$2=5$ $4=7$	$0=5$ $3=7$	X	X	X	X	
	S0	S1	S2	S3	S4	S5	S6	

# Implication Table cont.

S1	$\begin{matrix} 1=2 \\ 3=4 \end{matrix}$						
S2	$0=1$	$\begin{matrix} 0=2 \\ 3=4 \end{matrix}$					
S3	X	X	X				
S4	X	X	X	$\begin{matrix} 3=4 \\ 5=6 \end{matrix}$			
S5	X	X	X	<del><math>\begin{matrix} 4=7 \\ 5=6 \end{matrix}</math></del>	<del><math>3=7</math></del>		
S6	X	X	X	<del><math>4=7</math></del>	<del><math>\begin{matrix} 6=7 \\ 3=7 \end{matrix}</math></del>	$5=6$	
S7	<del><math>\begin{matrix} 1=5 \\ 3=7 \end{matrix}</math></del>	<del><math>\begin{matrix} 2=5 \\ 4=7 \end{matrix}</math></del>	<del><math>\begin{matrix} 0=5 \\ 3=7 \end{matrix}</math></del>	X	X	X	X
	S0	S1	S2	S3	S4	S5	S6

$S0 \equiv S1 \equiv S2$   
 $S3 \equiv S4$   
 $S5 \equiv S6$