CSM51A Discussion #6

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Outline

- Review HW5
- Chapter 8
  - Timing Parameters of Flipflops
- Chapter 7
  - Mealy vs. Moore machine
  - State transition table
  - State Diagram
  - State Minimization

TIMING PARAMETERS OF A BINARY CELL

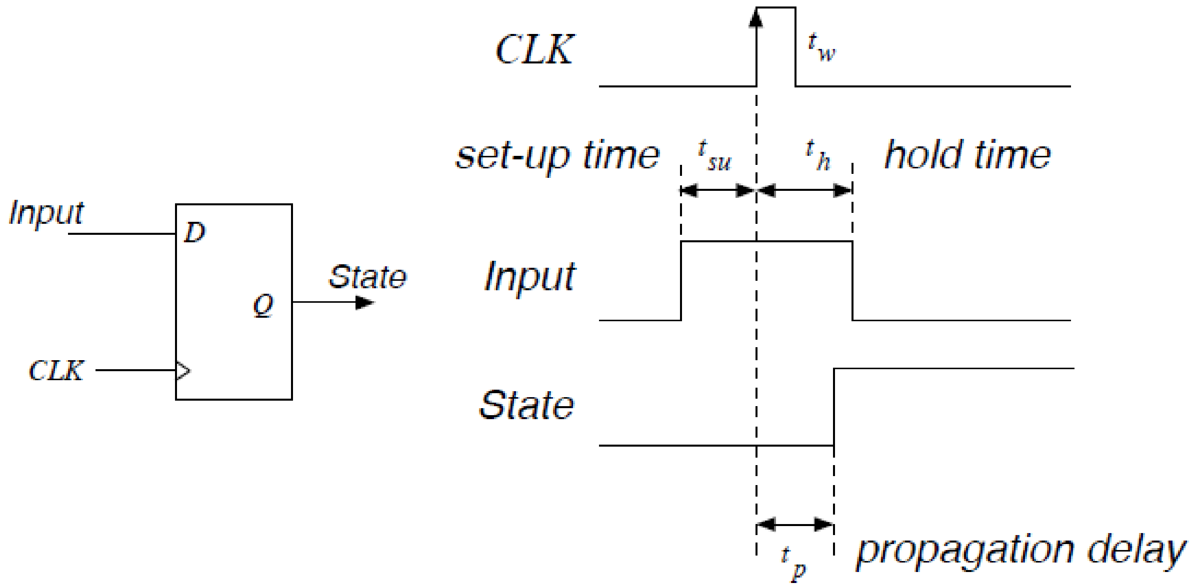
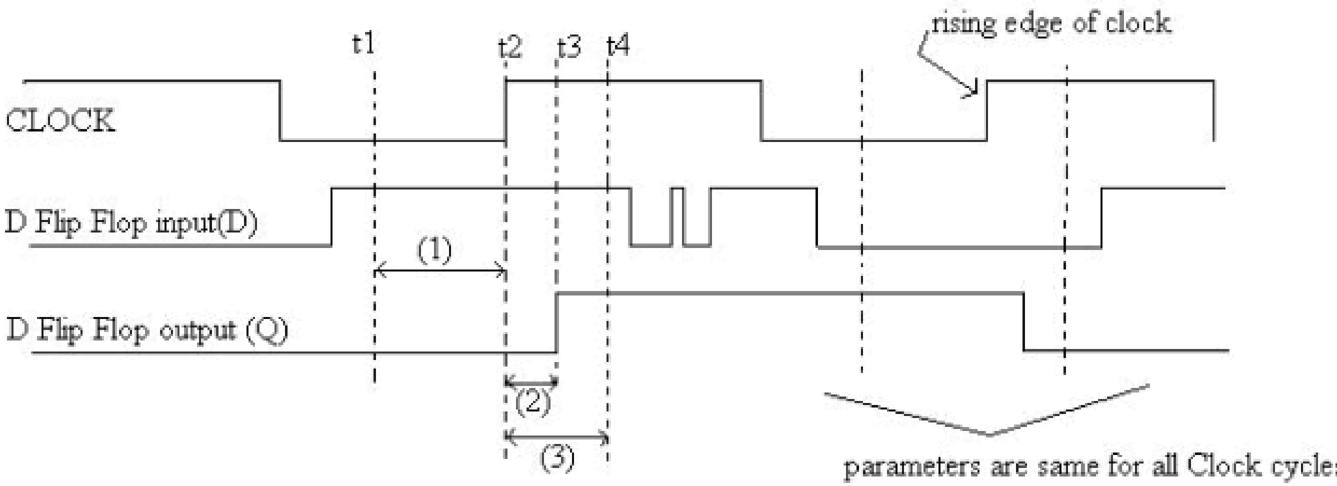


Figure 8.12: TIME BEHAVIOR OF CELL.

Violation of set-up time or hold time causes a undefined output.

Example



(1) the **Setup Time** [t2 - t1]: the minimum amount of time Input must be held constant BEFORE the clock tick.

(2) the **Propagation delay** of the Flip Flop [t3 - t2]: this is the time that it takes for the new input to be to propagate and influence the output.

(3) the **Hold time** [t4 - t2]: the minimum amount of time the Input is held constant AFTER the clock tick: Most current FF has **zero** (negative) hold time

MEALY AND MOORE MACHINES

Mealy machine

$$z(t) = H(s(t), x(t))$$

$$s(t+1) = G(s(t), x(t))$$

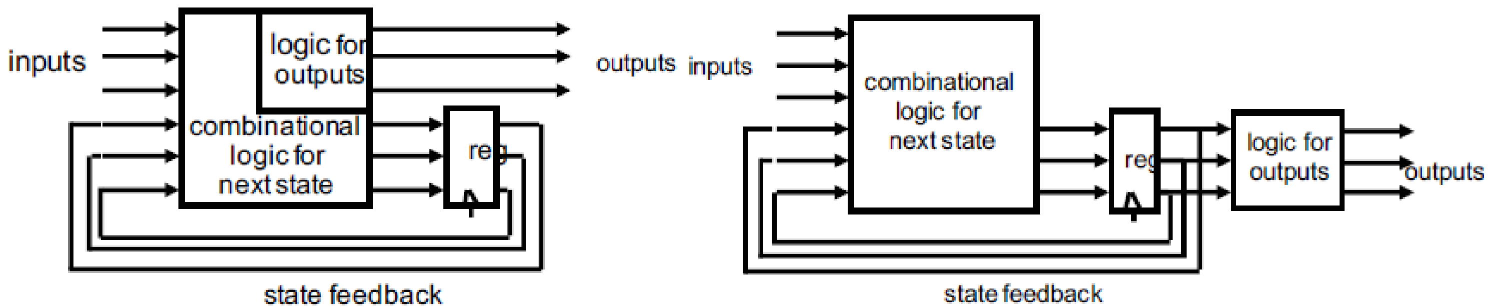
Moore machine

$$z(t) = H(s(t))$$

$$s(t+1) = G(s(t), x(t))$$

- EQUIVALENT IN CAPABILITIES

Mealy vs Moore

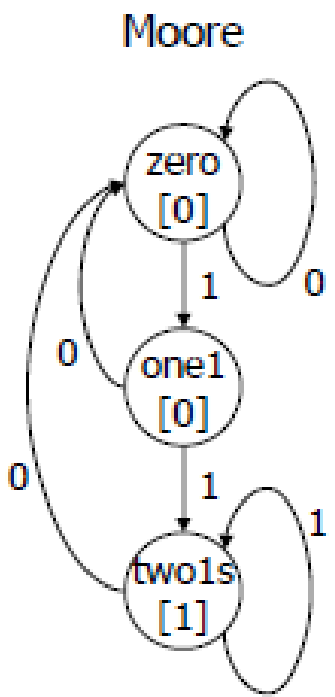


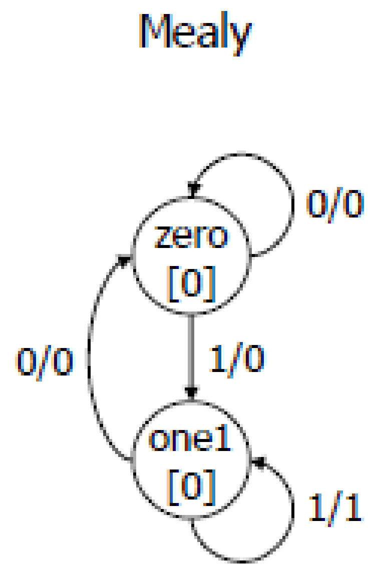
- Mealy
  - Less states
    - #output on arcs (n2) than states (n)
  - Input change can cause output change in a clock period -> X

- Moore
  - Usually more states than Mealy
  - Safer to use
    - Outputs change at clock edge

Mealy vs Moore

- Example
  - "11" pattern detector





Ex7.1 A sequential system has one input with values a, b, and c and one output with values p and q. The output is q whenever the input sequence has an even number of a's and an odd number of b's. Obtain a state description of the system.

Input:

$$x(t) \in \{a, b, c\}$$

Output:

$$z(t) \in \{p, q\}$$

Function:

$$z(t) = \begin{cases} q & \text{if number of a's in } x(0, t-1) \text{ is even and number of b's is odd.} \\ p & \text{otherwise} \end{cases}$$

Initial state:

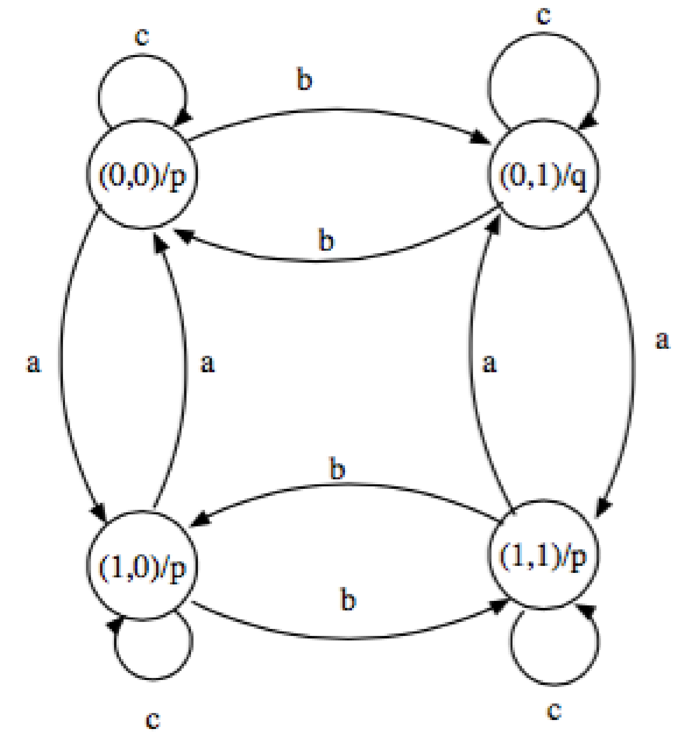
$$\begin{aligned} s_a(0) &= 0 \\ s_b(0) &= 0 \end{aligned}$$

Transition function:

$$\begin{aligned} s_a(t+1) &= \begin{cases} s_a(t)' & \text{if } x(t) = a \\ s_a(t) & \text{otherwise} \end{cases} \\ s_b(t+1) &= \begin{cases} s_b(t)' & \text{if } x(t) = b \\ s_b(t) & \text{otherwise} \end{cases} \end{aligned}$$

	Input			
PS	$x = a$	$x = b$	$x = c$	
(0,0)	(1,0)	(0,1)	(0,0)	p
(0,1)	(1,1)	(0,0)	(0,1)	q
(1,0)	(0,0)	(1,1)	(1,0)	p
(1,1)	(0,1)	(1,0)	(1,1)	p
	NS			Output (z)

Mealy or Moore?



Ex7.5 Determine the state diagram for the sequential system described by the following expressions:

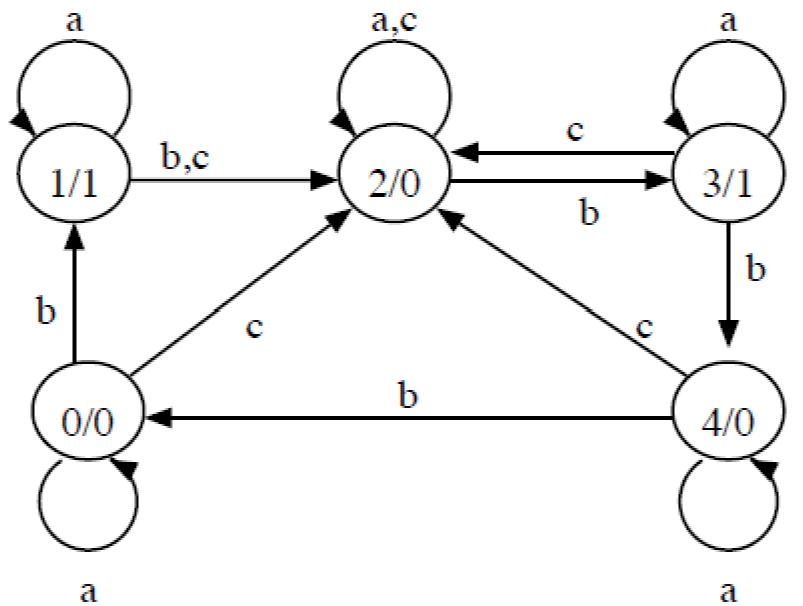
$$s(t+1) = \begin{cases} s(t) & \text{if } x=a \\ (s(t)+1) \bmod 5 & \text{if } x=b \\ 2 & \text{if } x=c \end{cases}$$

$$z(t) = \begin{cases} 0 & \text{if } s(t) \text{ is even} \\ 1 & \text{if otherwise} \end{cases}$$

The system has five states labeled 0, 1, 2, 3, and 4

Mealy or Moore?

Ex7.5 Solution



Ex7.15 Determine the minimal state table that is equivalent to the following:

	input	
PS	x=0	x=1
a	f, 0	b, 0
b	d, 0	c, 0
c	f, 0	e, 0
d	g, 1	a, 0
e	d, 0	c, 0
f	f, 1	b, 1
g	g, 0	h, 1
h	g, 1	a, 0
	NS, z	

Exercise 7.15

From the state table we get

$$P_1 = (a,b,c,e)(d,h)(f)(g)$$

To obtain P_2, we determine the class of P_1 to which the successors of the states belong.

	1 (a,b,c,e)	2 (d,h)	3 (f)	4 (g)
0	3 2 3 2	4 4	3	4
1	1 1 1 1	1 1	1	2

Thus,

$$P_2 = (a,c)(b,e)(d,h)(f)(g)$$

To obtain P_3, we determine the group of states of P_2 to which the successors of the state belong.

	1 (a,c)	2 (b,e)	3 (d,h)	4 (f)	5 (g)
0	4 4	3 3	5 5	4	5
1	2 2	1 1	1 1	2	3

Therefore, $P = P_3 = P_2 = (a,c)(b,e)(d,h)(f)(g)$ and the reduced table is

	Input	
PS	$x=0$	$x=1$
a	$f,0$	$b,0$
b	$d,0$	$a,0$
d	$g,1$	$a,0$
f	$f,1$	$b,1$
g	$g,0$	$d,1$
	$NS, Output$	

Ex7.17 Determine the minimal state table equivalent to the following one:

	Input			
PS	**x=a**	**x=b**	**x=c**	**x=d**
A	**E, 1**	**C, 0**	**B, 1**	**E, 1**
B	**C, 0**	**F, 1**	**E, 1**	**B, 0**
C	**B, 1**	**A, 0**	**D, 1**	**F, 1**
D	**G, 0**	**F, 1**	**E, 1**	**B, 0**
E	**C, 0**	**F, 1**	**D, 1**	**E, 0**
F	**C, 1**	**F, 1**	**D, 0**	**H, 0**
G	**D, 1**	**A, 0**	**B, 1**	**F, 1**
H	**B, 1**	**C, 0**	**E, 1**	**F, 1**
	NS, z			

Exercise 7.17
Based on the outputs for each state we get the first partition

$$P_1 = (A, C, G, H)(B, D, E)(F)$$

To obtain P_2, we determine the class of P_1 to which the successors of the states belong.

	group 1				group 2			group 3
	A	C	G	H	B	D	E	F
a	2	2	2	2	1	1	1	
b	1	1	1	1	3	3	3	
c	2	2	2	2	2	2	2	
d	2	3	3	3	2	2	2	

Partition P_2 is

	group 1	group 2			group 3			group 4
	A	C	G	H	B	D	E	F
a		3	3	3	2	2	2	
b		1	1	2	4	4	4	
c		3	3	3	3	3	3	
d		4	4	4	3	3	3	

Partition P_3 is

	group 1	group 2		group 3	group 4			group 5
	A	C	G	H	B	D	E	F
a		4	4		2	2	2	
b		1	1		5	5	5	
c		4	4		4	4	4	
d		5	5		4	4	4	

STOP.

The equivalent states are: {A}, {B,D,E}, {C,G}, {F}, {H}

Minimal state transition table:

PS	$x = a$	$x = b$	$x = c$	$x = d$
A	$B/1$	$C/0$	$B/1$	$B/1$
B	$C/0$	$F/1$	$B/1$	$B/0$
C	$B/1$	$A/0$	$B/1$	$F/1$
F	$C/1$	$F/1$	$B/0$	$H/0$
H	$B/1$	$C/0$	$B/1$	$F/1$
	$NS/output$			