



Moore and Mealy Machines

What is (Finite State Machine)FSM?

A finite state machine is a machine that has many states and has a logical way of changing from one state to the other under guiding rules.

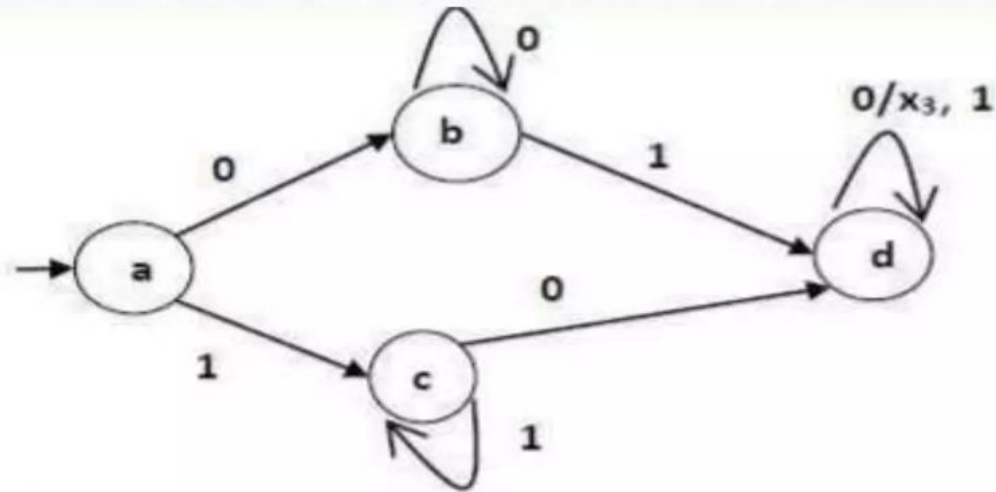
Mealy Machine

A Mealy Machine is an FSM whose output depends on the present state as well as the present input. In Mealy machine every transition for a particular input symbol has a fixed output.

Mealy Machine(Cont.)

- It can be described by a 6 tuple $(Q, \Sigma, O, \delta, X, q_0)$ where –
 1. Q is a finite set of states.
 2. Σ is a finite set of symbols called the input alphabet.
 3. O is a finite set of symbols called the output alphabet.
 4. δ is the input transition function where $\delta: Q \times \Sigma \rightarrow Q$
 5. X is the output transition function where $X: Q \rightarrow O$
 6. q_0 is the initial state from where any input is processed ($q_0 \in Q$).

State Diagram of Mealy Machine:



Mealy Transition Table

Present State	Next State			
	a = 0		a = 1	
	State	Output	State	Output
-> q0	q3	0	q1	1
q1	q0	1	q3	0
q2	q2	1	q2	0
q3	q1	0	q0	1

Moore Machine:

- In Moore machine. the value of output function is depend on the present state only. Moore machine is described by 6-tuples – $(Q, \Sigma, \Delta, \delta, \lambda, q_0)$ where

1. Q = Finite non-empty set of states;
2. Σ = Set of input alphabets.
3. Δ = Set of output alphabets.
4. δ = Transition function mapping $Q \times \Sigma \rightarrow Q$
5. λ = Output function mapping $Q \rightarrow \Delta$
6. q_0 = Initial state..

Moore Transition Table:

- There is no concept of final state in Moore machines we consider output for each state.

Present State	Next State		Output
	a = 0	a = 1	
-> q0	q3	q1	1
q1	q0	q3	0
q2	q2	q2	0
q3	q1	q0	1

Moore Machine to Mealy Machine

1. **Input:** Moore Machine
2. **Output:** Mealy Machine
3. **Step 1:** Take a blank Mealy Machine transition table format.
4. **Step 2:** Copy all the Moore Machine transition states into this table format..
5. **Step 3:** Check the present states and their corresponding outputs in the Moore Machine state table; if for a state Q_i output is m , copy it into the output columns of the Mealy Machine state table wherever Q_i appears in the next state..

Example:

- Let us consider Moore Table

Present State	Next State		Output
	a=0	a=1	
→ a	d	b	1
b	a	d	0
c	c	c	0
d	b	a	1

Step 1 & 2

Present State	Next State			
	a=0		a=1	
	State	Output	State	Output
→a	d		b	
B	a		d	
c	c		c	
d	b		a	

Step 3

Present State	Next State			
	a=0		a=1	
	State	Output	State	Output
⇒a	d	1	b	0
b	a	1	d	1
c	c	0	c	0
d	b	0	a	1

Mealy Machine To Moore Machine

1. **Input:** Mealy Machine
2. **Output:** Moore Machine
3. **Step 1:** Calculate the number of different outputs for each state (Q_i) that are available in the state table of the Mealy machine.
4. **Step 2:** If all the outputs of Q_i are same, copy state Q_i . If it has n distinct outputs, break Q_i into n states as Q_{in} where $n = 0, 1, 2, \dots$
5. **Step 3:** If the output of the initial state is 1, insert a new initial state at the beginning which gives 0 output.

Example:

- Let us consider the following Mealy Machine.

Present State	Next State			
	a=0		a=1	
	Next State	Output	Next State	Output
→a	d	0	b	1
b	a	1	d	0
c	c	1	c	0
d	b	0	a	1

Here, states 'a' and 'd' give only 1 and 0 outputs respectively, so we retain states 'a' and 'd'. But states 'b' and 'c' produce different outputs 1 and 0. So, we divide b into b0, b1 and c into c0, c1.

Conversion Cont....

Present State	Next State		Output
	a=0	a=1	
→a	d	b ₁	1
b ₀	a	d	0
b ₁	a	d	1
c ₀	c ₁	C ₀	0
c ₁	c ₁	C ₀	1
d	b ₀	a	0

Differences between Mealy and Moore state Machines

Mealy Machine

Output depends both upon present state and present input.

Generally, it has fewer states than Moore Machine.

Output changes at the clock edges.

Mealy machines react faster to inputs.

Moore Machine

Output depends only upon the present state.

Generally, it has more states than Mealy Machine.

Input change can cause change in output change as soon as logic is done.

In Moore machines, more logic is needed to decode the outputs since it has more circuit delays.

Advantages of Mealy and Moore state Machines

- Moore machines are cheap
- They are easy to use
- Moore state machines are very fast
- Mealy machines are reactive i.e. they have a low response time (they are fast)

Disadvantages of Mealy and Moore state Machines

- Mealy state machines are expensive to produce
- Number of states can become unmanageable (they become too many)

Uses of Mealy and Moore state Machines

- Mealy state machines are used in processors due to their property of having many states
- Mealy state machines are also used to provide a rudimentary mathematical model for cipher machines
- A Moore state machine is used as a write enable in SRAM because of its speed.
- It is used in SRAM because SRAM needs a level-sensitive control (signal has to be asserted for an amount of time)

Conclusion

- In conclusion, Mealy and Moore state machines are very important concepts in digital design
- These state machine can be used in the design of mathematical algorithms
- Mealy and Moore state machines can come in both simple (having one input and output) to complex (having many inputs and outputs) types