Computer Architecture

Week 4: Finite State Machine

Fenerbahçe University

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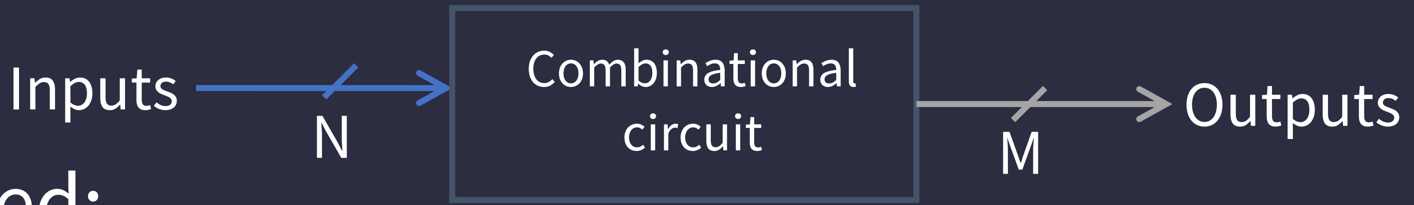
Course Plan

- Finite State Machine

Stateful Components

Combinationial logic

- Output computed directly from inputs
- System has no internal state
- Nothing depends on the past!



Need:

- To record data
- To build stateful circuits
- A state-holding device

Sequential Logic & Finite State Machines

Finite State Machines

An electronic machine which has

- external inputs
- externally visible outputs
- internal state

Output and next state depend on

- inputs
- current state

Abstract Model of FSM

Machine is

$$M = (S,\ I,\ O,\ \delta)$$

S: Finite set of states

I: Finite set of inputs

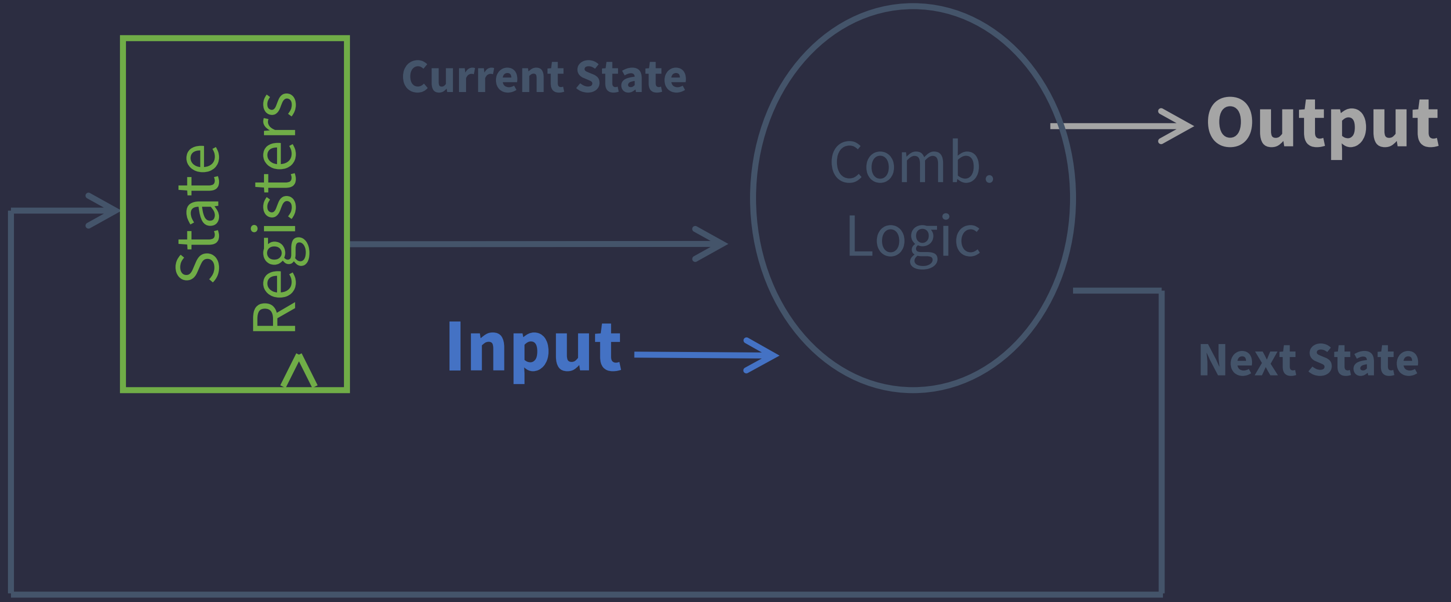
O: Finite set of outputs

δ: State transition function

Next state depends on present input *and* present state

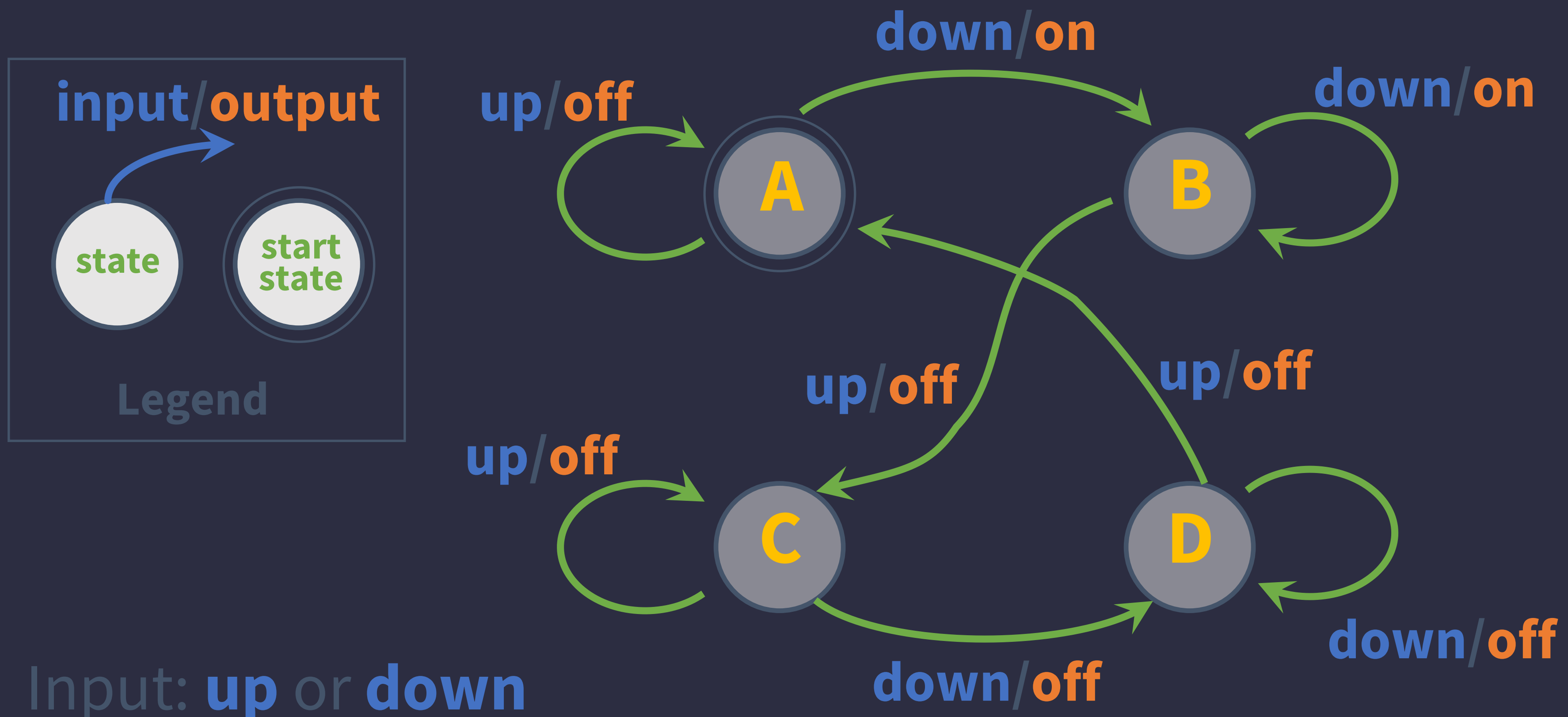
Automata Model

Finite State Machine



- inputs from external world
- outputs to external world
- internal state
- combinational logic

FSM Example

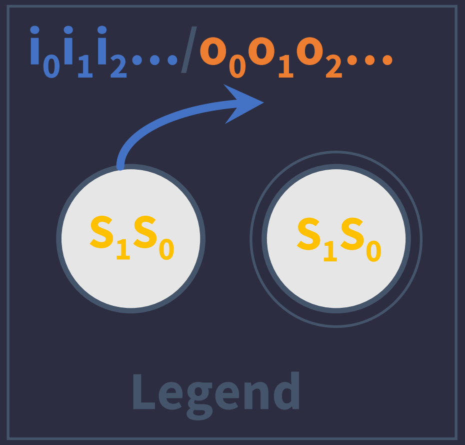


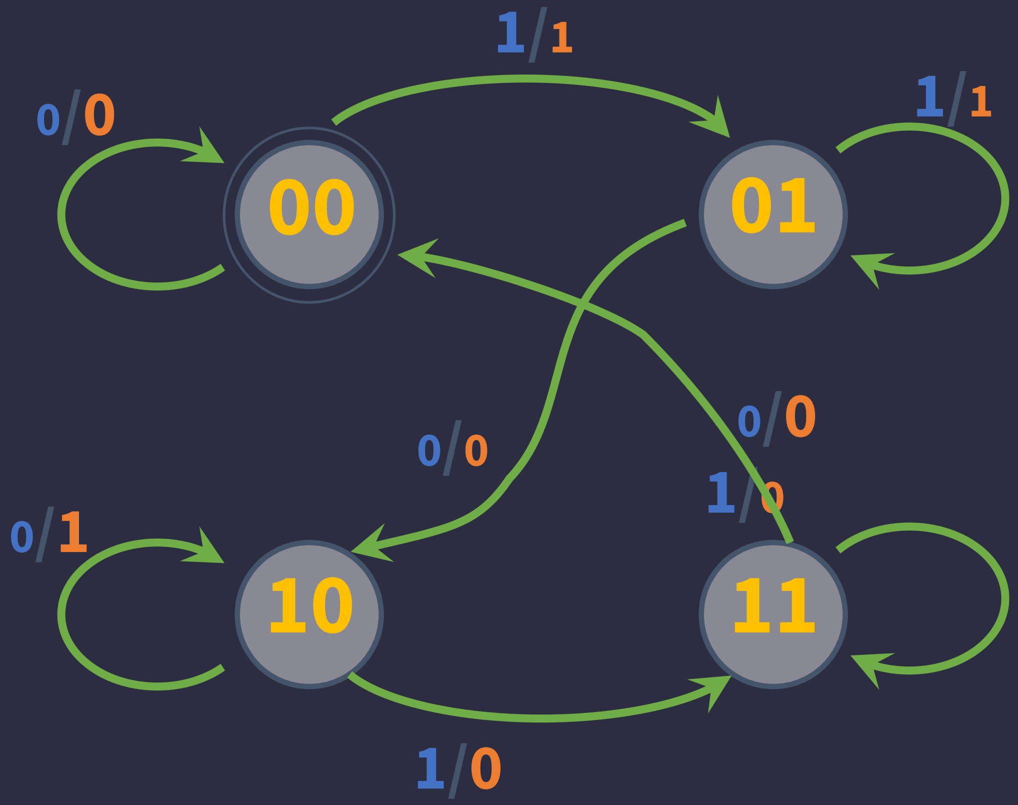
Input: **up** or **down**

Output: **on** or **off**

States: **A**, **B**, **C**, or **D**

FSM Example





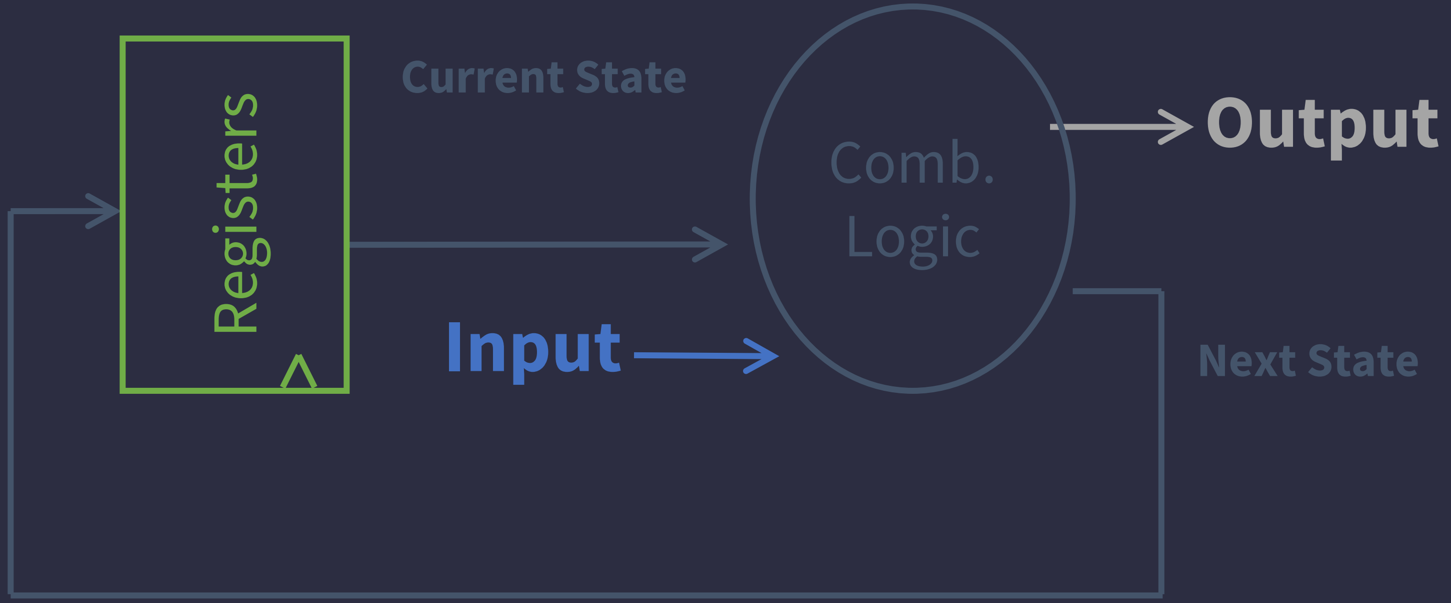
Input: **0**=up or **1**=down

Output: **1**=on or **0**=off

States: **00**=A, **01**=B, **10**=C, or **11**=D

Mealy Machine

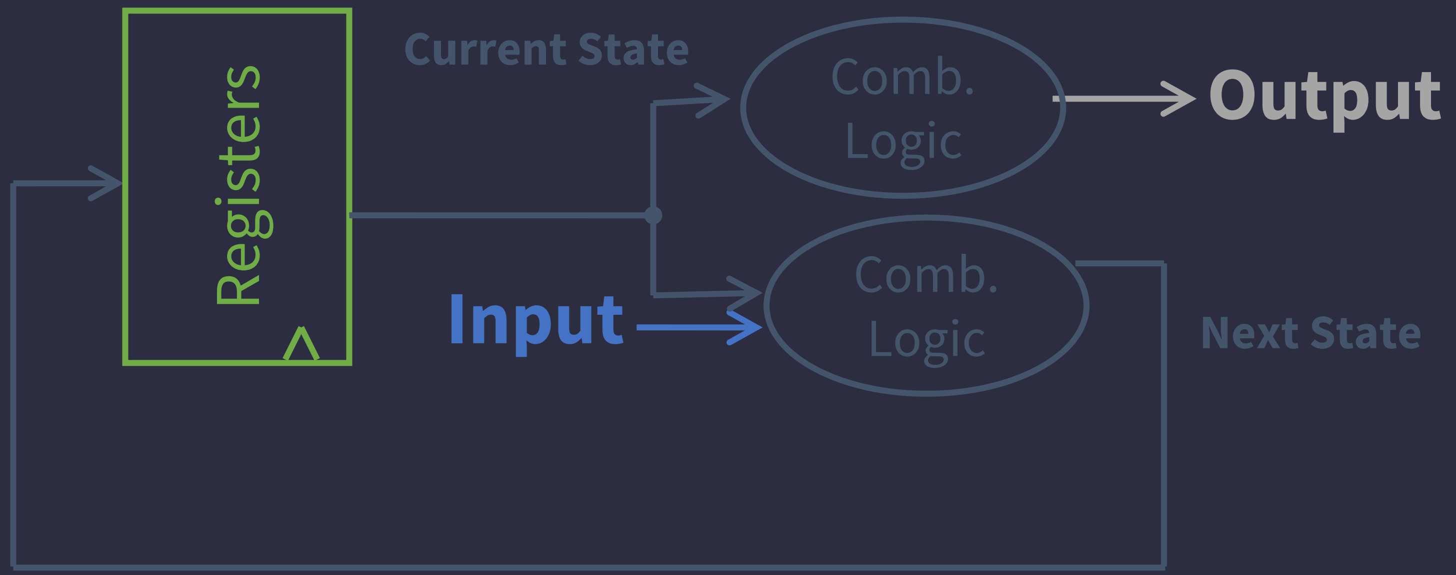
General Case: Mealy Machine



Outputs and next state depend on both current state and input

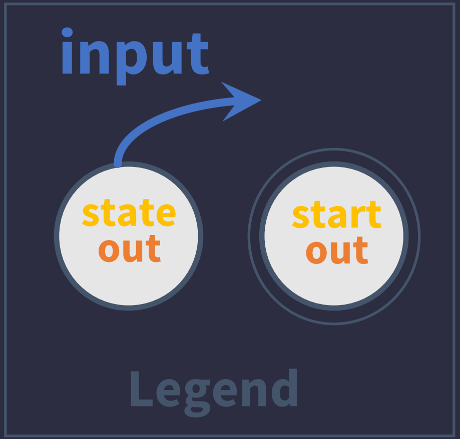
Moore Machine

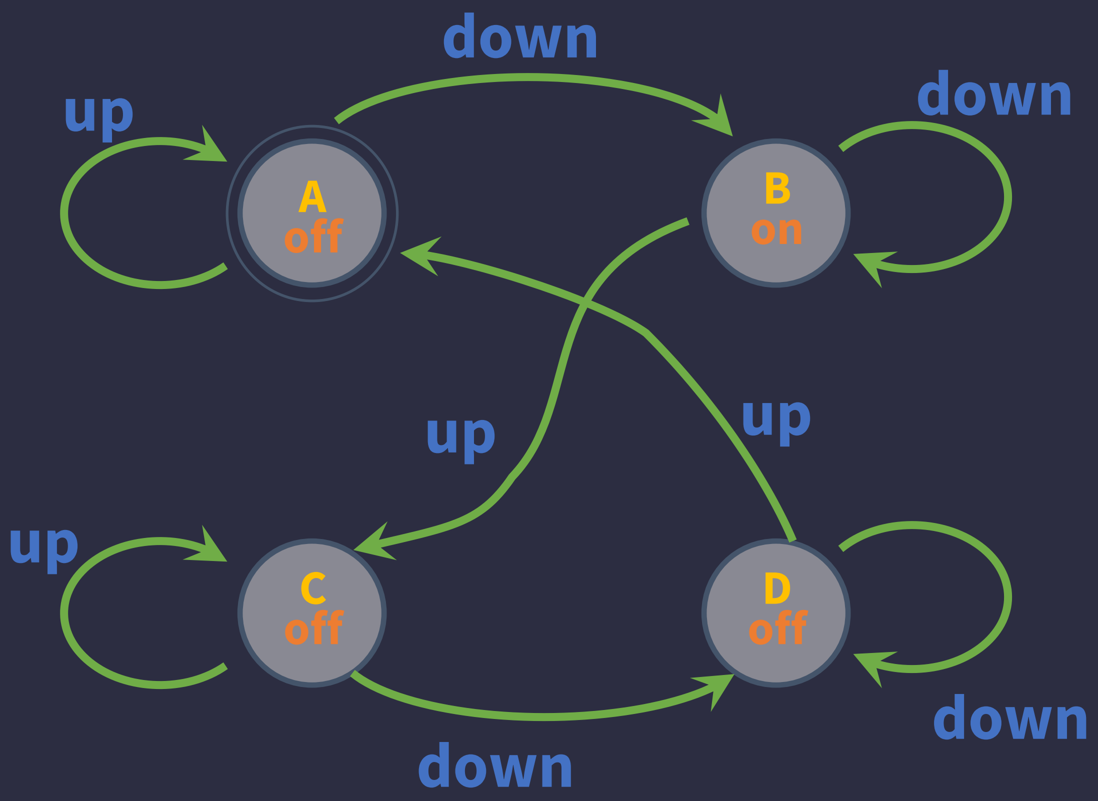
Special Case: Moore Machine



Outputs depend only on current state

Moore Machine FSM Example





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Output: **on** or **off**

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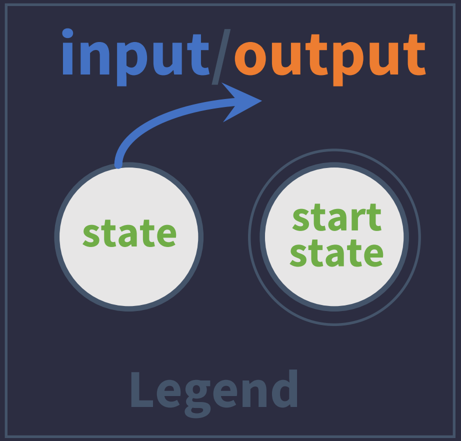
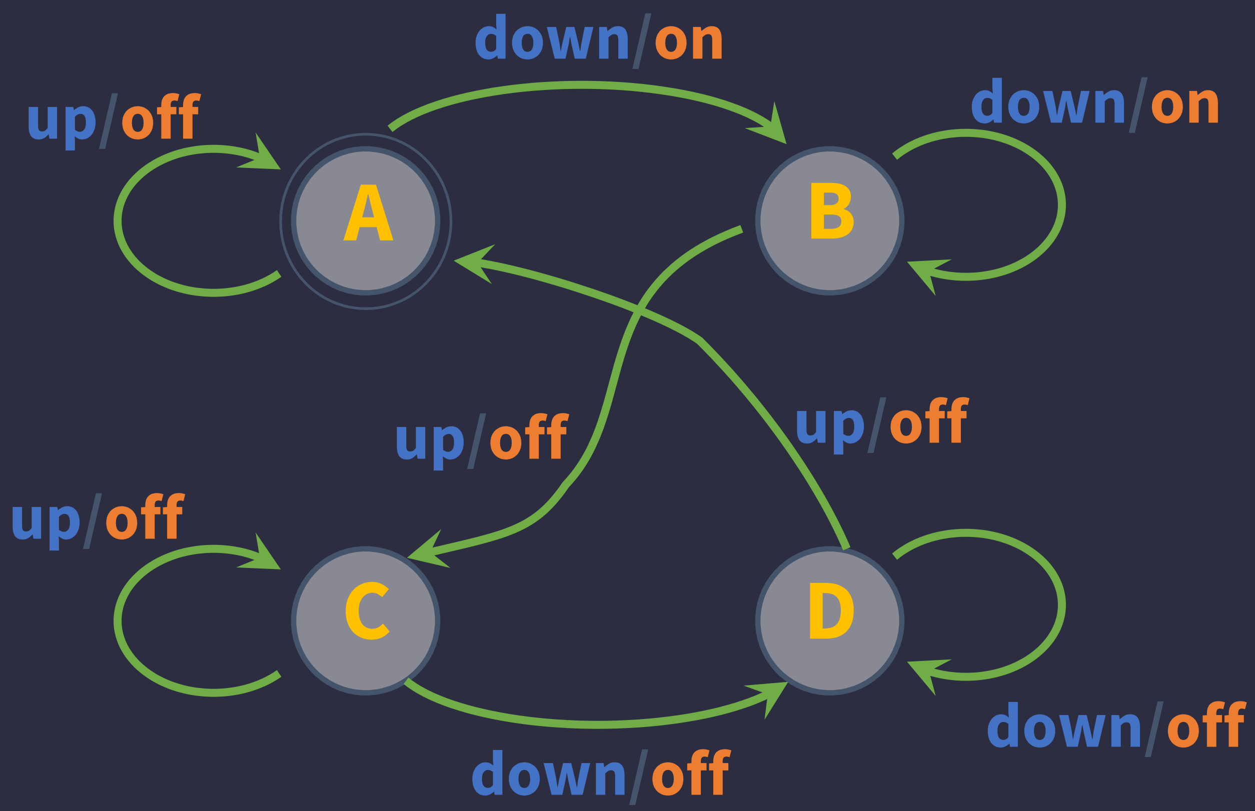
Mealy Machine FSM Example





Input: **up** or **down**

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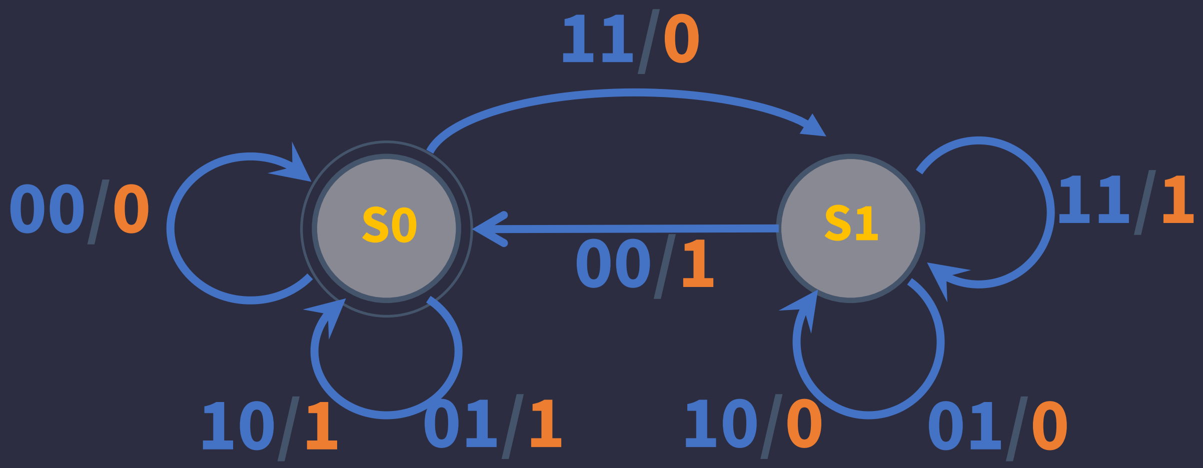
FSM Example

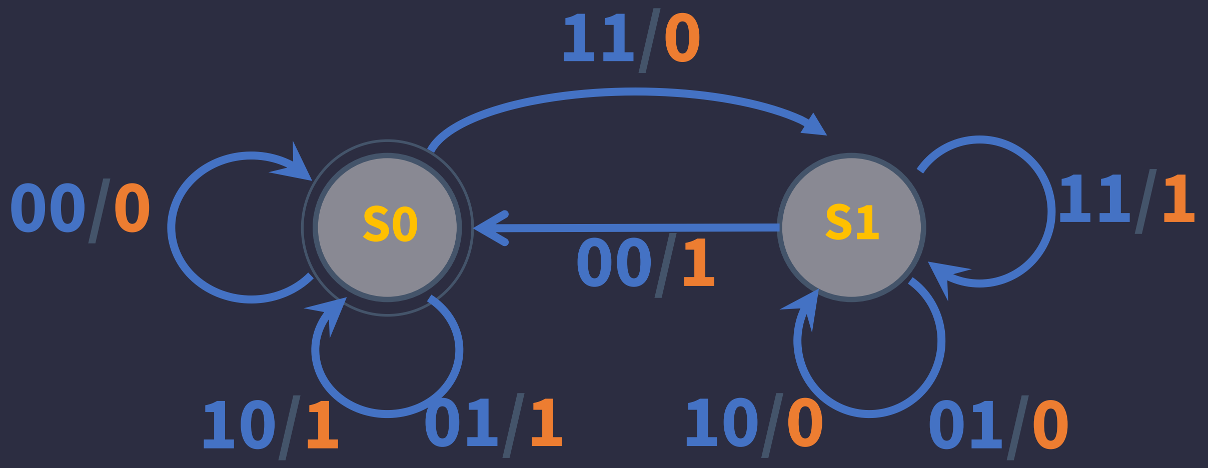


Two states: S0 (no carry in), S1 (carry in)
Inputs: a and b
Output: z

- z is the sum of inputs a, b, and carry-in (one bit at a time)
- A carry-out *is* the next carry-in state.
- Arcs labeled with input bits a and b, and output z

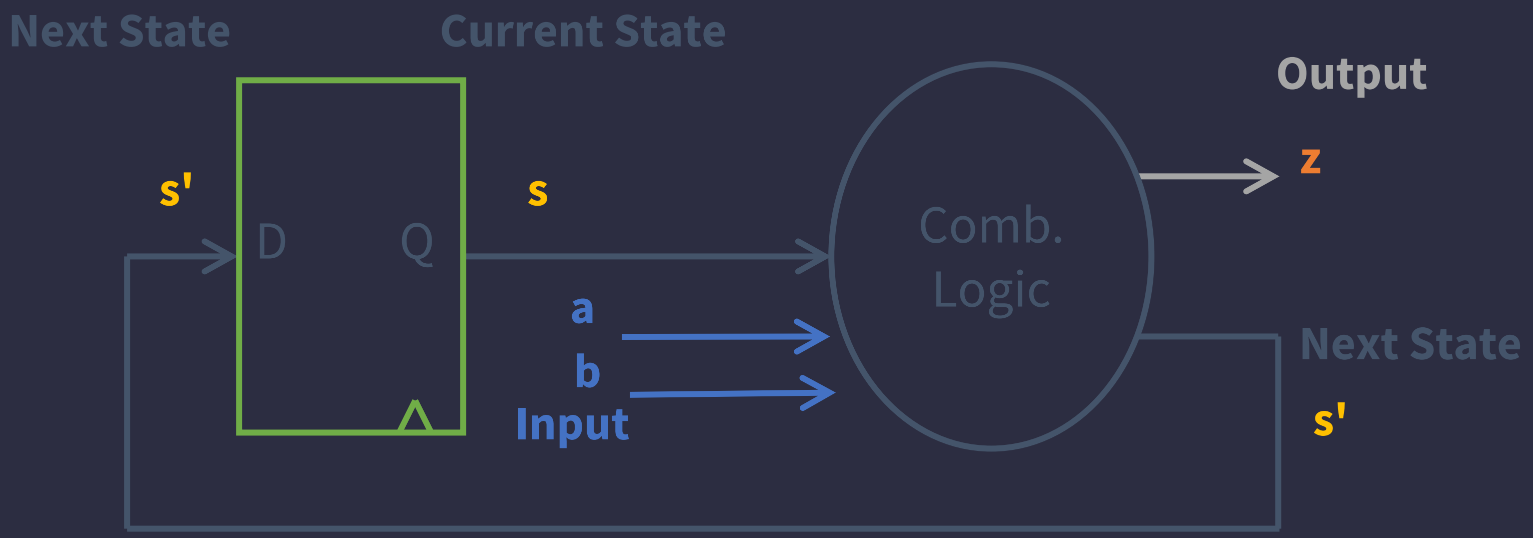
FSM Example

a	b	Current state	z	Next state
0	0	S0	0	S0
0	1	S0	1	S0
1	0	S0	1	S0
1	1	S0	0	S1
0	0	S1	1	S0
0	1	S1	0	S1
1	0	S1	0	S1
1	1	S1	1	S1



FSM Example

a	b	s	z	s'
0	0	0	0	0
0	1	0	1	0
1	0	0	1	0
1	1	0	0	1
0	0	1	1	0
0	1	1	0	1
1	0	1	0	1
1	1	1	1	1



Combinational Logic Equations

$$z = \bar{a}b\bar{s} + a\overline{bs} + \overline{ab}s + abs$$

$$s' = ab\bar{s} + \bar{a}bs + a\bar{b}s + abs$$

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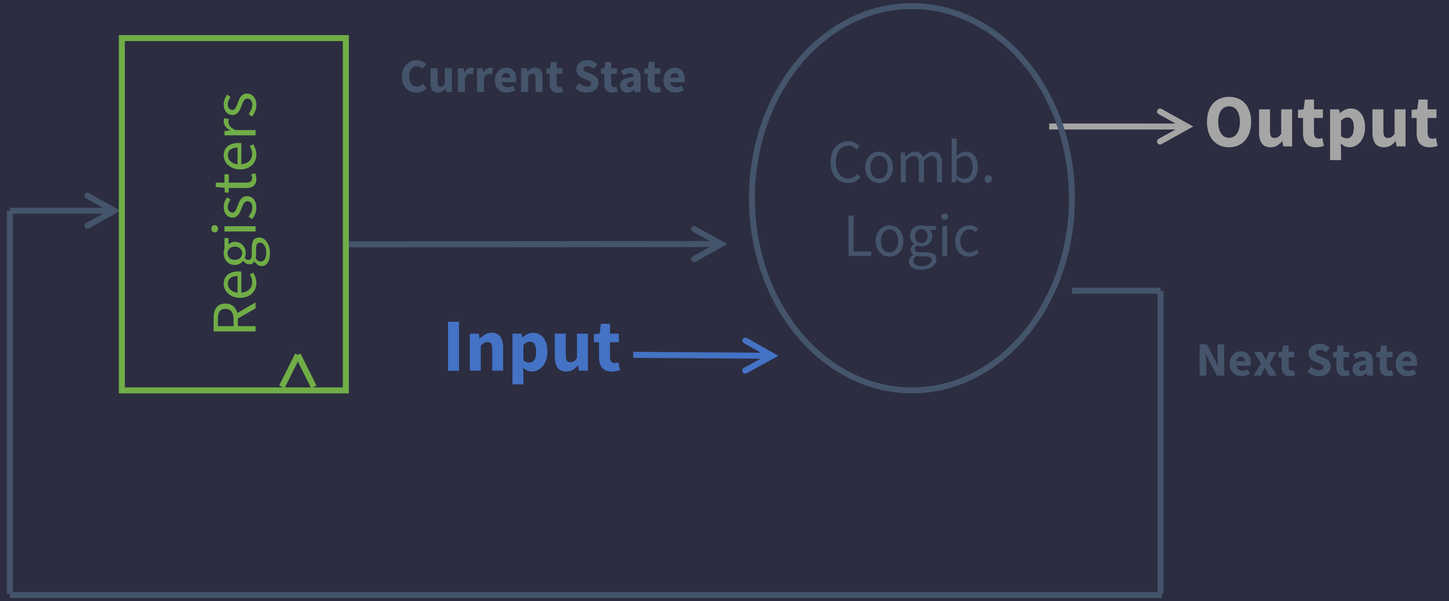

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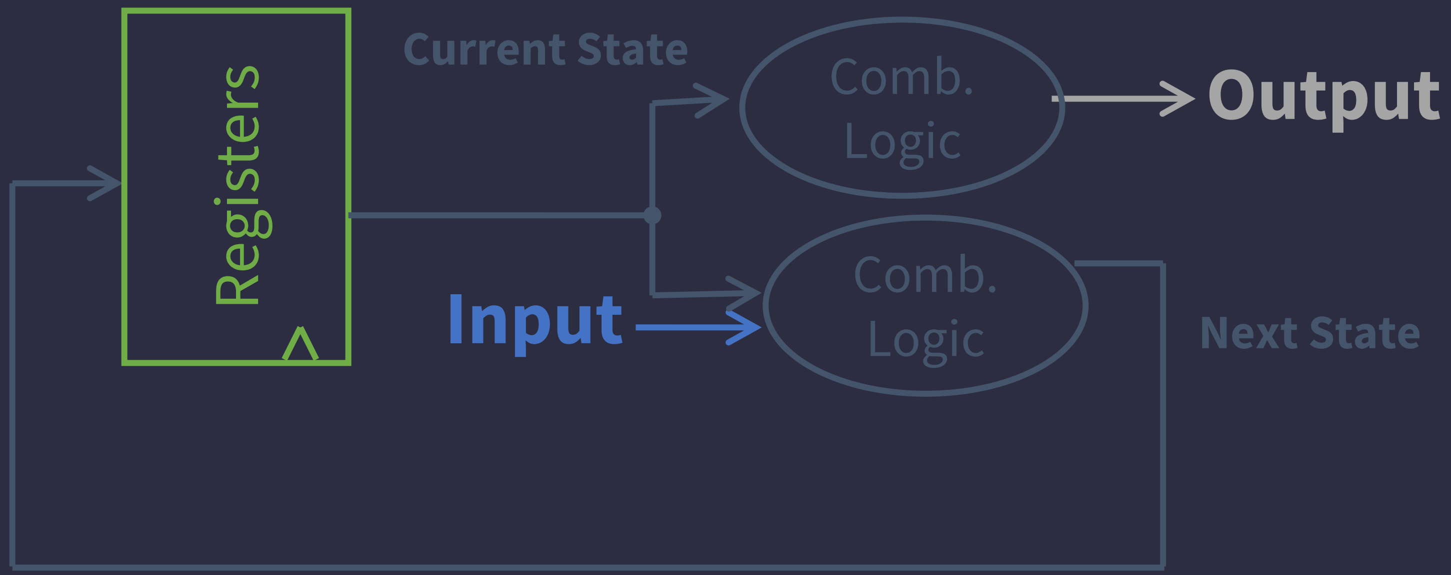
Special Case: Moore Machine



Outputs depend only on current state