LUND UNIVERSITY

EITF35: Introduction to Structured VLSI Design

Part 1.2.1: Finite State Machines

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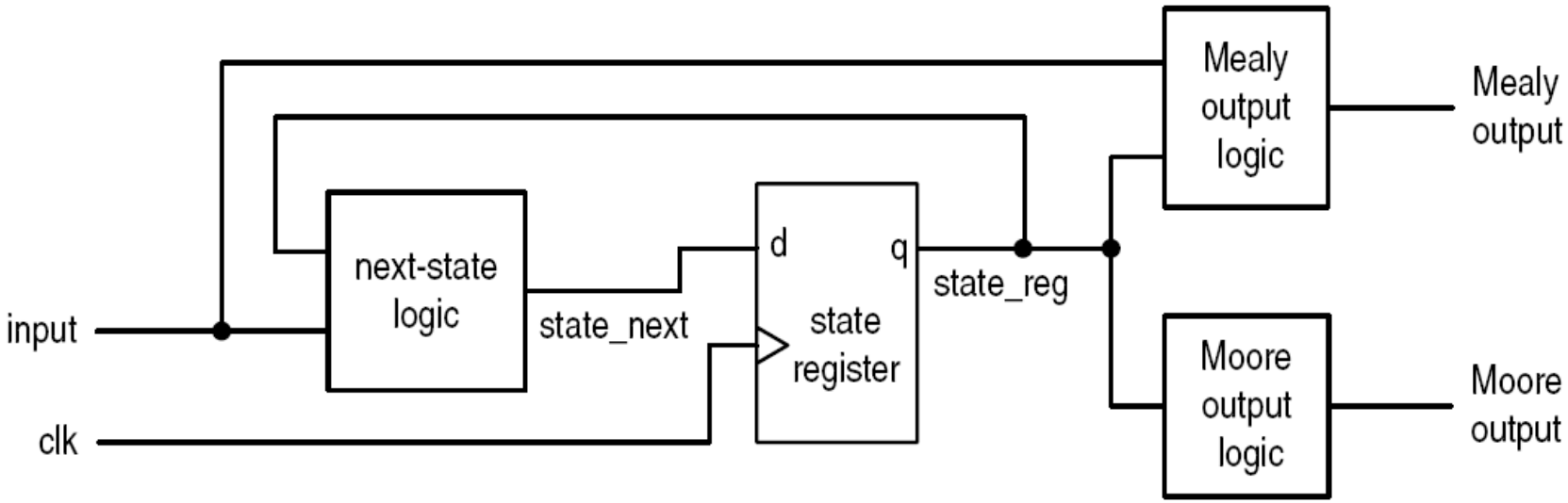
Outline

- FSM Overview
- FSM Representation
  - examples
- Moore vs. Mealy Machine
- Exercise

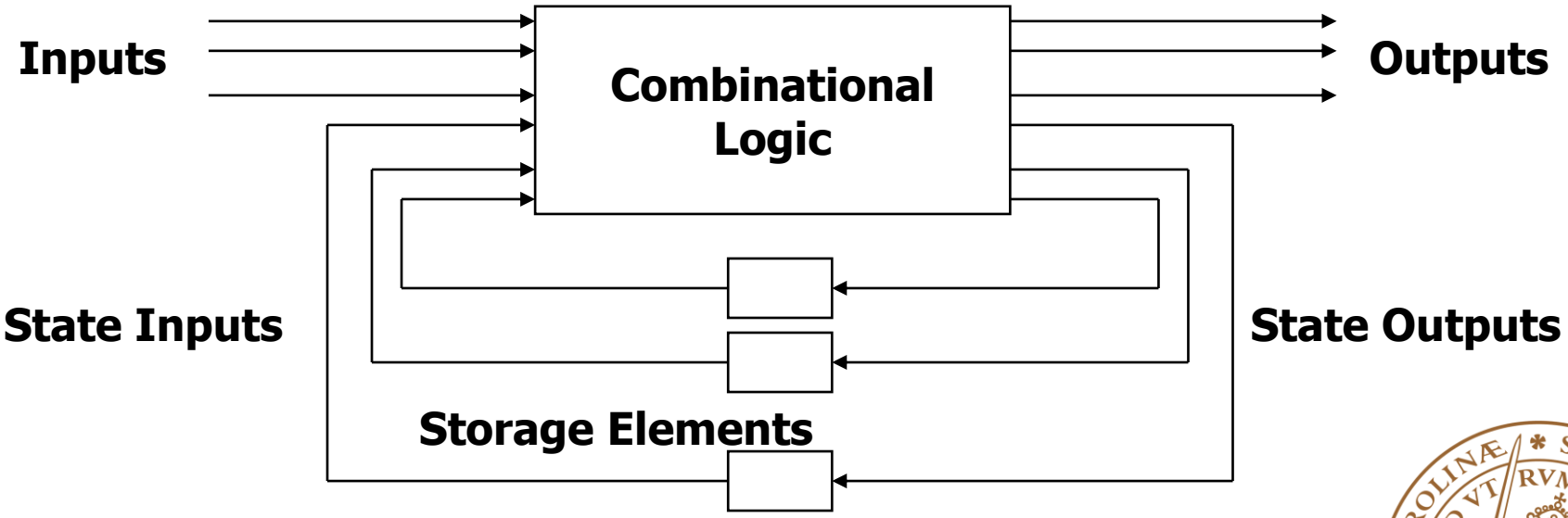
FSM Overview

- It has at most a finite number of states
- Models for representing sequential circuits
- Used mainly as a controller in a large system
- Moore vs. Mealy machines



Abstraction of state elements

- A FSM consists of several states. Inputs into the machine are combined with the *current state* of the machine to determine the new state or *next state* of the machine.
- Depending on the state of the machine, outputs are generated based on either the state or the state and inputs of the machine.
- Divide circuit into combinational logic and state



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- FSM Overview
- **FSM Representation**
- Moore vs. Mealy Outputs
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FSM Representation

- Can be represented using a state transition table which shows the *current state*, *input*, any *outputs*, and the *next state*.

Input / Current State	$Input_0$	$Input_1$	....	$Input_n$
$State_0$	Next State / Output		....	Next State / Output
$State_1$	....	....		....
....	....	....		....
$State_n$	....	....		....

FSM Representation

- **It can also be represented using a *state diagram* which has the same information as the state transition table.**

- **Mealy Output**

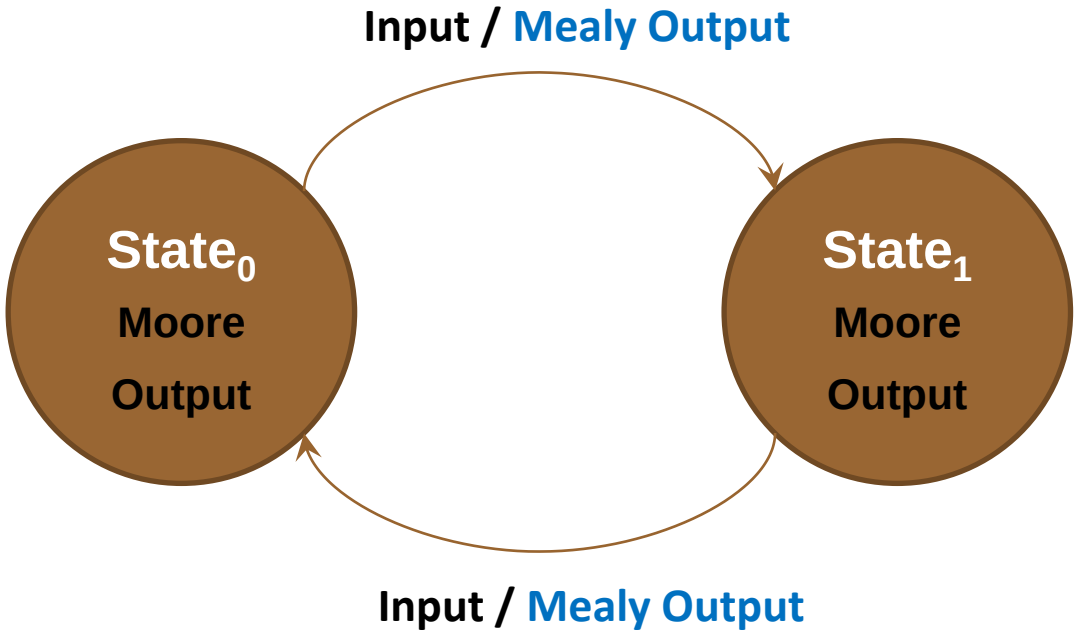
Outputs =F(*Inputs*, *Current state*)

Next state = F(*Inputs*, *Current state*)

- **Moore Output**

Outputs = F(*Current state*)

Next state = F(*Inputs*, *current state*)



Example 1: A Mod-4 Synchronous Counter

- **Function: Counts from 0 to 3 and then repeats.**
- **It has a clock (*CLK*) and a *RESET* input.**
- **Outputs appear as a sequence of values (q1 and q0)**
- **As the outputs are generated, a new state (s1 s0) is generated which takes on values of 00, 01, 10, and 11.**

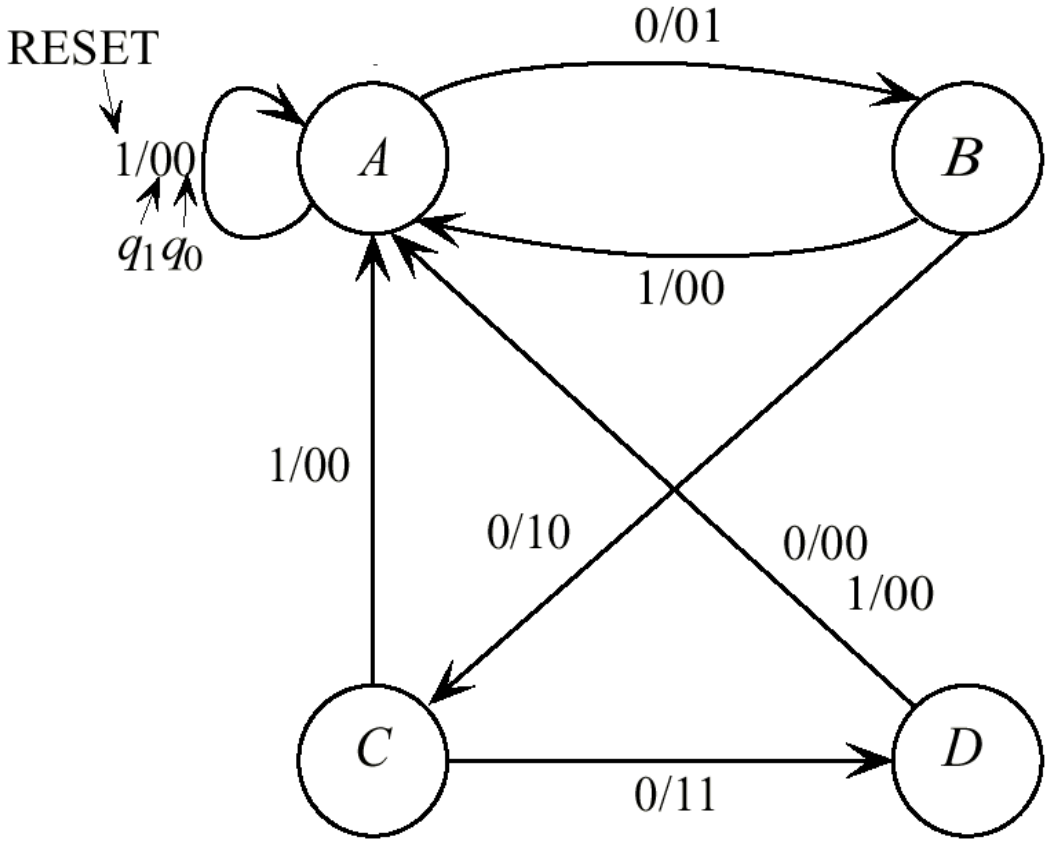
State Transition Table of Mod-4 Counter

Present state (S_t) \ Input	*RESET* 0	*RESET* 1
A:00	01/01	00/00
B:01	10/10	00/00
C:10	11/11	00/00
D:11	00/00	00/00

Next State

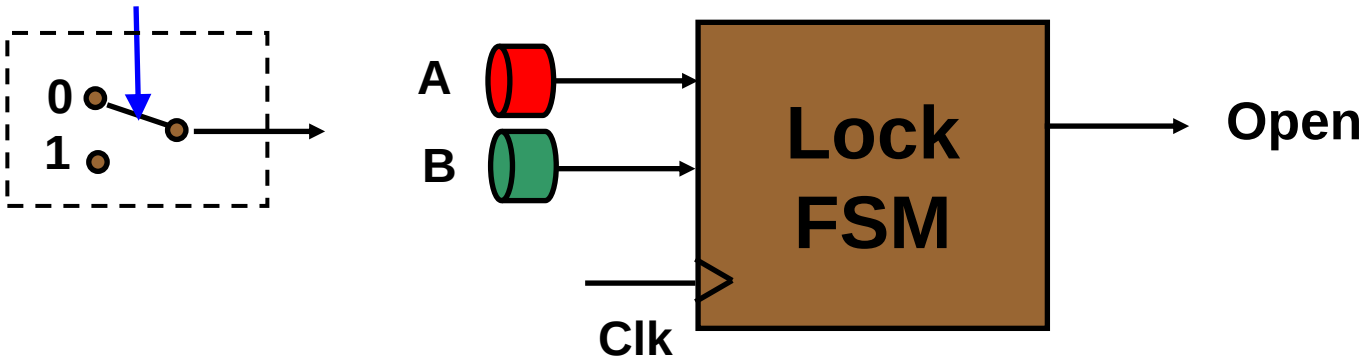
Output

State Transition Diagram for the Mod-4 Counter



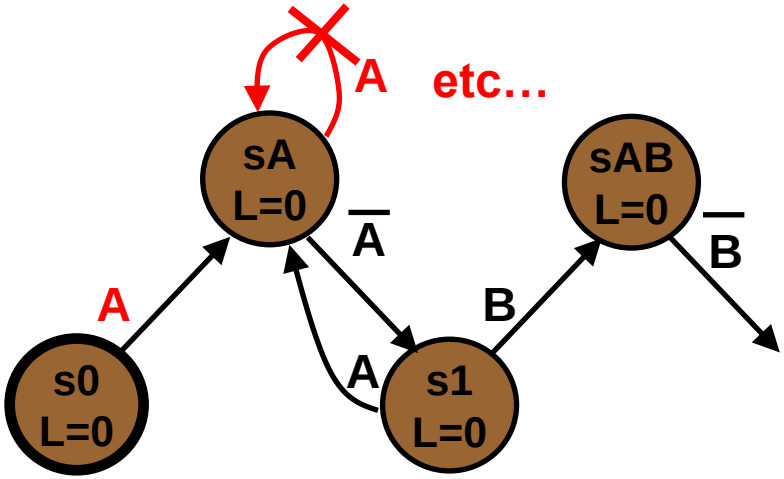
Example 2: Lock

- Pushing: * { A; B; B; A } => Open
  - A & B never push at the same time
  - Have to release the button before next pushing



State Diagram for lock-FSM

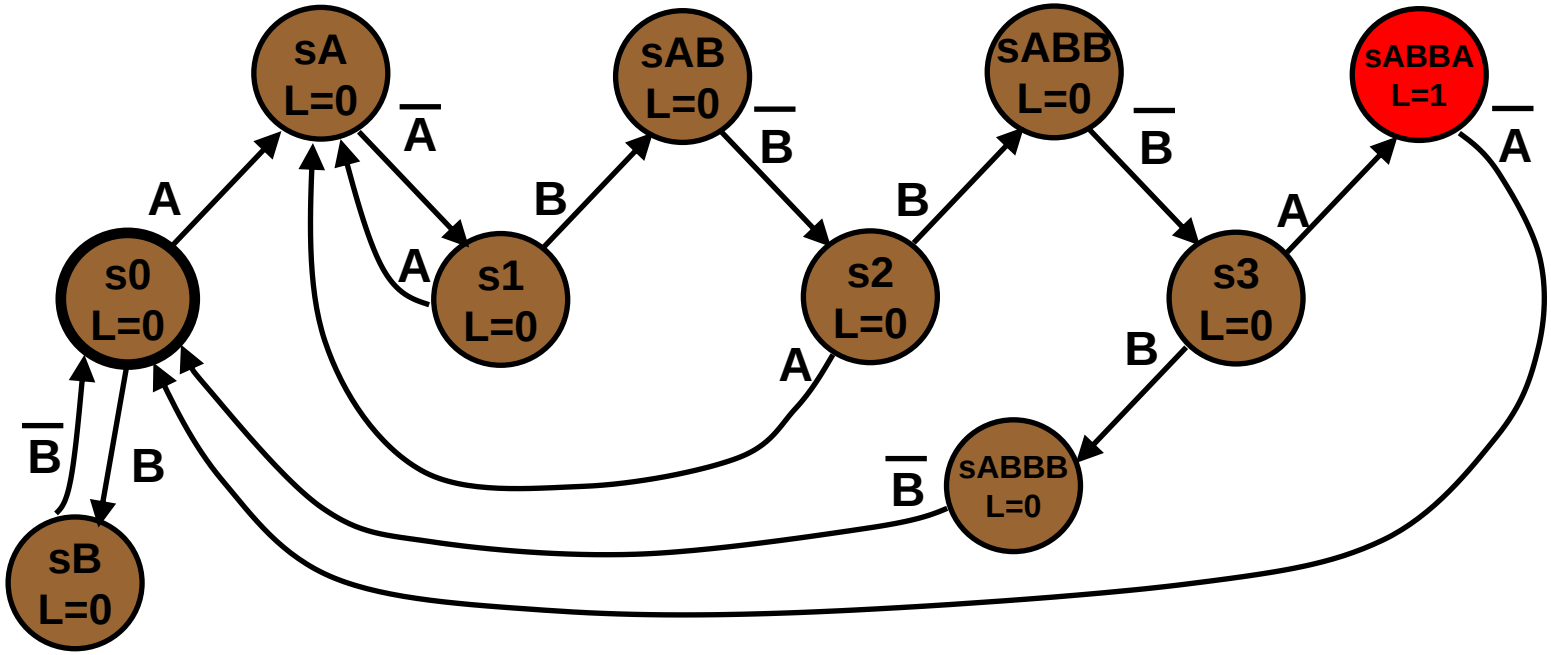
- A and B are never pressed at the same time …
- Debounce before next pushing



Finish the state graph for the Lock-FSM (5min)

State Diagram for lock-FSM

- A and B are never pressed at the same time …
- Debounce before next pushing



Hmmm: Is this a Mealy FSM or a Moore FSM?

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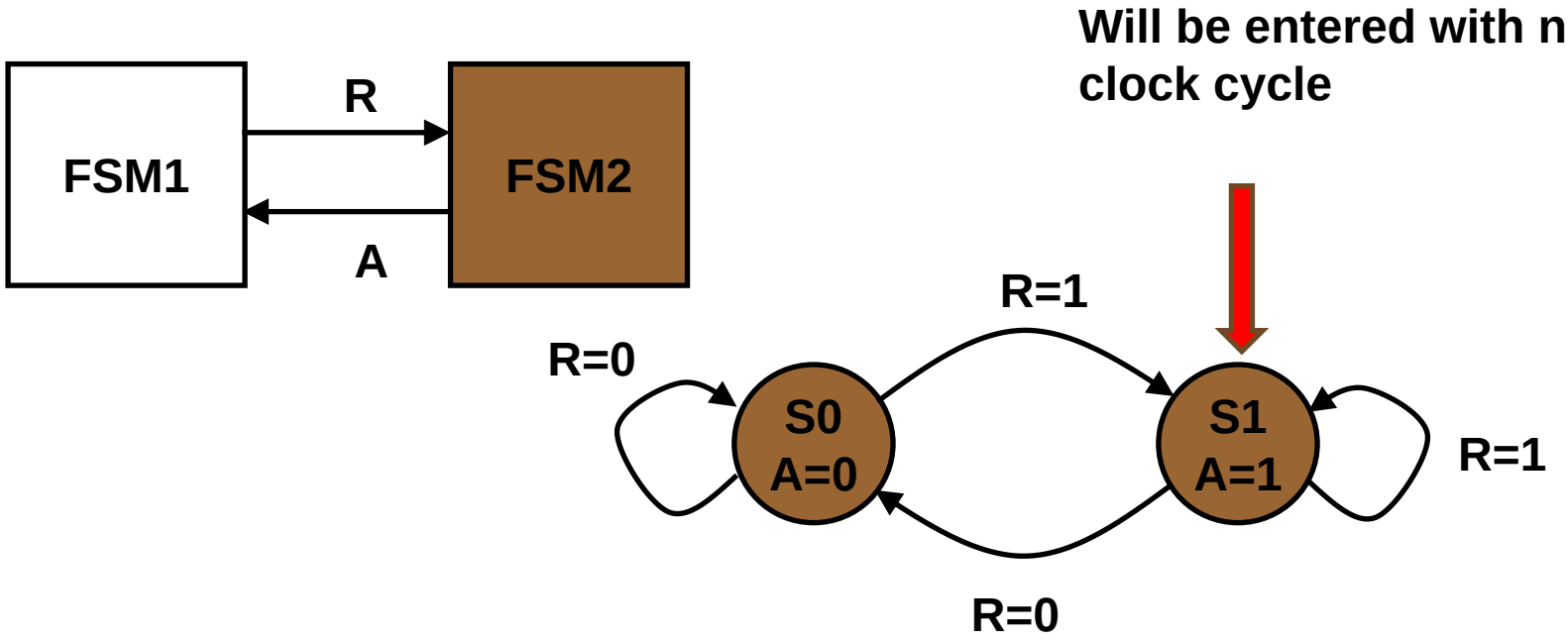
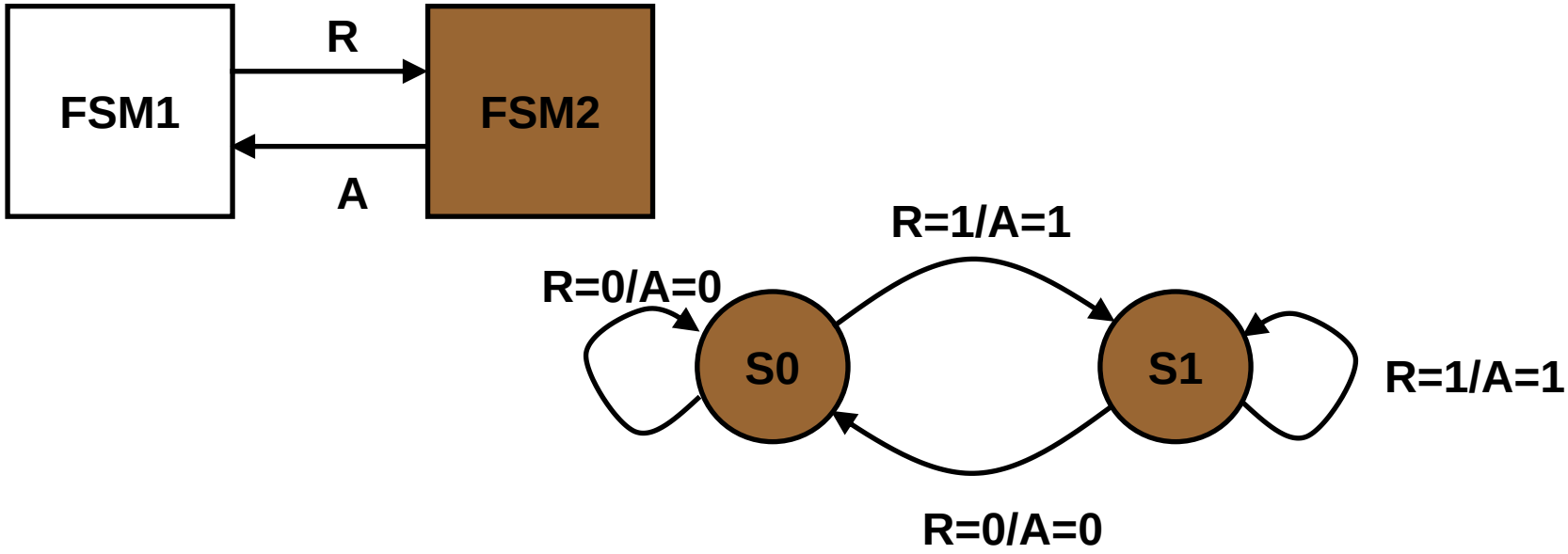
Output Timing: Moore



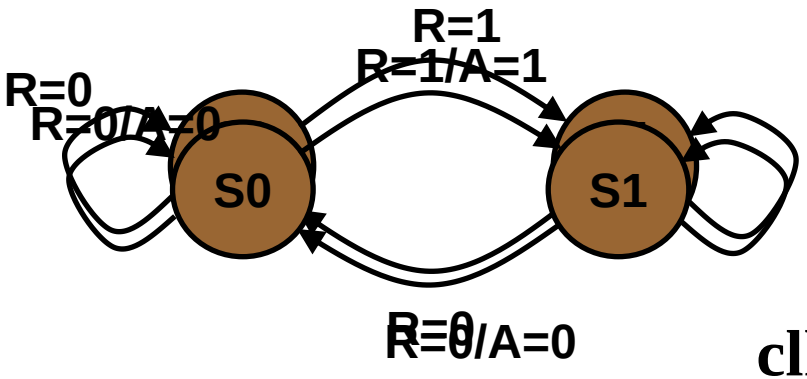
- … a Moore machine is not able to produce A->1 until the next clock when it enters s1

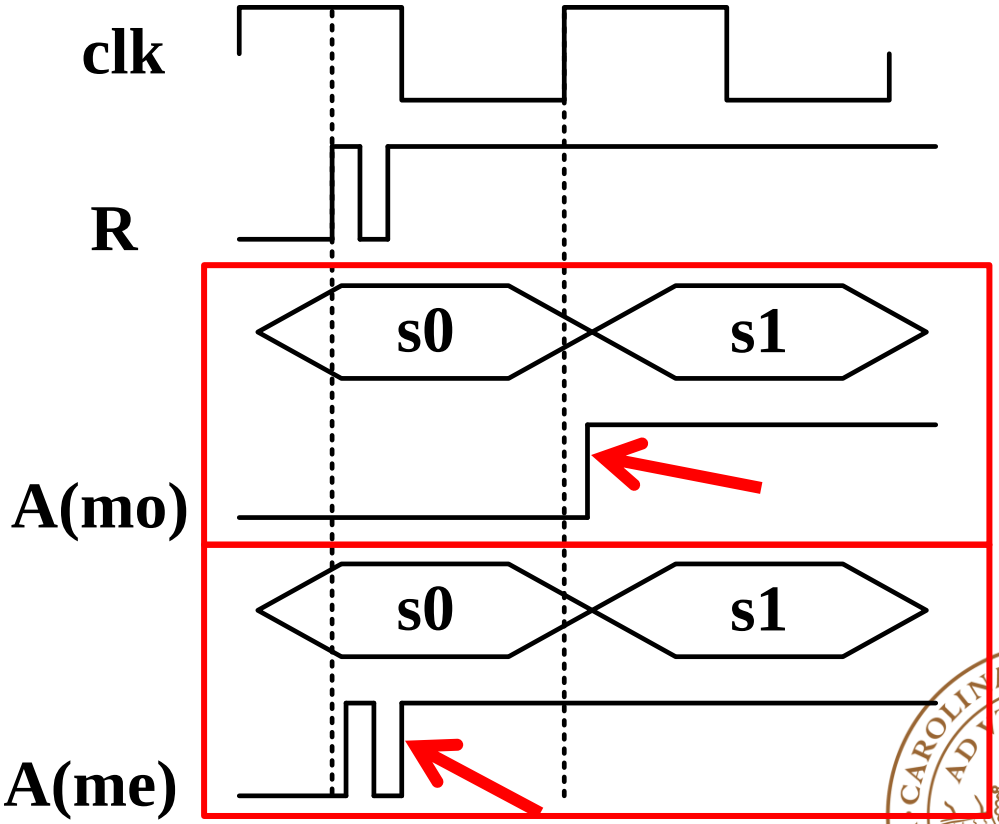
Output Timing: Mealy



- When in s0, a Mealy machine may produce A->1 immediately in response to R->1

Output Timing: Moore and Mealy

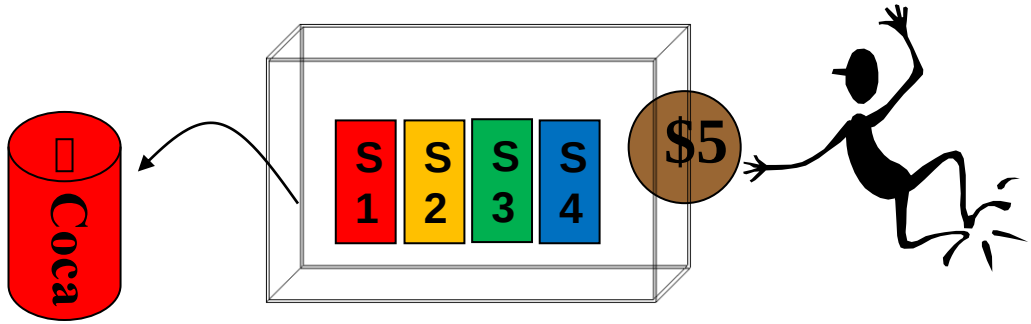




Moore vs. Mealy (summary)

- A Moore machine produces glitch free outputs.
- A Moore machine produces outputs depending only on states, and in some situations this may allow using a faster clock.
- A Mealy machine can be specified using less states because it is capable of producing different outputs in a given state.
- A Mealy machine can be faster because an output may be produced immediately instead of at the next clock tick.
- Which one is better?
  - Edge sensitive control
    - *E.g., enable signal of counter*
    - *Both can be used but Mealy is faster*
  - Level sensitive control
    - *E.g., write enable signal of SRAM*
    - *Moore is preferred*

FSM Homework: *Vending Machine*



Operation of Vending Machine

- When the user puts in money, money counter tells the control unit, the amount of money inserted in the Vending Machine.
- When the user presses the button to purchase the item that he wants, the control unit dispenses the product if correct amount is inserted.
- If there is any change, machine will return it to the user.

Select Bottom	Product	Price
S1	Snakes	10
S2	Coffee	15
S3	Cold Drink	20
S4	Candies	20

Coins
1 SEK
5 SEK
10 SEK

?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