Finite State Machine

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Part of slides adopted from Hung-Wei Tseng

Recap: Combinational v.s. sequential logic

- Combinational logic
  - The output is a pure function of its current inputs
  - The output doesn't change regardless how many times the logic is triggered — Idempotent
- Sequential logic
  - The output depends on current inputs, previous inputs, their history

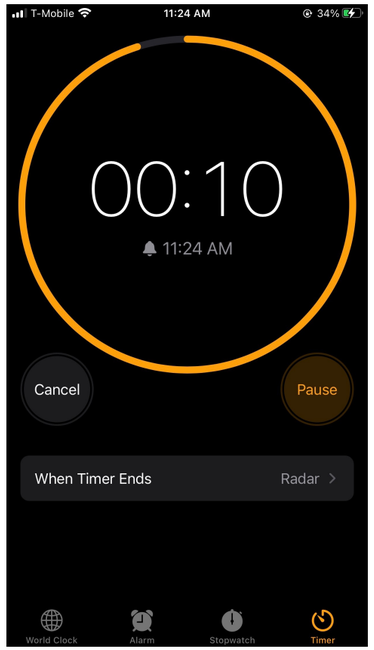
Sequential circuit has memory!

Recap: Theory behind each

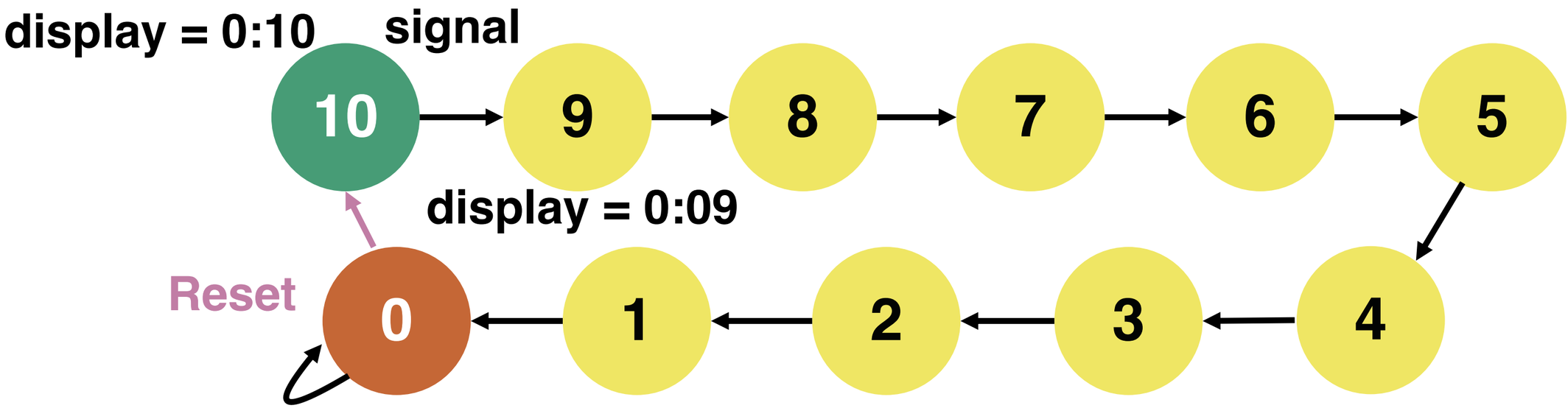
- A **Combinational logic** is the implementation of a **Boolean Algebra** function with only Boolean Variables as their inputs
- A **Sequential logic** is the implementation of a **Finite-State Machine**

Count-down Timer

Initial state



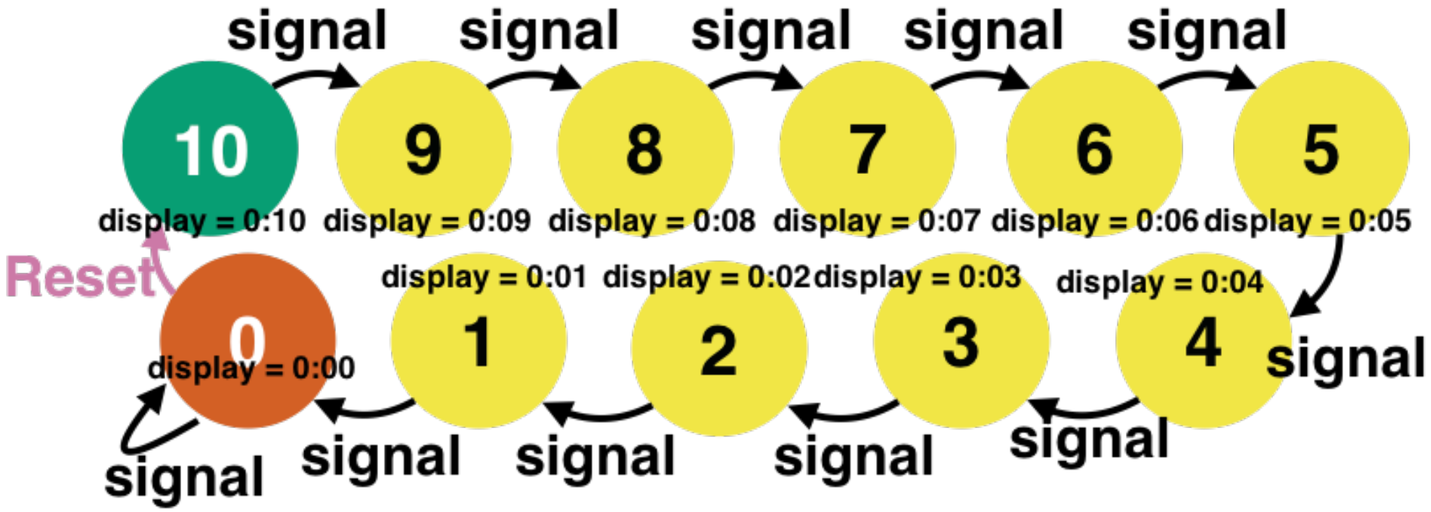
- What do we need to implement this timer?
  - Set an initial value/“state” of the timer
  - “Signal” the design every second
  - The design changes its “state” every time we received the signal until we reaches “0” — the final state



Finite State Machines

- FSM consists of
  1. Set of states
  2. Set of inputs, set of outputs
  3. Initial state
  4. Set of transitions
     - Only one can be true at a time
- FSM representations:
  1. State diagram
  2. State table

State diagram



CurrentState	Next State Signal	
	0	1
10	10	9
9	9	8
8	8	7
7	7	6
6	6	5
5	5	4
4	4	3
3	3	2
2	2	1
1	1	0
0	0	0

State table

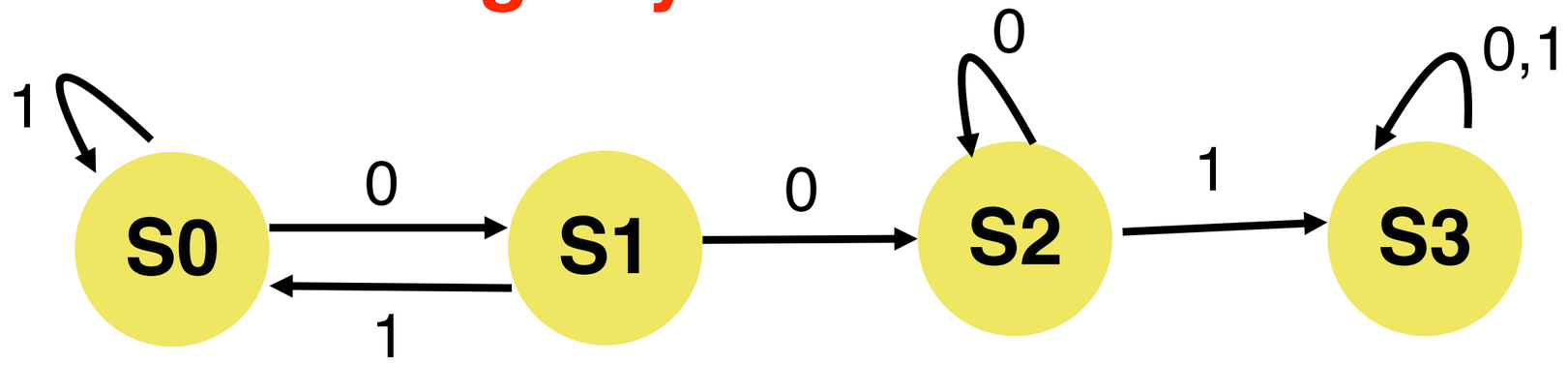
Outline

- Finite State Machines
- The Basic Form of Memory
- Clock

Finite-State Machines (cont.)

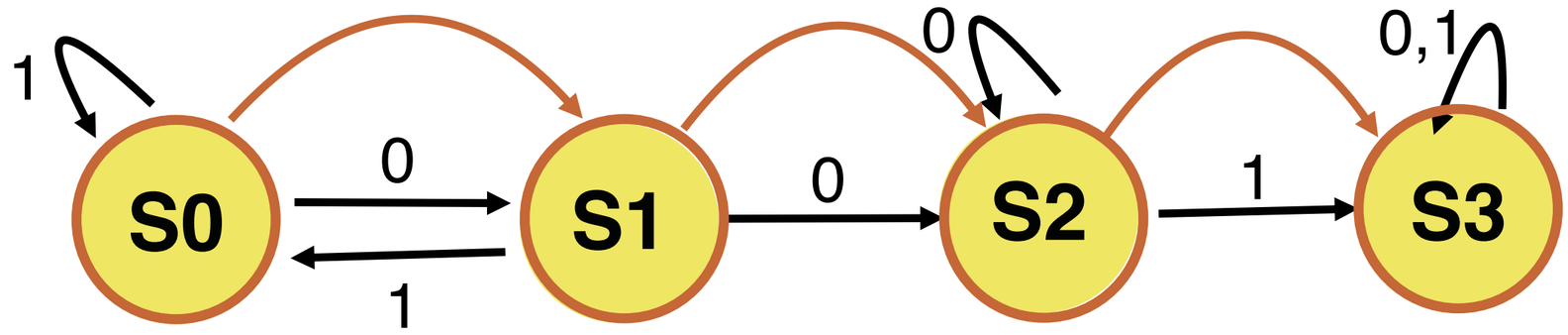
POLL-1

What is the longest string this FSM can recognize without visiting any state more than once?



A. 1
B. 2
C. 3
D. 4
E. None of the above

What is the longest string this FSM can recognize without visiting any state more than once?



A. 1

B. 2

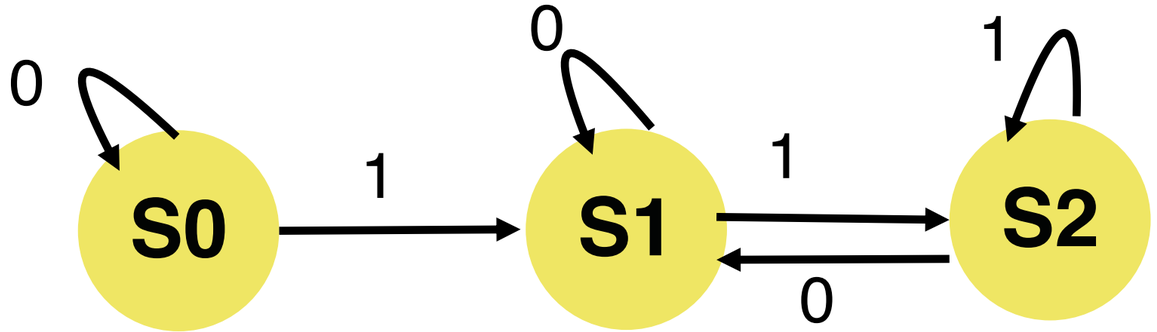
C. 3

D. 4

E. None of the above

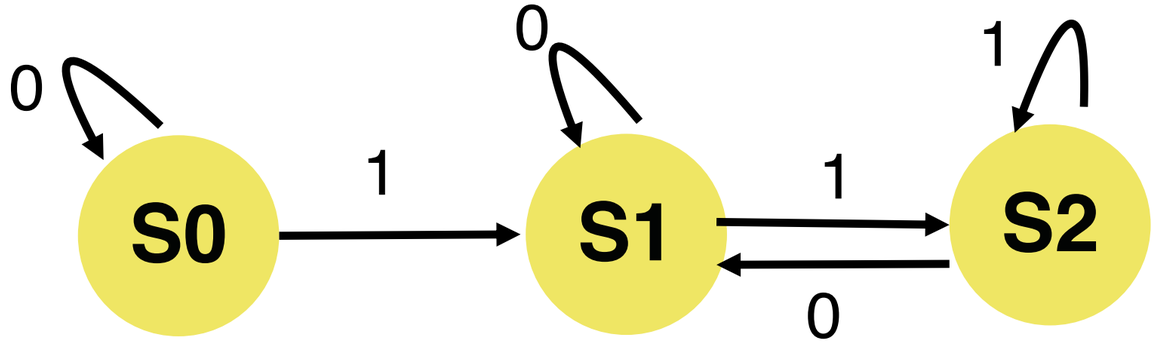
POLL-2

What is the longest string this FSM can recognize without visiting any state more than once?



A. 1
B. 2
C. 3
D. 4
E. None of the above

What is the longest string this FSM can recognize without visiting any state more than once?



A. 1

B. 2

C. 3

D. 4

E. None of the above

Life on Mars

- Mars rover has a binary input x. When it receives the input sequence x(t-2 : t) = 001 from its life detection sensors, it means that the it has detected life on Mars and the output y(t) = 1, otherwise y(t) = 0 (no life on Mars).
- This pattern recognizer should have
  A. One state because it has one output
  B. One state because it has one input
  C. Two states because the input can be 0 or 1
  D. More than two states because ….

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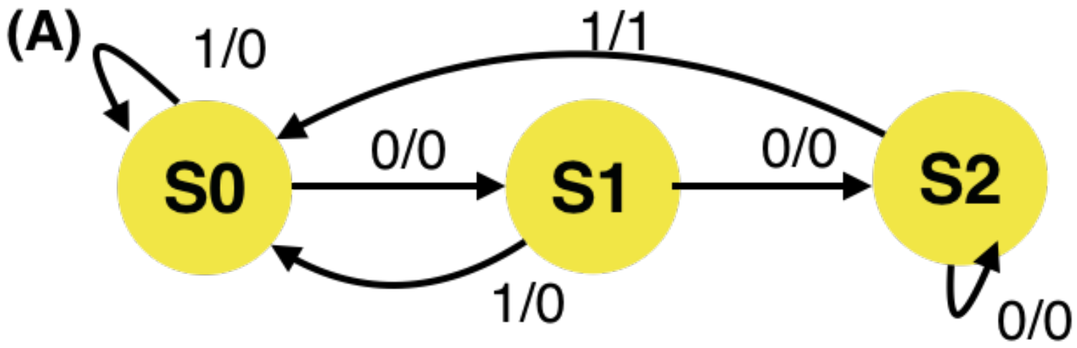
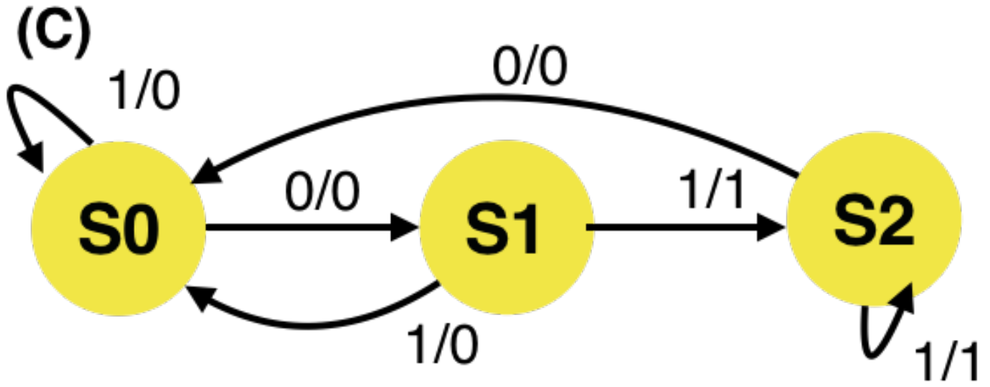
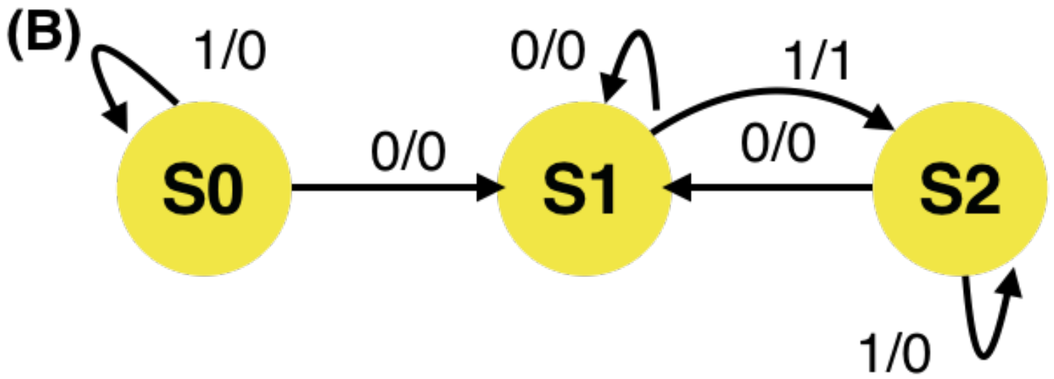
FSM for Life on Mars

1/0 == Input 1/Output 0

- Which of the following diagrams is a correct FSM for the 001 pattern recognizer on the Mars rover? (If sees “001”, output “1”)







(D) All are correct

(E) None is correct

FSM for Life on Mars

1/0 == Input 1/Output 0

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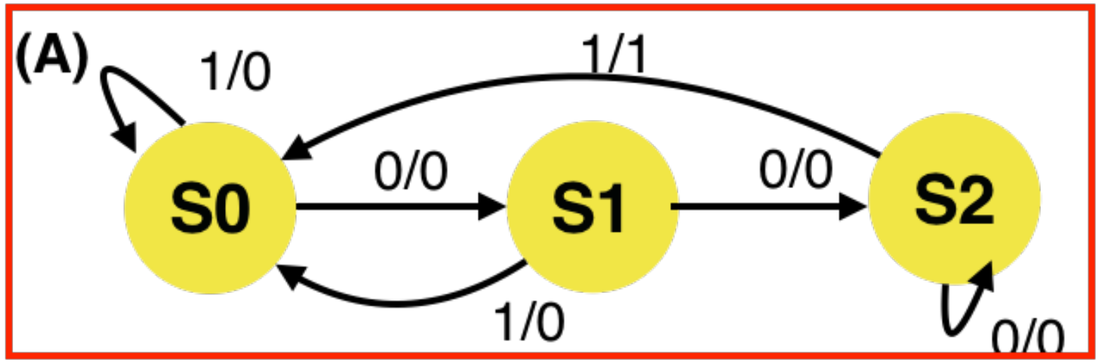
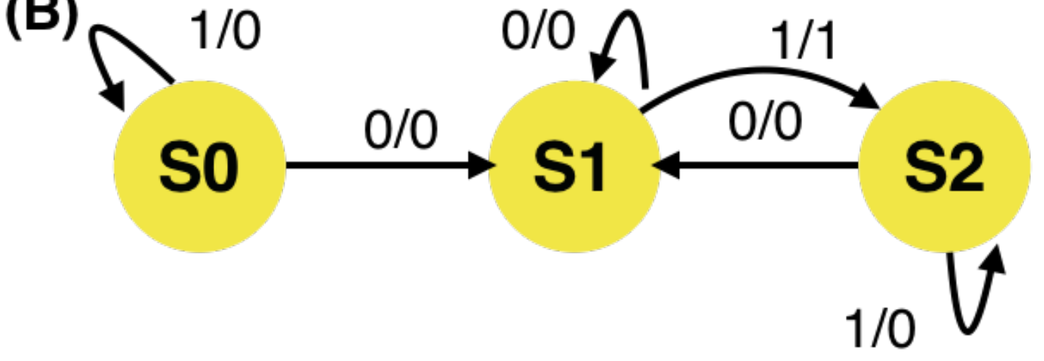
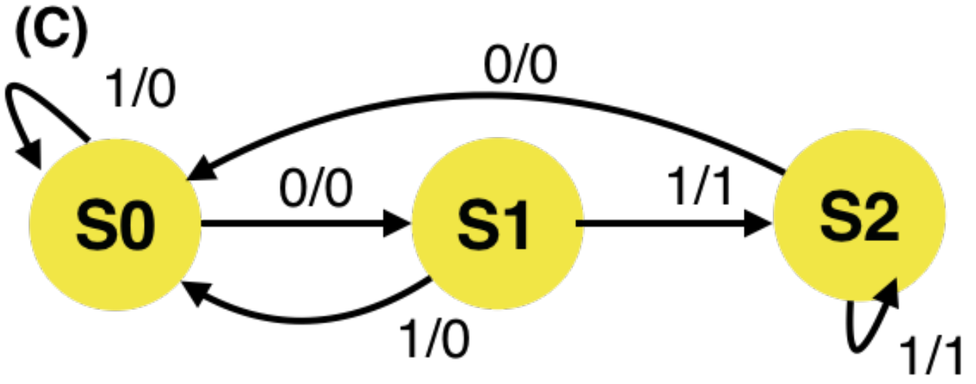
(A)



(B)



(C)

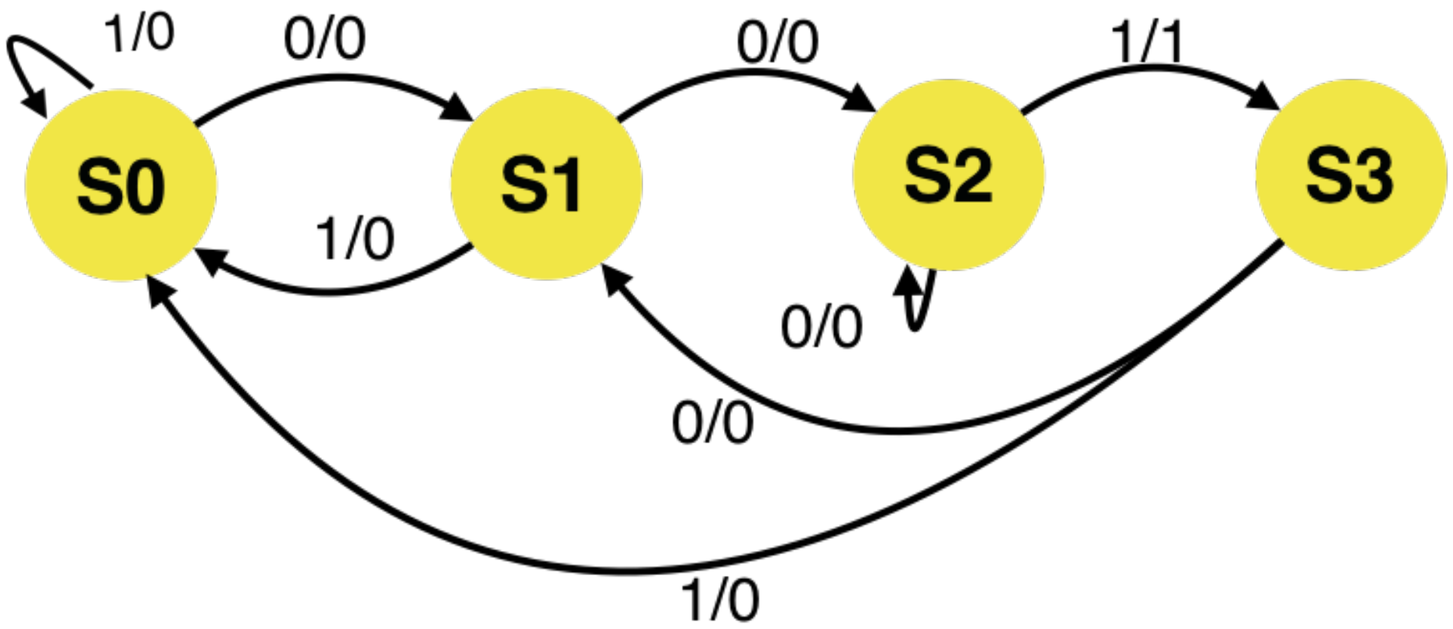


(D) All are correct

(E) None is correct

Alternative FSM for Life on Mars

If sees ‘001’, output ‘1’

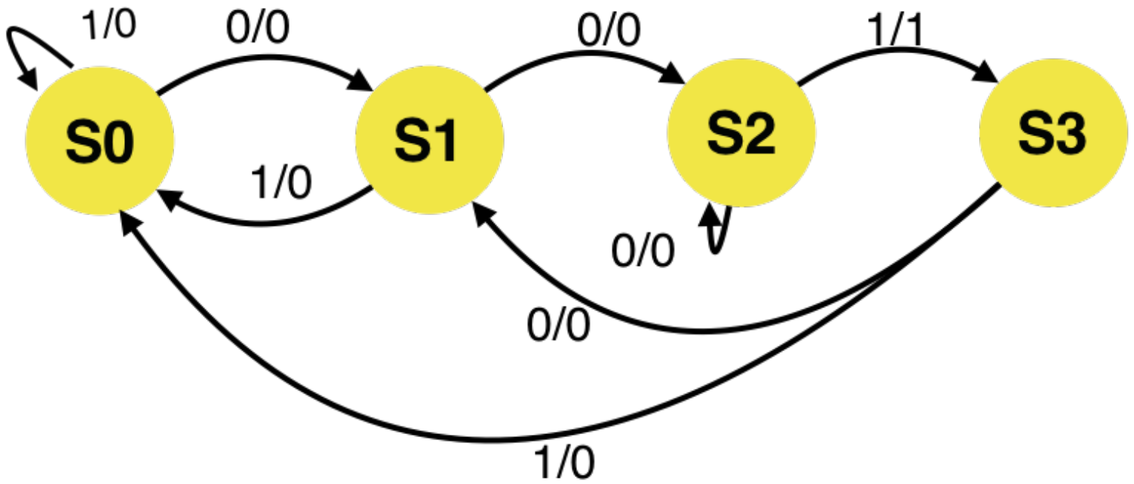


All the outputs of S3 are equal to S0!

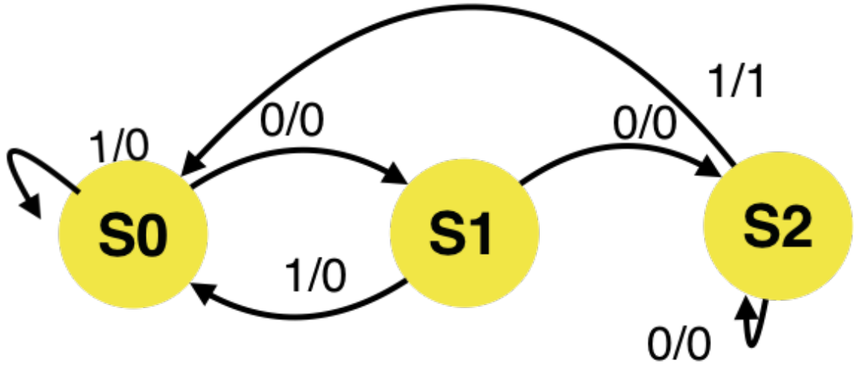
Merge S3 into S0

FSM for Life on Mars

Before the merging



After the merging



Merge S3 into S0

State Transition Table of Life on Mars

CurrentState	Next State	
	Input	
	0	1
S0 — something else	S1, 0	S0, 0
S1 — 0	S2, 0	S0, 0
S2 — 00	S2, 0	S3, 1
S3 — 001	S1, 0	S0, 0

POLL-3

FSM 101

- Mars rover has a binary input x. When it receives the input sequence x(t-2 : t) = **101** from its life detection sensors, it means that the it has detected life on Mars and the output y(t) = 1, otherwise y(t) = 0 (no life on Mars).
- How many states in the FSM of the pattern recognizer should have
  A. 1
  B. 2
  C. 3
  D. 4
  E. None of the above

State Transition Table of Life on Mars

CurrentState	Next State	
	Input	
	0	1
S0 — something else	S0, 0	S1, 0
S1 — 1	S2, 0	S1, 0
S2 — 10	S0, 0	S3, 1
S3 — 101	S2, 0	S1, 0

FSM 101

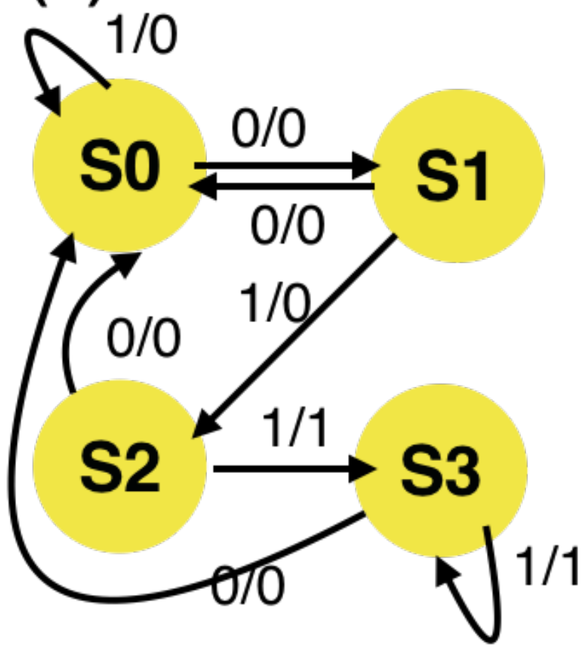
- Mars rover has a binary input x. When it receives the input sequence x(t-2, t) = **101** from its life detection sensors, it means that the it has detected life on Mars and the output y(t) = 1, otherwise y(t) = 0 (no life on Mars).
- How many states in the FSM of the pattern recognizer should have
  - A. 1
  - B. 2
  - C. 3
  - D. 4
  - E. None of the above

FSM 101

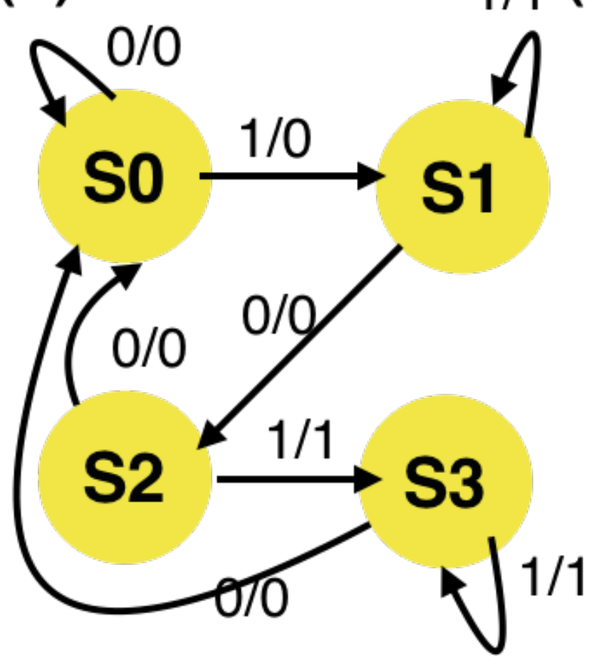
1/0 == Input 1/Output 0

- Which of the following diagrams is a correct FSM for the "101" pattern recognizer? (If sees "101", output "1")

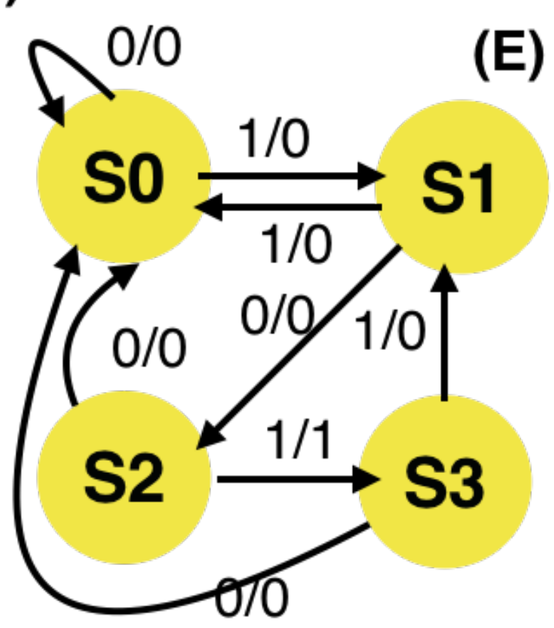
(A)



(B)



(C)



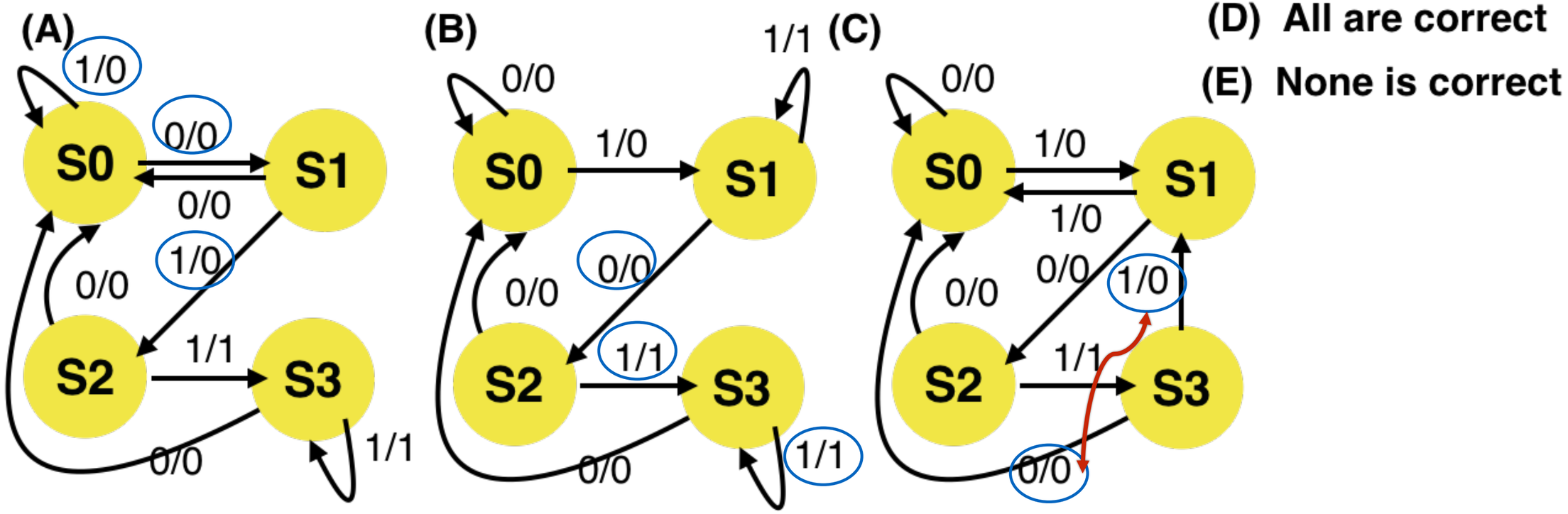
(D) All are correct

(E) None is correct

FSM 101

1/0 == Input 1/Output 0

- Which of the following diagrams is a correct FSM for the "101" pattern recognizer? (If sees "101", output "1")



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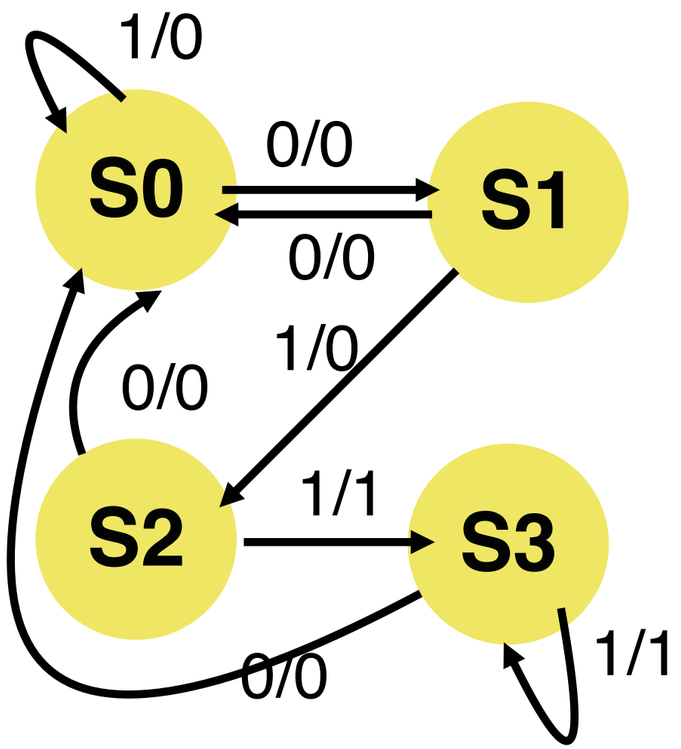
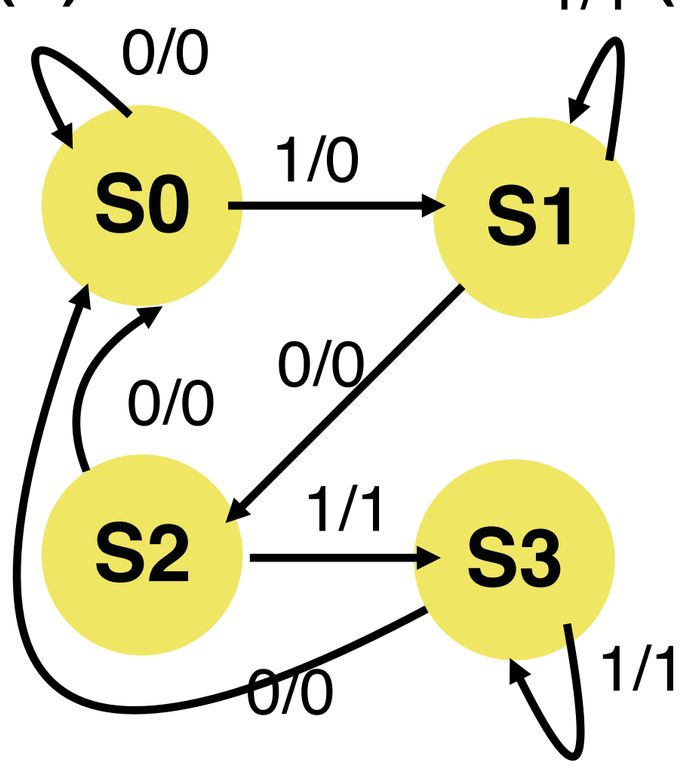
(A)



(B)



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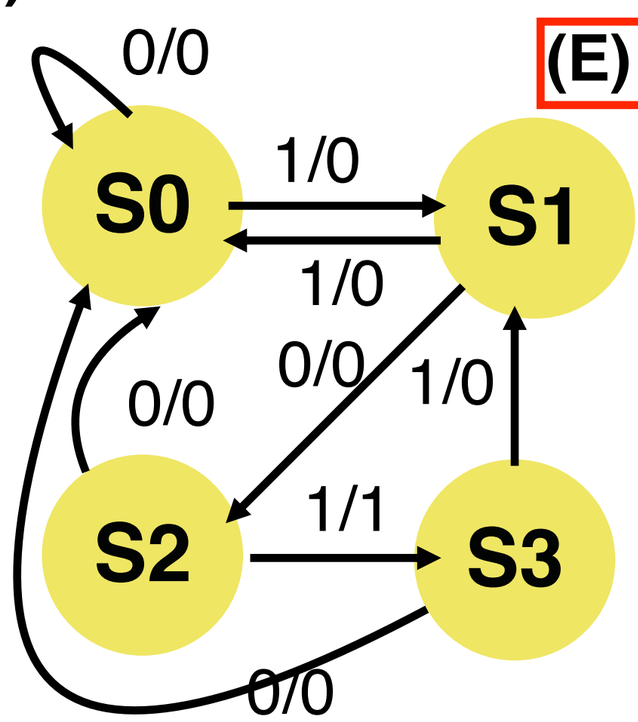

(D) All are correct

(E) None is correct

State Transition Table of FSM 111

CurrentState	Next State Input 0	 1
S0 — something else	S0, 0	S1, 0
S1 — 1	S0, 0	S2, 0
S2 — 11	S0, 0	S3, 1
S3 — 111	S0, 0	S3, 1