CPU ORGANIZATION

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Overview

- This lecture
  - Finite state machine
    - State representation/transition
    - Flip-flops and counters
  - Processor overview

State Representation

- Consider a light bulb with two states ON and OFF

OFF

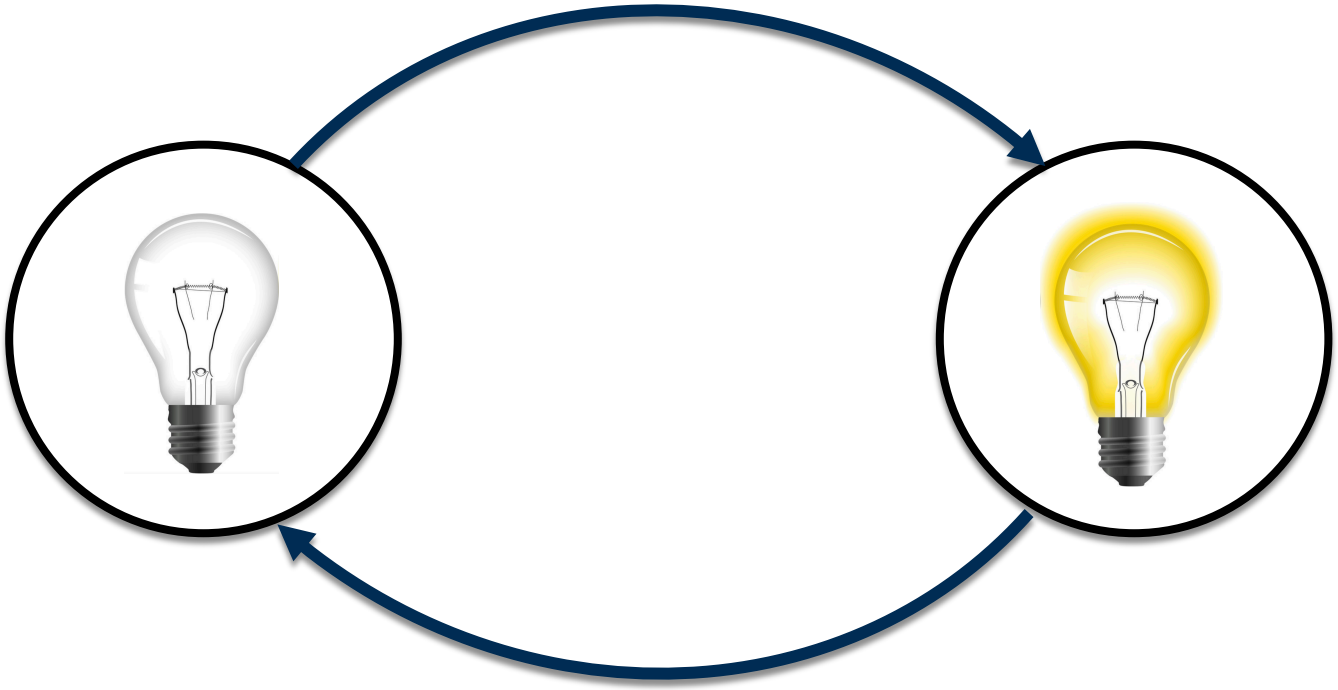
ON

State Representation

- Consider a light bulb with two states ON and OFF

State Transitions

- An input switch is used to transition between ON and OFF



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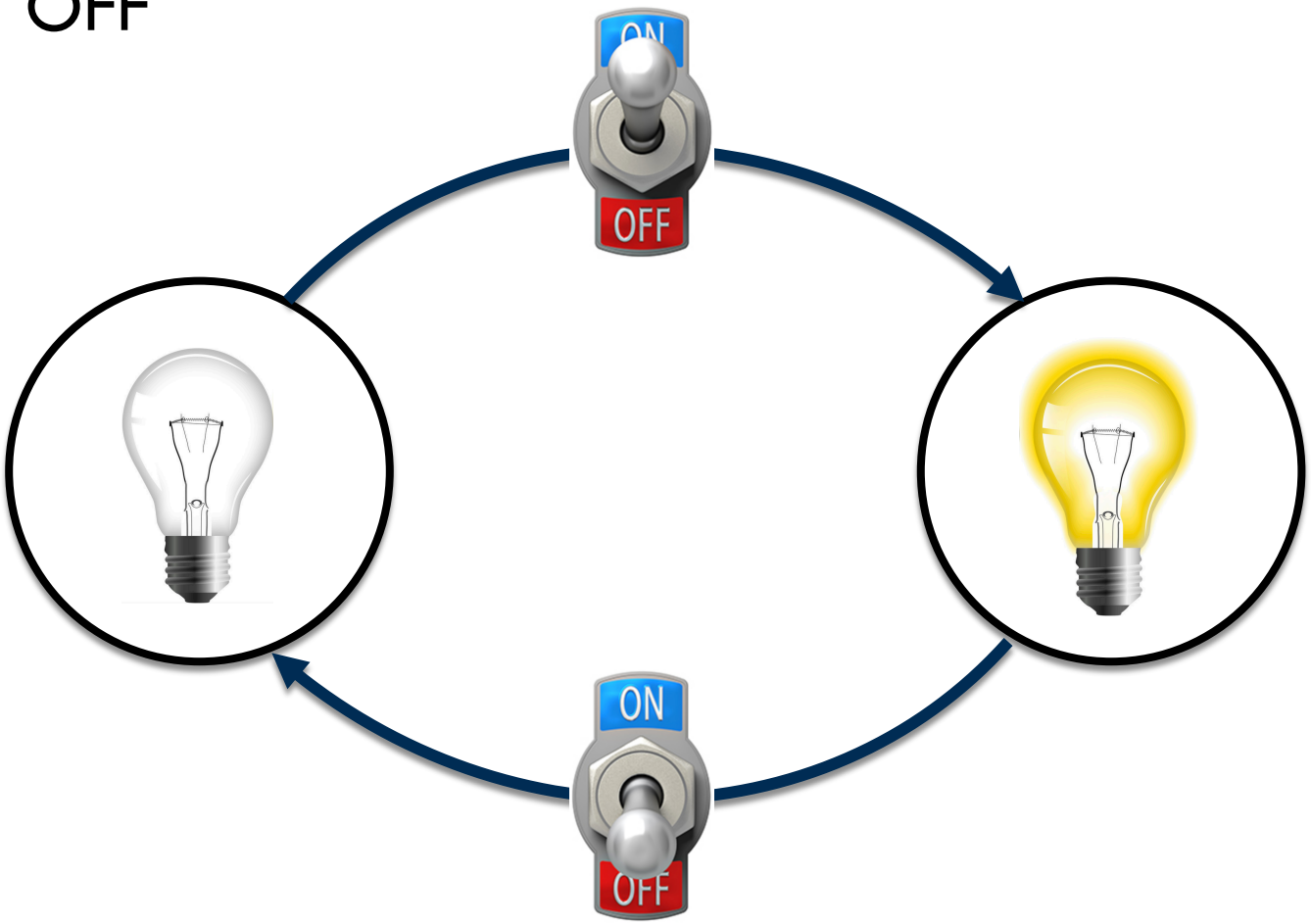
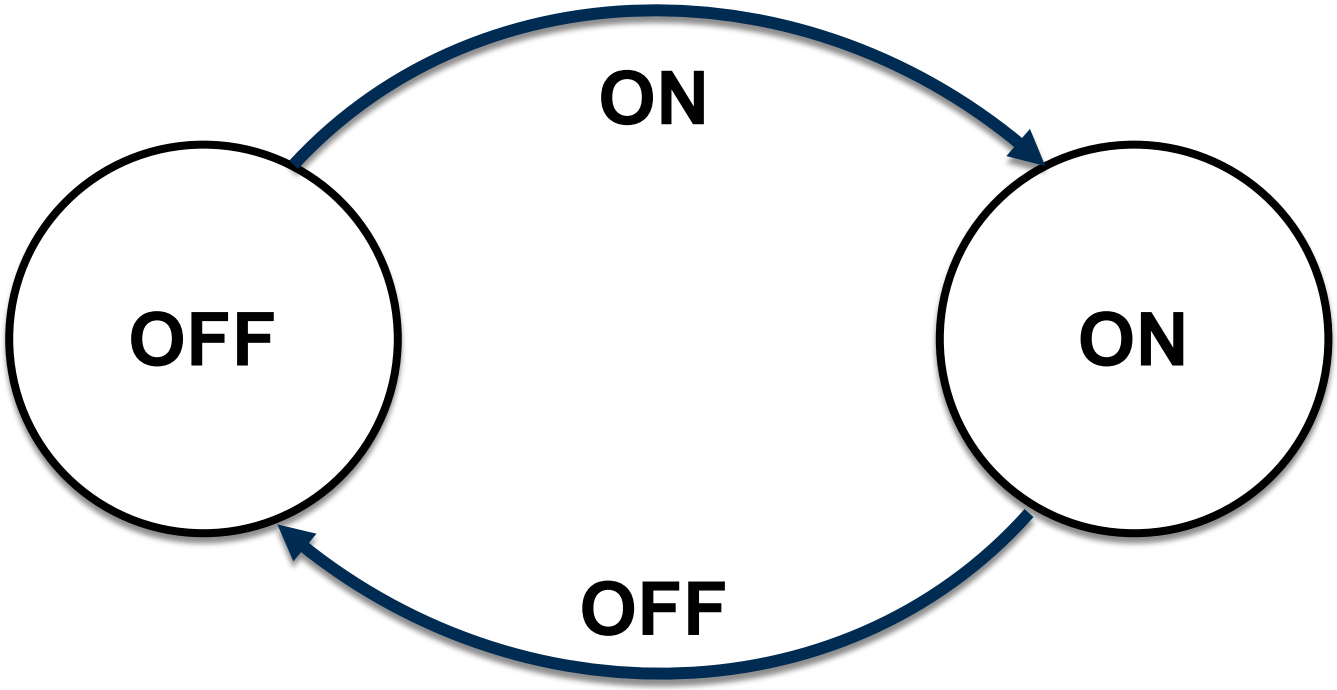


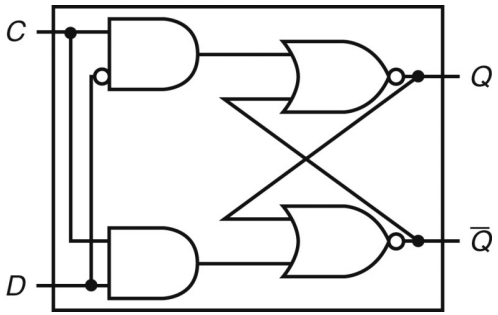
State Diagram

- A graphical representation of states and transitions.

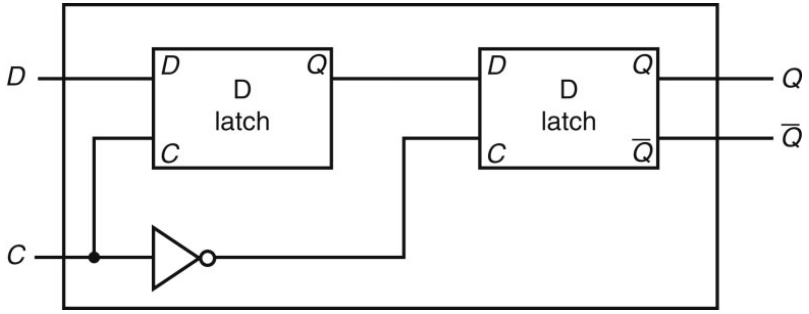


Key Memory Elements in CPU

- D-Latch: output can change any time the clock is asserted.



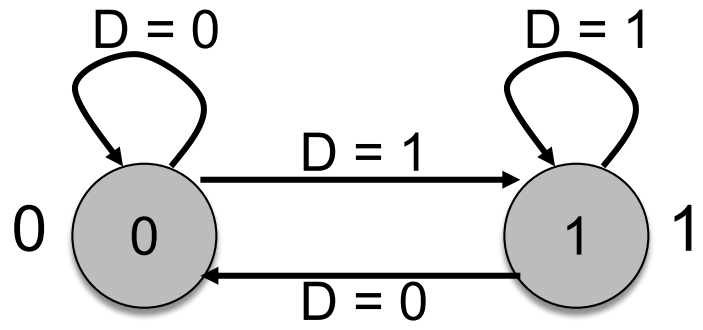
- D-Flip Flop: output can change only on a clock edge.



State Diagram

- Each state is shown with a circle, labeled with the state value
  - the contents of the circle are the outputs

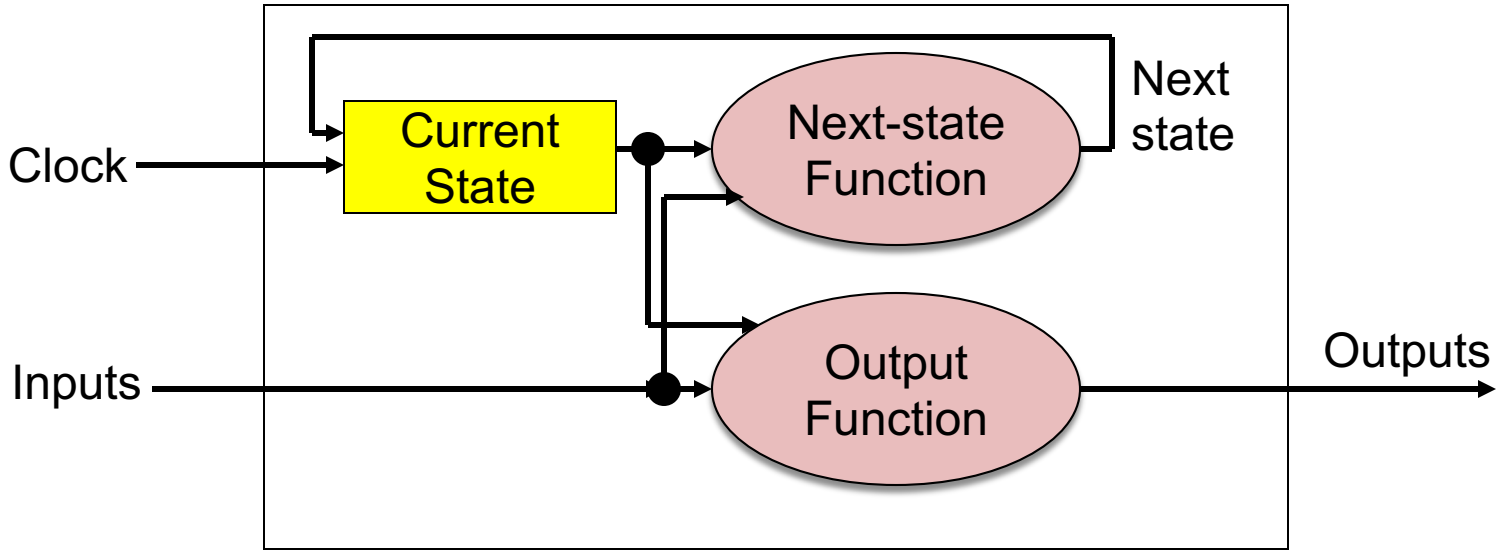
- An arc represents a transition to a different state, with the inputs indicated on the label



What is this state diagram for?

Finite State Machine

- A sequential circuit is described by a finite state diagram.
  - We use variation of a truth table for inputs and outputs
  - Note that state is updated only on a clock edge



Example: Counters

- Counters are an important class of finite state machines

- Design: a circuit that stores a 3-bit number and increments the value on every clock edge.
  - It starts again from 0 when reaching the largest value.
  - Draw the state diagram; how many states and inputs?

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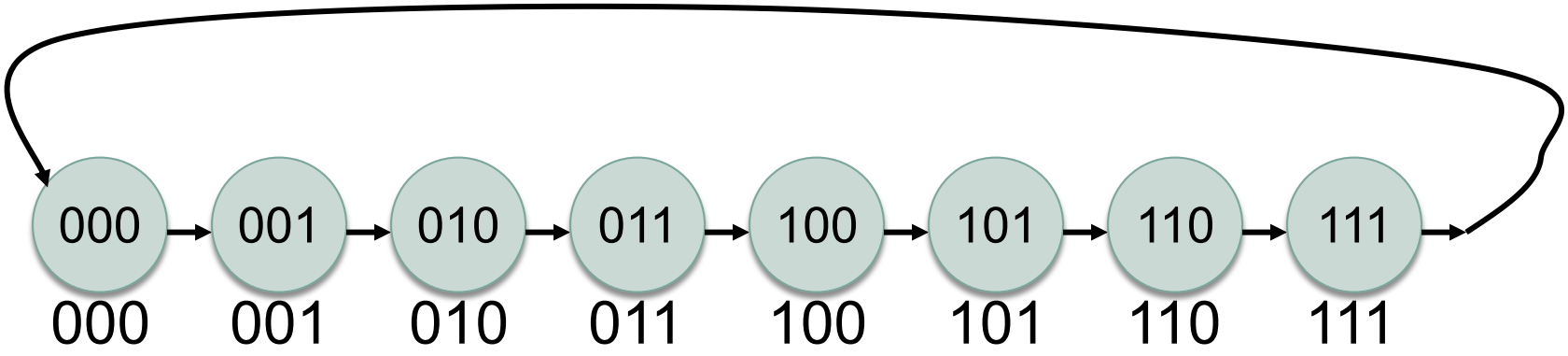

Example: Traffic Control Light

- A traffic light with only green and red; either the North-South road has green or the East-West road has green (both can't be red).

- Design: there are detectors on the roads to indicate if a car is on the road; the lights are updated every 30 seconds; a light need change only if a car is waiting on the other road
  - How many inputs, outputs, and states?

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State Transition Table:

CurrState	InputEW	InputNS	NextState=Output
N	0	0	N
N	0	1	N
N	1	0	E
N	1	1	E
E	0	0	E
E	0	1	N
E	1	0	E
E	1	1	N

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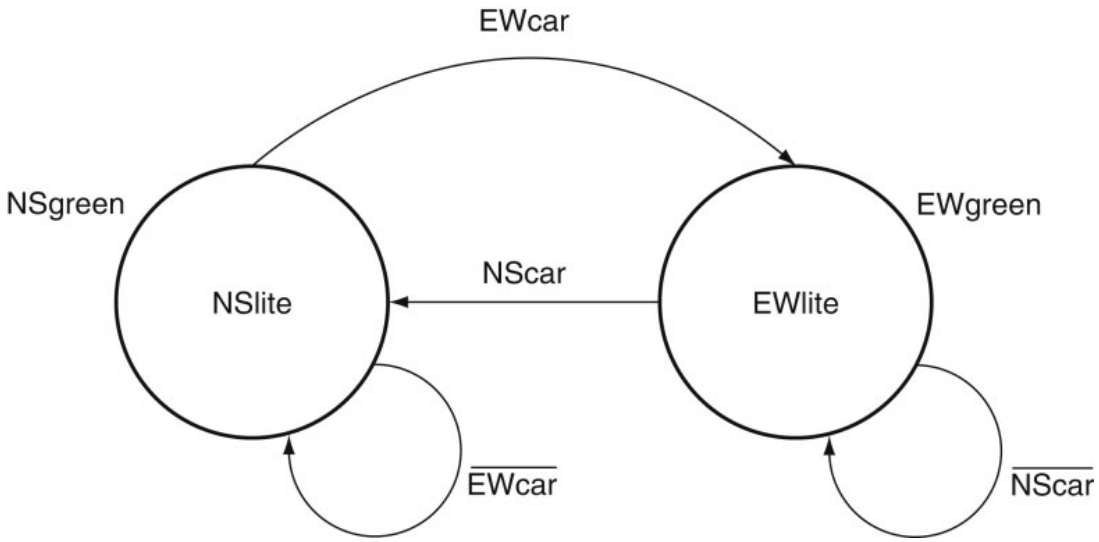


Who invented the traffic light?

- “The first electric traffic light using red and green lights was invented in 1912 by Lester Farnsworth Wire, a police officer in Salt Lake City, Utah, according to Family Search. Wire's traffic signal resembled a four-sided bird-house mounted on a tall pole.”

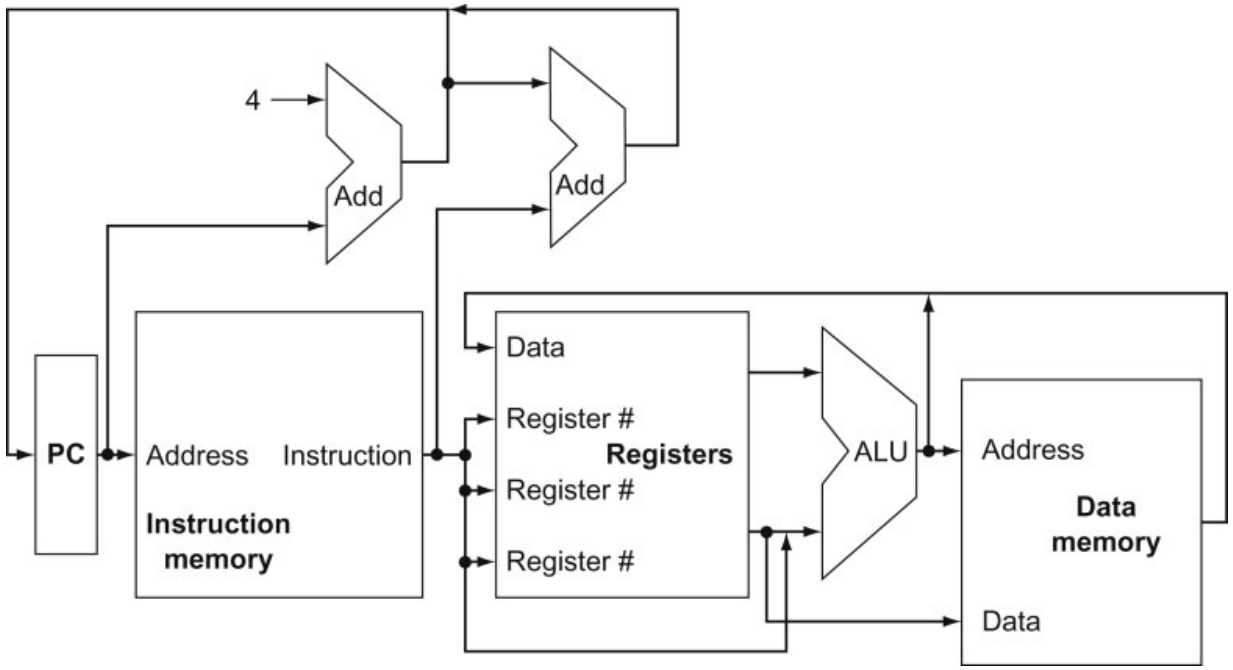
— Ref : https://www.livescience.com/

A Simple Processor

- What do we need for a basic MIPS processor?
  - basic math (add, sub, and, or, slt)
  - memory access (lw and sw)
  - branch and jump instructions (beq and j)
- Main components
  - Memory
    - Data and instructions
  - Register, ALU, and control logic
  - Common operations
    - Fetch unit
    - Register read

Overview of the Processor

- What is the role of the Add units?
- Explain the inputs to the data memory unit
- Explain the inputs to the ALU
- Explain the inputs to the register unit



Clocking the Processor

- Which of the units need a clock?
- What is being saved (latched) on the rising edge of the clock?
- Keep in mind that the latched value remains there for an entire cycle