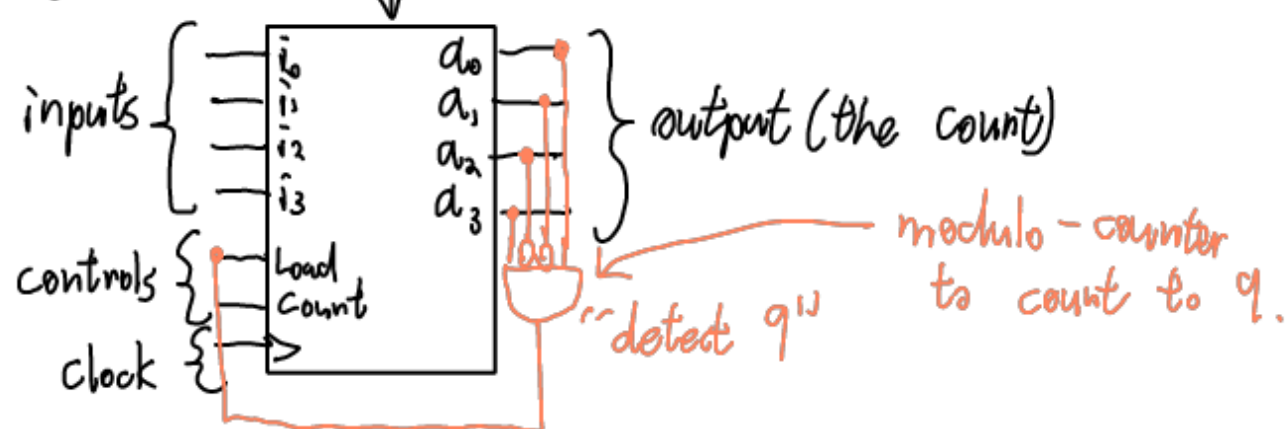<u>Last Time:</u>

Binary Counters – both <u>asynchronous</u> & <u>synchronous</u>
- count up or down.
- sequence is $0 \cdot 2^{n-1}$

$$0000 \longrightarrow 0001 \rightarrow \text{...} \rightarrow 1111$$

e.g., — 4 bit binary up-counter

inputs

controls

clock

Load
Count

i_0 i_1 i_2 i_3

a_0 a_1 a_2 a_3

output (the count)

"detect 9"

modulo-counter
to count to 9.

<u>Modulo-Counter</u>

Doesn't count all the way to 2^{n-1}.
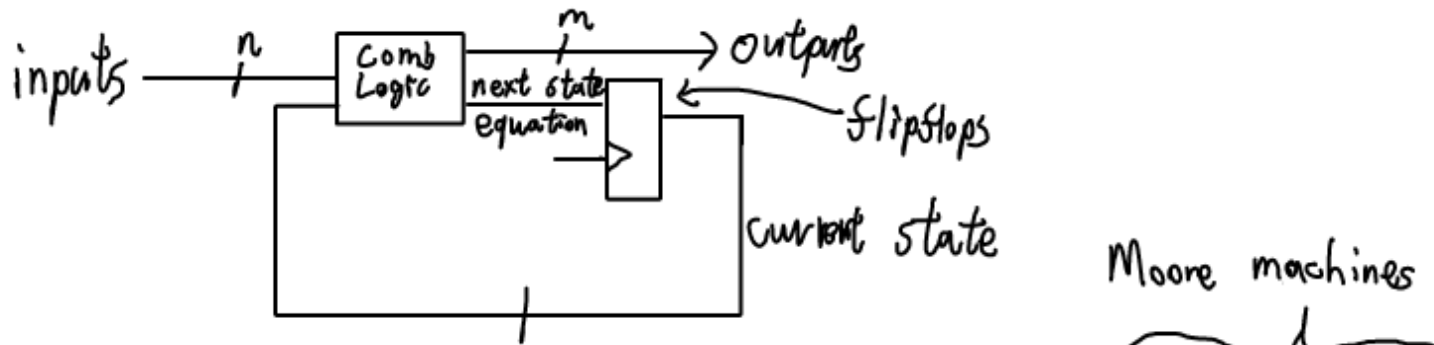
e.g., modulo-10 counter counts 0...9

$$0000 \rightarrow 0001 \rightarrow \text{.....} \rightarrow 1001$$

* Can you do this given a binary counter.
* Look at above diagram *

<u>Clocked Sequential Circuits</u>

* Counters/Registers are one example of a clocked
  sequential circuit.

Outputs can be either a function of the current state only *(Moore machines)* or both the current state and the inputs. *(Mealy machines)*
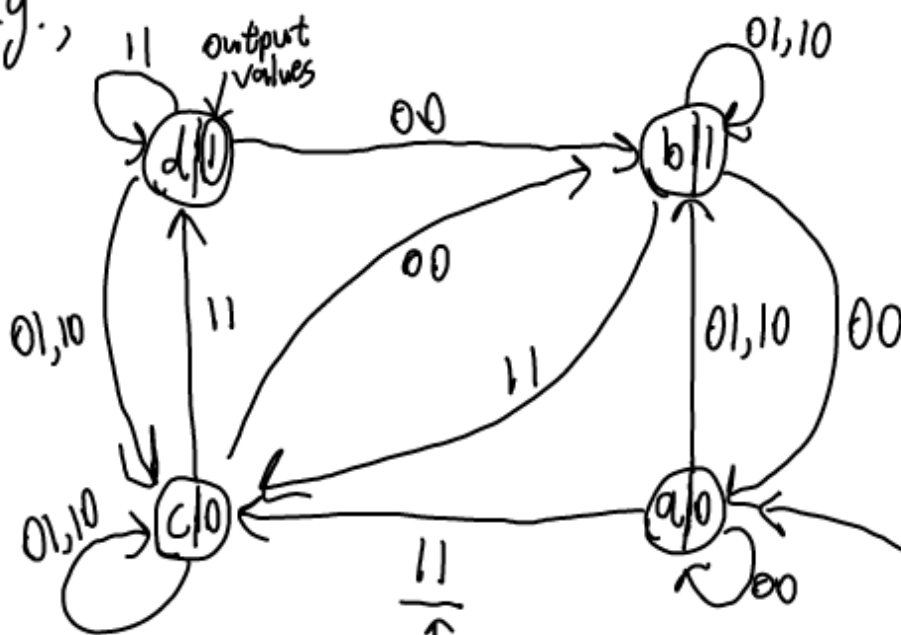
State Diagrams

*Sequential Circuits are represented abstractly via a <u>state diagram</u>.
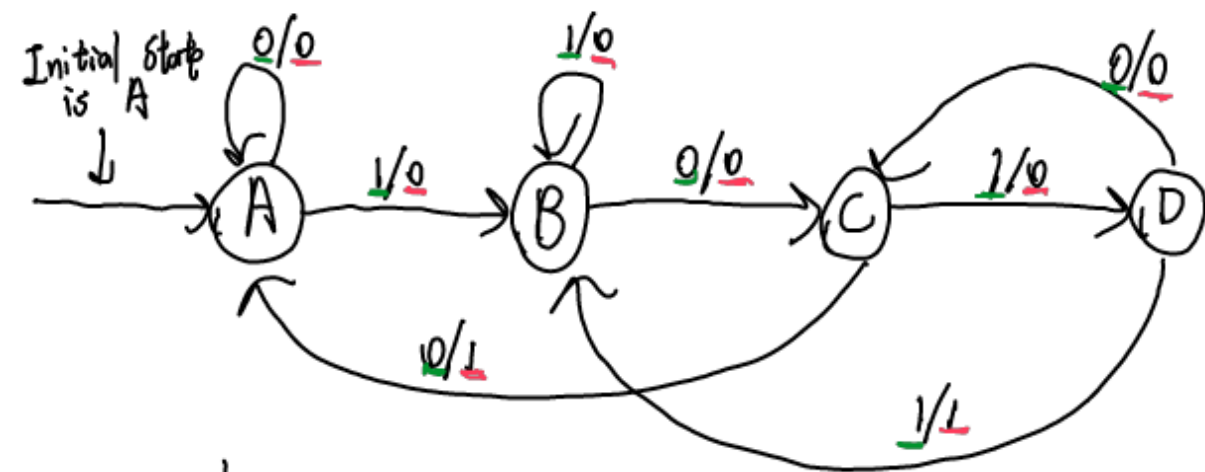
- bubbles to represent states
- directed edges to represent transitions between states based on input.
- outputs labeled appropriately.

e.g.,

output values

⟹ 1 output
4 states: a, b, c, d
⟹ 2 inputs

outputs inside bubbles
⟹ depend only on state
∴ Moore State Diagram

initial state

input values that cause me to go a → c

0/0   1/0   0/0

1/0   0/0   1/0

0/1

1/1

input / output

$\Rightarrow$ 1 input
$\Rightarrow$ 1 output

4 states

depends on state and input

$\therefore$ Mealy Machine

X: 0 0 1 1 0 1 1 1 1 0 1 0 0 0 - - - - - - - -
State: A A B B C D B B B B C D C A A - - - - - - -
Z: 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 - - - - - - -

$\Rightarrow$ This circuit outputs 1 when it sees the
4 bit pattern "1101" at the input.

"Sequence detector"