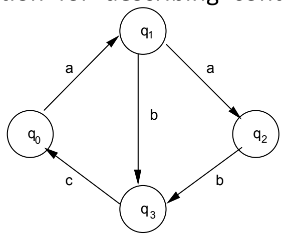
Finite State Machines

Book to Refer: Fundamentals of Software Engineering by Ghezzi, Jazayeri and Mandrioli

Finite state machines (FSMs)

- Simple and widely used formal notation for describing control aspects of the information system
- An FSM consists of,
  - a finite set of states, Q;
  - a finite set of inputs, I;
  - a transition function δ : Q x I → Q
  - (δ can be a partial function)

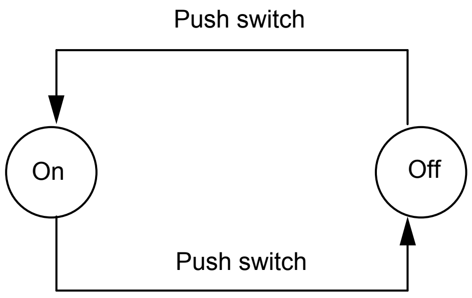


- Shown by a graph in which node represent states; an arc labeled i goes from q_1 to q_2 iff $\delta(q_1,i) = q_2$

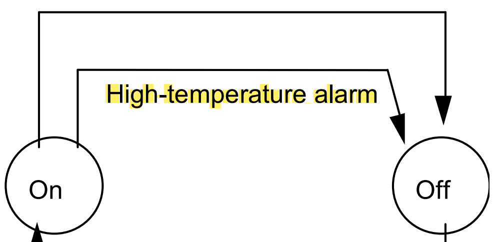
Finite state machines (FSMs) contd…

- FSMs are suitable for describing systems that can be,
  - in a finite set of states and
  - that can go from one state into another as a consequence of some event, modeled by an input symbol

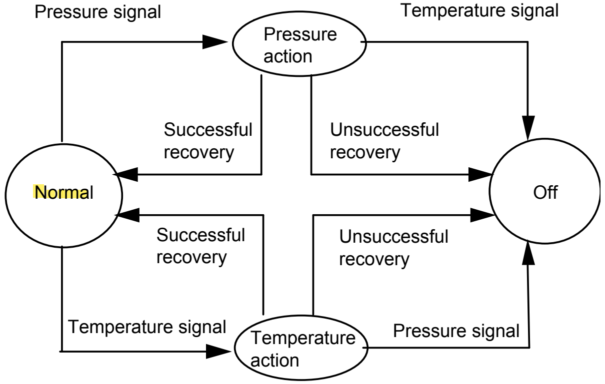
Example: a lamp



Another example: a plant control system



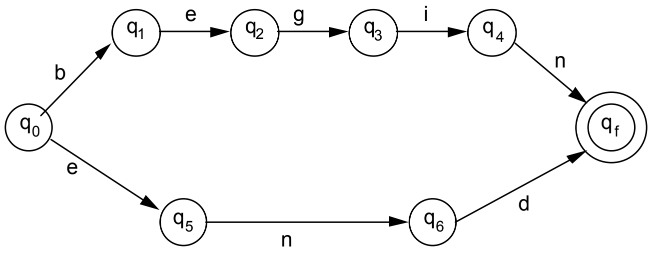
A refinement



Classes of FSMs

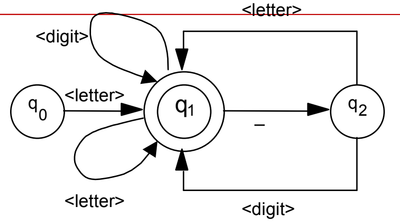
- Deterministic/nondeterministic
- FSMs as recognizers
  - introduce final states
- FSMs as transducers
  - introduce set of outputs
- . . .

FSMs as recognizers



q_f is a final state

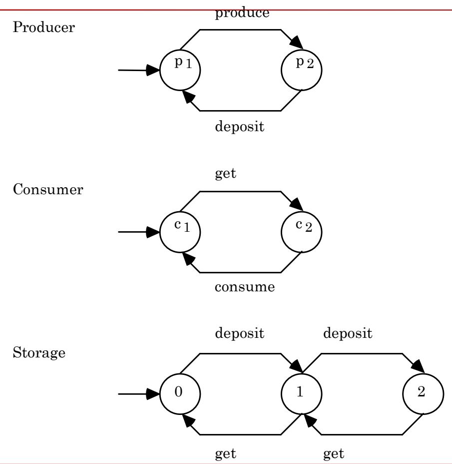
FSMs as recognizers



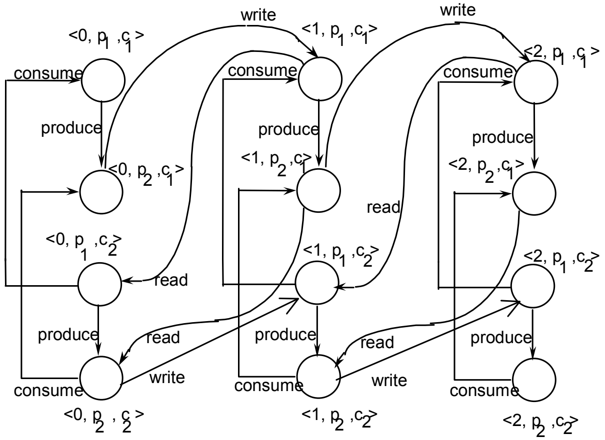
Legend: <letter> is an abbreviation for a set of arrows labeled a, b,..., z, A,..., Z,

<digit> is an abbreviation for a set of arrows labeled 0, 1,..., 9, respectively

State explosion: an example



The resulting FSM



Limitations

- Finite memory
  - Expressive power is limited
- State explosion
  - Given a number of FSMs with k_1, k_2, … k_n states, their composition is a FSM with k_1 * k_2 *… * k_n. This growth is exponential with the number of FSMs, not linear (we would like it to be $k_1 + k_2 +\ldots + k_n$)
- FSMs are essentially a synchronous model (at any time, a global state of the system must be defined and a single transition must occur.)

A few examples…

1. Using FSMs, describe a lighting system consisting of one lamp and two buttons. If the lamp is off, pushing either button causes the lamp to switch on, and conversely.
2. Describe a system with two lamps and one button. When the lights are off, pushing the button causes the first lamp to go on. Pushing the button again causes the second lamp to go on and the first to go off. Pushing the button yet again causes both lamps to go on, and pushing it once more switches both lamps off.

A few examples…

3. Modify the specification given by the FSM of chemical plant control discussed earlier to accomplish following requirements:
   a. The system should be able to cope also with simultaneous signals.
   b. Considering that the temperature and pressure each have two different associated signals, one indicating a slight deviation from the acceptable value and the other a dangerous deviation from the acceptable value. In the latter case, the system must be shut off immediately.