Deterministic Finite Automata

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Introduction

- Any physical body or machine, or animal, or even solar system, which changes its **states** with time, can be represented by Automata.
- Given any initial state and final state, we can think of intermediate discrete states, through which transition have taken place.
- Objective: Use automata to model the behaviour of computer, and other real life machines, having finite states or assumed to have finite states.
- Automata theory: Abstract mathematical representation of computational procedures. FA is used in design of lexical analyzers in compilers, for searching patterns in arbitrarily large texts, natural language processing, text processing, etc.
- FA is simplest computing model, it is a restricted program without variables.
- FA shares its features with computer. It has finite – a very limited memory, present in CPU only.

Finite Automata

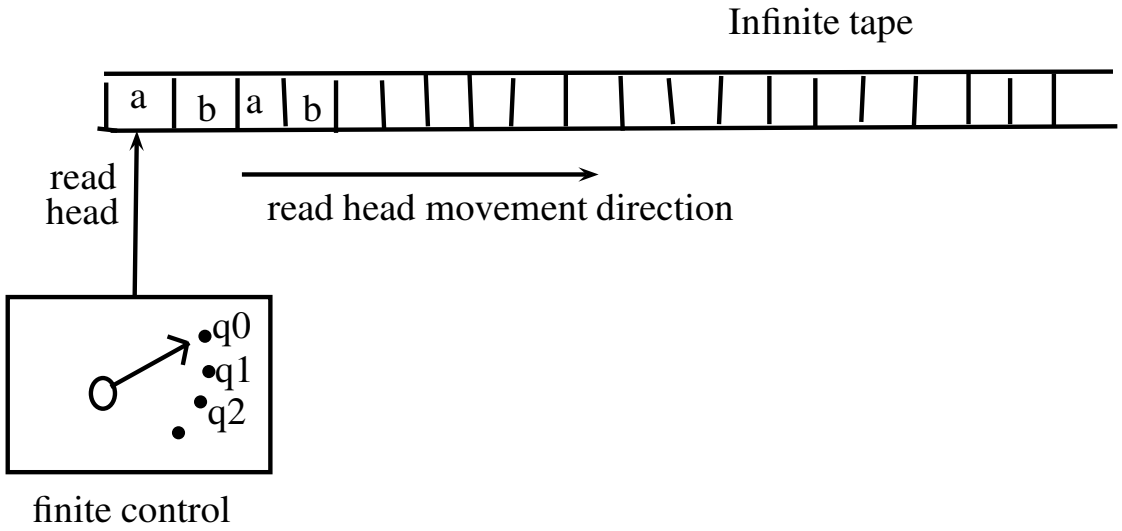

Figure 1: Finite Automaton

- A finite automaton has finite set of states Q it can undergo, an alphabet set Σ, a set of accepting or final states F, where $F \subseteq Q$, a starting state s, and a transition function δ, where $\delta : Q \times \Sigma = Q$. Thus, a FA $M = (Q, \Sigma, \delta, s, F)$.
- If a FA is in state p and makes a transition to state q on reading of symbol $a \in \Sigma$, then this transition is represented as $\delta(p, a) = q$.

Finite automata

- If there is an input $w = abcd$ on tape, and transitions are like this: $\delta(p,a) = q, \delta(q,b) = r, \delta(r,c) = s, \delta(s,d) = t$. Thus, at the begin we have state and input as $(p, abcd)$, which is called as initial **configuration** or **ID**(Instantaneous description) of the FA.
- The sequence of transitions through which it will go are:

  $(p, abcd) \vdash_M (q, bcd) \vdash_M (r, cd) \vdash_M (s, d) \vdash_M (t, \varepsilon)$ or we can say that configuration $(p, abcd)$ goes to configuation (t, ε) through zero or more transitions, written as: $(p, abcd) \vdash_M^* (t, \varepsilon)$; the symbol $\vdash$ is called "derives."
- The language of M:
  $L = L(M) = \{w | w \in \Sigma^*, (p, abcd) \vdash_M^* (t, \varepsilon), \text{ and } t \in F\}$, $\vdash_M^*$ is transitive relation, and defined as $\vdash_M$: $Q \times \Sigma^* \to Q \times \Sigma^*$
- Given any input symbol and current state there is a definite next state. Thus, given a start state, and input string it is possible to determine entire behaviour of a FA. Hence, this FA is called DFA (deterministic FA).

FA Example

- What is regular expressions and FA for:
  $Q = \{q_0, q_1, q_2\}, \Sigma = \{0, 1\}, F = \{q_1\}$, and δ is given as:

current state	input 0	1
q_0	q_0	q_1
q_1	q_0	q_2
q_2	q_2	q_1

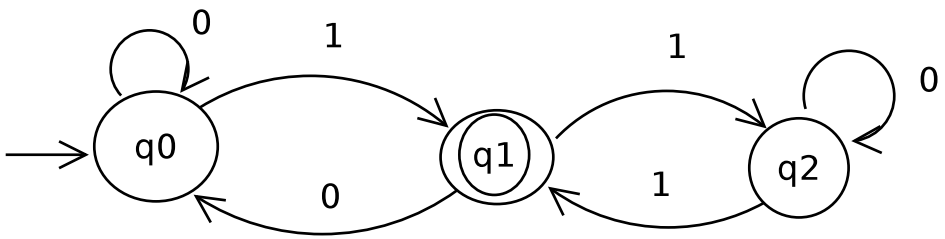

Figure 2: Transition diagram of corresponding FA.

$$\text{Regular expression} = 0^*1(0^+1 + 10^*1)^*$$

Self test

- Which of following are FA? Justify.
  1. Digital computer,
  2. analog computer,
  3. digital voltmeter,
  4. analog voltmeter,
  5. chemical reaction,
  6. interaction of radiation with matter,
  7. transformation of water into vapor.