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Deterministic Finite Automata -(DFA) and equivalence with regular expressions

Chapter - 2: Regular languages and finite automata

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What is a DFA?

Definition:

A Deterministic Finite Automaton (DFA) is a mathematical model of computation used to recognize regular languages.

Key Feature:

For each state and input symbol, there is exactly one transition.

Formal Definition of DFA

A DFA is a 5-tuple:

$M = (Q, \Sigma, \delta, q_0, F)$

Where:

- Q = finite set of states
- Σ = input alphabet
- δ = transition function ($\delta: Q \times \Sigma \rightarrow Q$)
- q_0 = start state ($q_0 \in Q$)
- F = set of accept (final) states ($F \subseteq Q$)

DFA Example

Alphabet: $\Sigma = \{0, 1\}$

Language: Strings ending with '01'

States: $Q = \{q_0, q_1, q_2\}$

Start state: q_0

Accept state: q_2

Transitions:

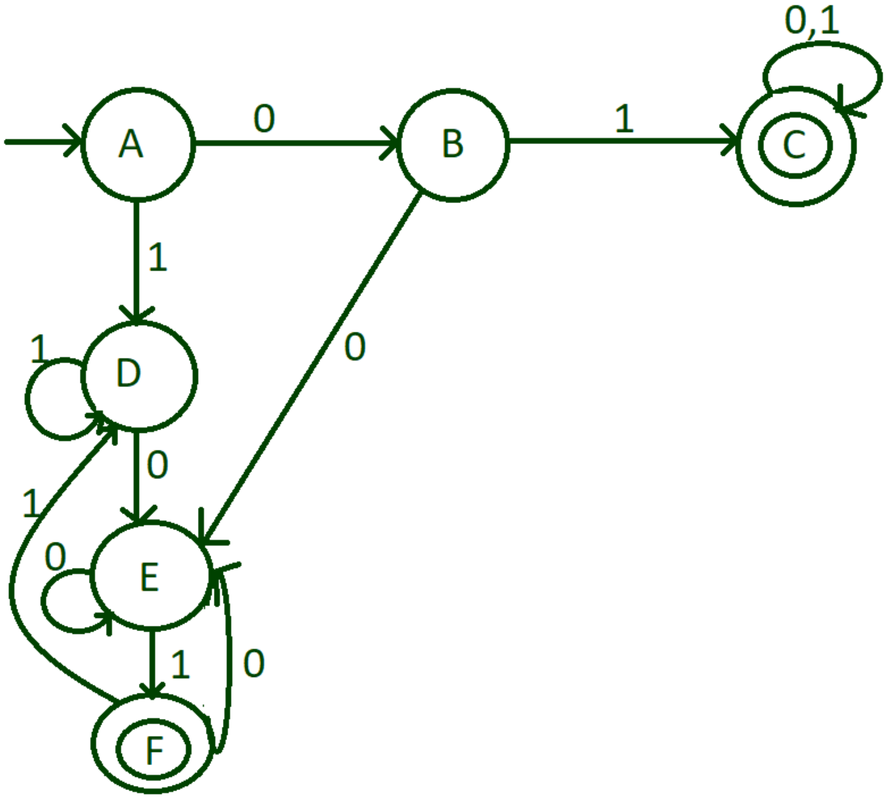
$\delta(q_0, 0) = q_0$

$\delta(q_0, 1) = q_1$

$\delta(q_1, 0) = q_2$

$\delta(q_1, 1) = q_1$

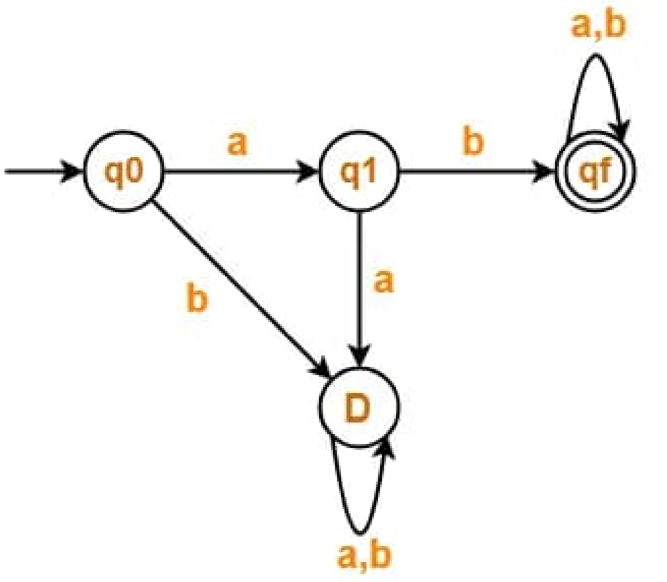
$\delta(q_2, 0/1) = q_0$ (or dead state)



DFA Example

Draw a DFA for the language accepting strings starting with ‘ab’ over input alphabets ∑ = {a, b}

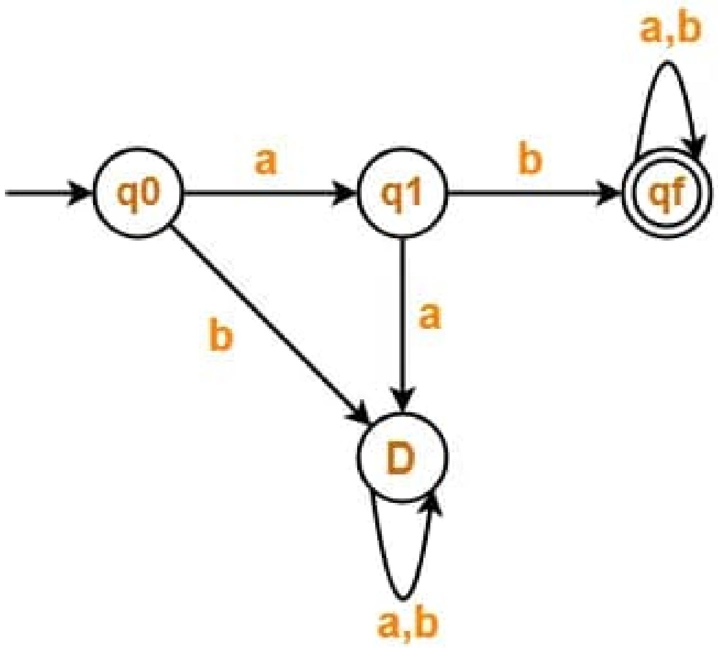
Regular expression for the given language = ab(a + b)*



DFA Example

Draw a DFA for the language accepting strings starting with ‘a’ over input alphabets ∑ = {a, b}

Regular expression for the given language = a(a + b)*



Equivalence of DFA and Regular Expressions

A language is regular if it can be represented by a DFA or a Regular Expression.

Example:

Conversions:

- RE → DFA:
  - Convert RE to NFA
  - Convert NFA to DFA
- DFA → RE:

  Use state elimination method or GNFA construction

RE to DFA – Steps

Convert RE → NFA (using Thompson’s Construction)

NFA → DFA (subset construction)

DFA → minimized DFA (optional)

Example:

RE = (a + b)*ab

→ Build NFA

→ Convert to DFA that accepts strings ending in "ab"

DFA to RE – State Elimination

Basic Steps:

1. Add new start and end states (if needed)
2. Eliminate states one by one
3. Update transitions using Res
4. Final expression between new start and end is the RE

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