NFA – Formal Definition

- A Non Deterministic Finite State Automata M is a **5 tuple**.
- **$M=(Q,\Sigma,\delta,q_o,F)$**
- Where
- Q – is a finite set of states
- Σ – is a finite set of input alphabets
- q_o- initial state. It belongs to set Q.
- F – set of final states/ accept states. It is subset of Q.
- δ – It is transition function or mapping from set **Q and Σ to power set of Q (2^Q).**
- It maps a given state p and input symbol a to **zero or more next state i.e subset of Q.** It can be specified using a state transition function, table or diagram.
- **Symbolically $\delta : Q \times \Sigma \rightarrow 2^Q$**

DFA vs NFA Comparison

DFA

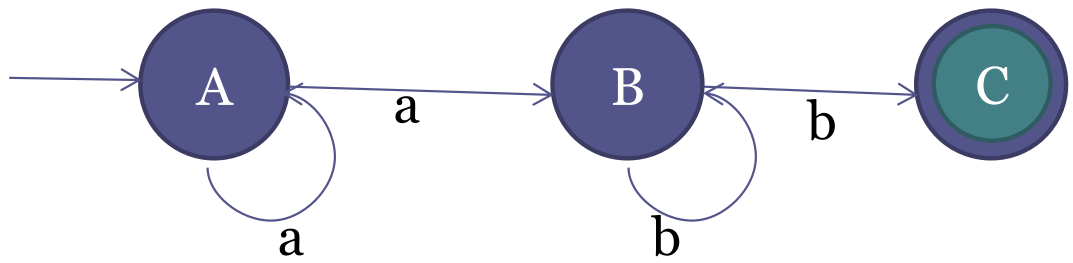
- In DFA, for **every possible state and input alphabet** (q,a) combination there is a transition to next state p.
- In DFA, there is a **unique transition** from a state and input alphabet (q,a) combination to some state p.
- Every DFA is also an NFA

NFA

- In NFA, for **every possible state and input alphabet** (q,a) combination there may not be a transition to next state. [**No Transition**]
- In NFA, there may be **multiple transitions** from a state and input alphabet (q,a) combination to states p1,p2,..
- Every NFA is not a DFA

NFA Examples

State Transition Diagram



State Transition Function

$\delta(A,a)=\{A,B\}$

$\delta(A,b)=\Phi$

$\delta(B,a)= \Phi$

$\delta(B,b)=\{B,C\}$

$\delta(C,a)= \Phi$

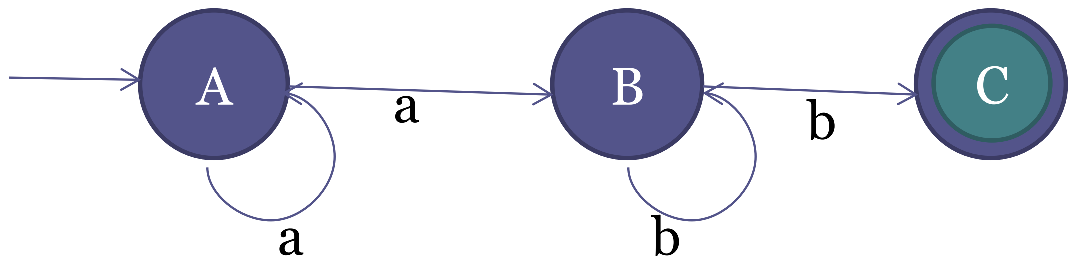
$\delta(C,b)= \Phi$

State Transition Table

δ	**a**	**b**
A	{A.B}	Φ
B	Φ	{B,C}
C	Φ	Φ

NFA Working

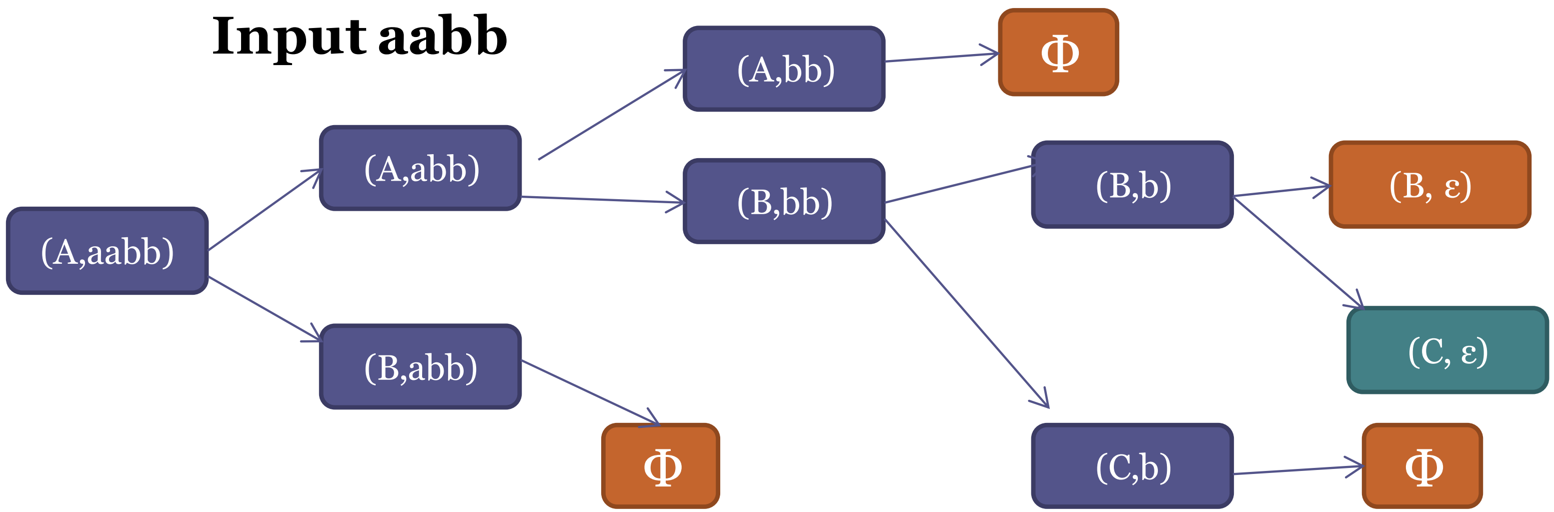
State Transition Diagram



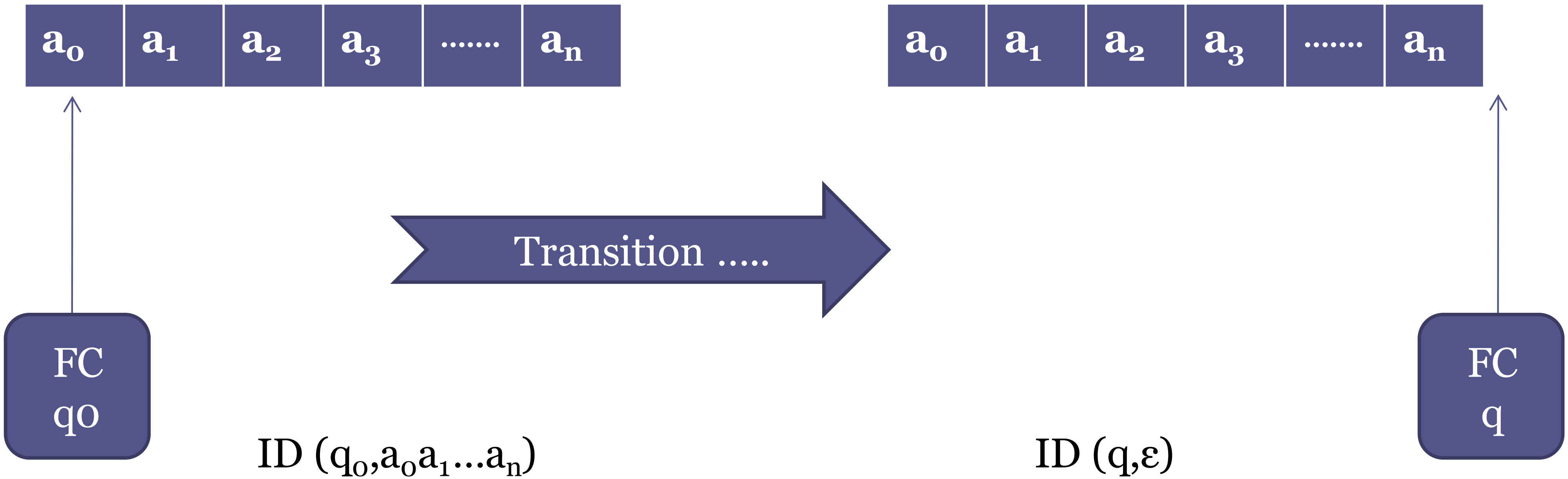
State Transition Function

$\delta(A,a)=\{A,B\}$
$\delta(A,b)=\Phi$
$\delta(B,a)= \Phi$
$\delta(B,b)=\{B,C\}$
$\delta(C,a)= \Phi$
$\delta(C,b)= \Phi$

Input aabb



Acceptance of String w



A string w is said to be accepted by NFA M if NFA M reaches a final state after reading input string w one symbol at a time **through at least one computation path.**

Symbolically

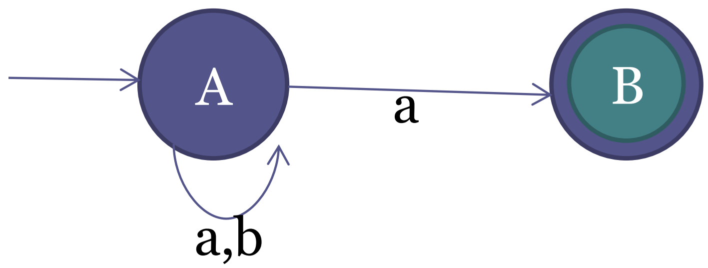
$(q_0, w) \vdash^* (q, \varepsilon)$ where $q \in F$ for some computation path

Language accepted by NFA M

- The language accepted by NFA M is defined as set of all strings w belonging to $\sum^*$ such that $(q_o,w)|\!-^*(q, \varepsilon)$ and q ε F (final/accept state) **for some computation path of M**
- $L(M)=\{w$ **ε** $\sum^* \mid (q_o,w)|\!-^*(q, \varepsilon)\ \Lambda\ q\ \varepsilon\ F$ **for some computation path of M**$\}$

NFA Examples I

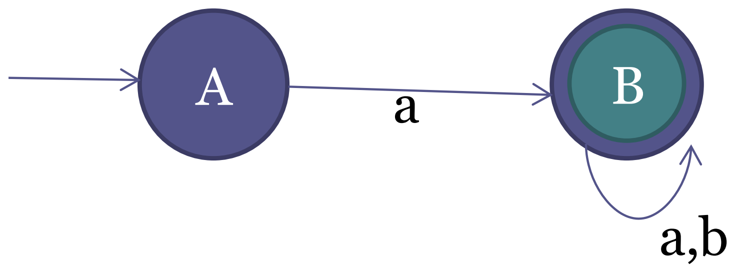
State Transition Diagram



L(M)={w ε {a.b}*| w ends with ‘a’}

NFA Examples II

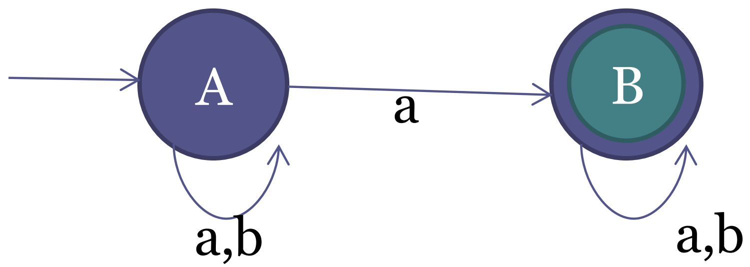
State Transition Diagram



L(M)={w ε {a.b}*| w starts with ‘a’}

NFA Examples III

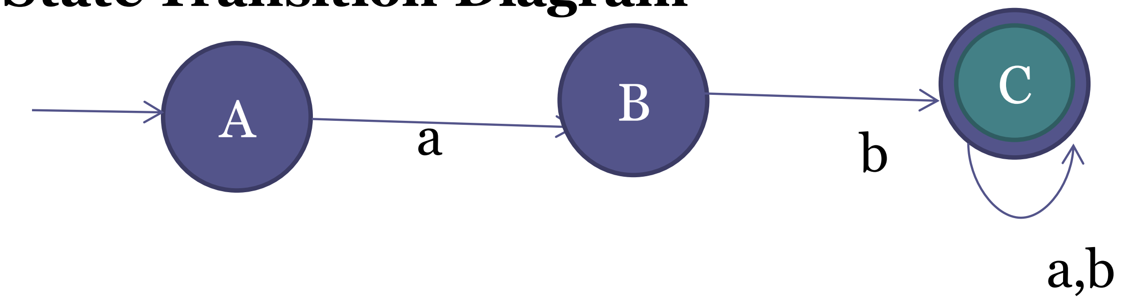
State Transition Diagram



L(M)={w ε {a.b}*| w contains 'a'}

NFA Examples IV

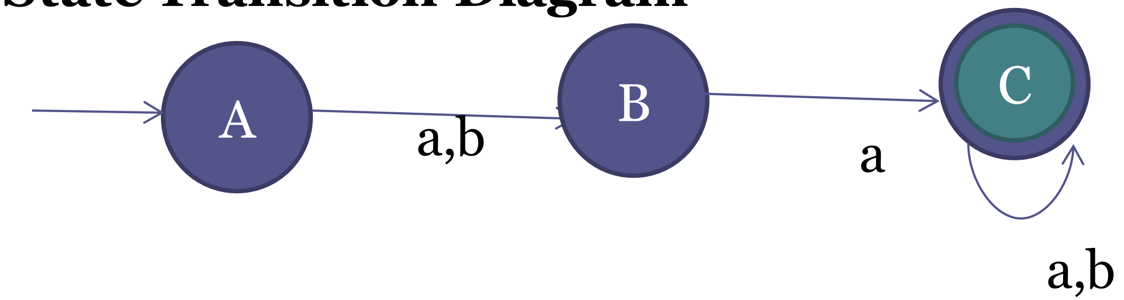
State Transition Diagram



L(M)={w ε {a.b}*| w begins with ‘ab’}

NFA Examples V

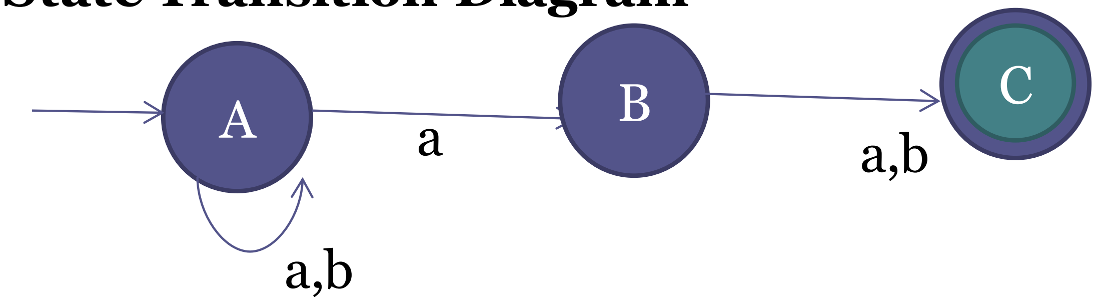
State Transition Diagram



L(M)={w ε {a.b}*| second symbol of w from LHS is ‘a’}

NFA Examples VI

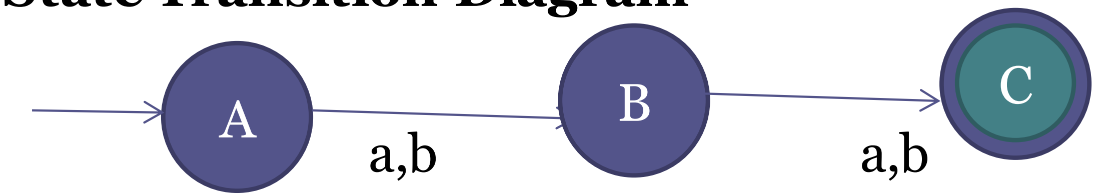
State Transition Diagram



L(M)={w ε {a.b}*| second symbol of w from RHS is ‘a’}

NFA Examples VII

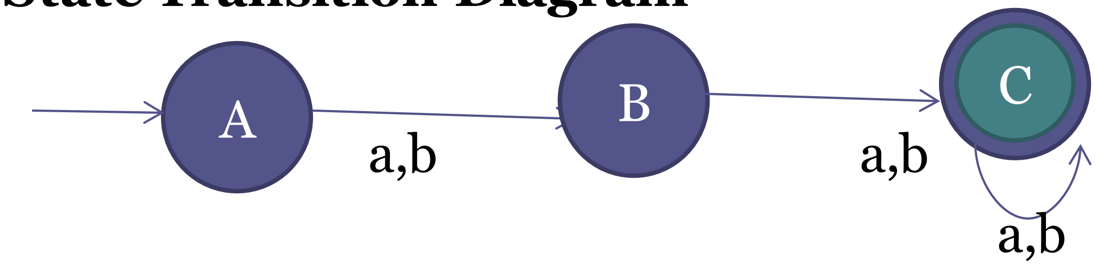
State Transition Diagram



L(M)={w ε {a.b}*| |w|=2}

NFA Examples VIII

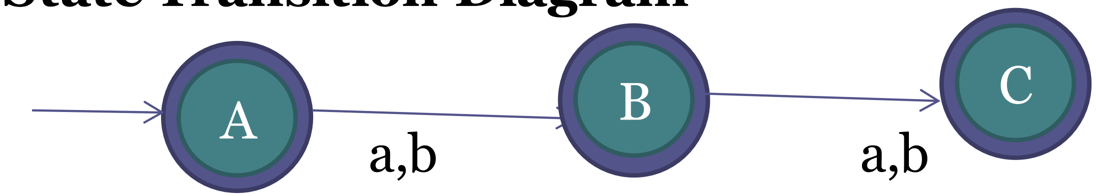
State Transition Diagram



L(M)={w ε {a.b}*| |w|>=2}

NFA Examples IX

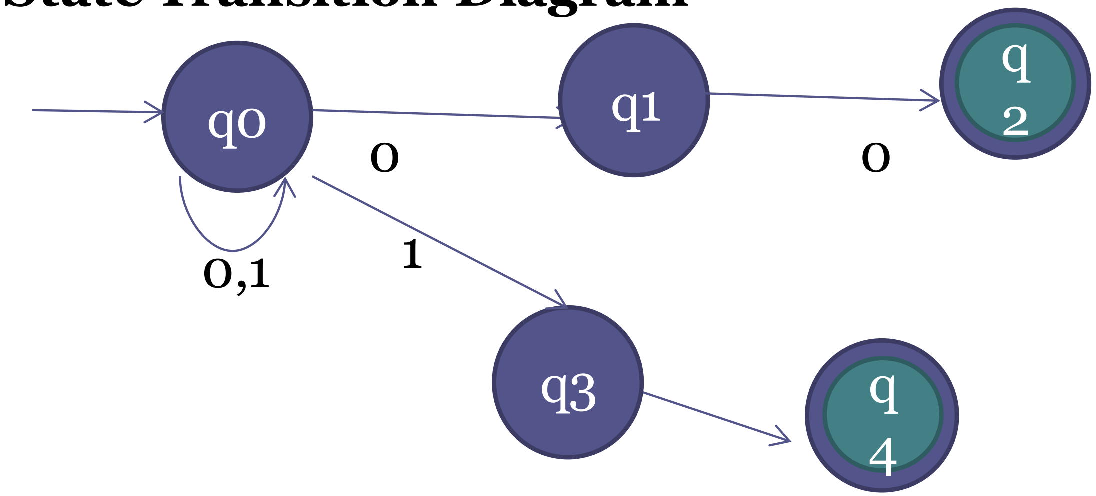
State Transition Diagram



L(M)={w ε {a.b}*| |w|<=2}

NFA Examples X

State Transition Diagram



L(M)={w ε {0,1}*| w ends with '00' or '11'}