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Wisdom & Virtue

MIRPUR UNIVERSITY OF SCIENCE AND TECHNOLOGY (MUST), MIRPUR
DEPARTMENT OF SOFTWARE ENGINEERING

Formal Methods in Software Engineering

Lecture [10]: Non-Deterministic Finite Automata (NFA)

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Topics discussed in Today's Lectures

- Non-Deterministic Finite Automata
- Graphical Representation of an NFA
- Examples of NFA

Non-Deterministic Finite Automata (NFA)

- NFA stands for non-deterministic finite automata
- It is easy to construct an NFA than DFA for a given regular language
- The finite automata are called NFA when there exist many paths for specific input from the current state to the next state
- Every NFA is not DFA, but each NFA can be translated into DFA.
- NFA is defined in the same way as DFA but with the following two exceptions, it contains:

  i. Multiple next states, and ii. ε transition*

Non-Deterministic Finite Automata (NFA)

- From state **q0** for input a, there are two next states **q1** and **q2**
- Similarly, from **q0** for input b, the next states are **q0** and **q1**
- Thus, it is not fixed or determined that with a particular input where to go next
- Hence this FA is called non-deterministic finite automata.

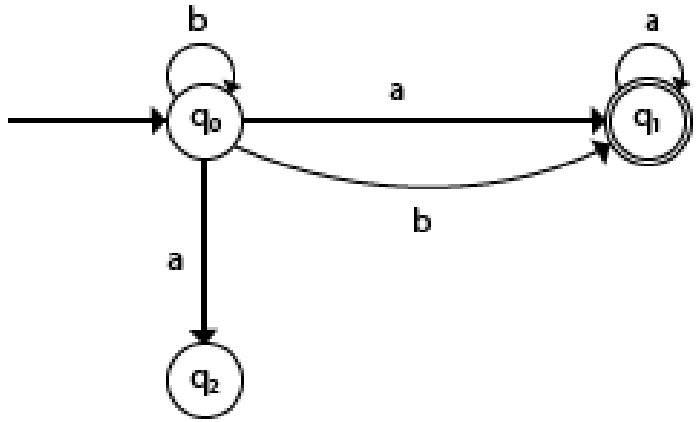


Fig:- NDFA

Formal definition of NFA

- NFA also has 5 states same as DFA, but with different transition function, as shown follows: $\delta: Q \times \Sigma \rightarrow 2^Q$

where,

1.Q: finite set of states

2.∑: finite set of the input symbol

3.q0: initial state

4.F: final state

5.δ: Transition function

Graphical Representation of an NFA

- An NFA can be represented by digraphs called state diagram. In which:
  - The state is represented by vertices/circles.
  - The arc labeled with an input character show the transitions.
  - The initial state is marked with an arrow.
  - The final state is denoted by the double circle

Examples of NFA

Example 1:

Q = {q0, q1, q2}

∑ = {0, 1}

q0 = {q0}

F = {q2}

Solution:

Transition diagram:

Fig: NFA

Present State	Next state for Input 0	Next State of Input 1
→q0	q0, q1	q1
q1	q2	q0
*q2	q2	q1, q2

Graphical Representation of an NFA

Example 2:

NFA with ∑ = {0, 1} accepts all strings with 01.

Solution:

Fig: NFA

Transition Table:

Present State	Next state for Input 0	Next State of Input 1
→q0	q1	ε
q1	ε	q2
*q2	q2	q2

Examples of NFA

Example 3:

NFA with ∑ = {0, 1} and accept all string of length atleast 2.

Solution:

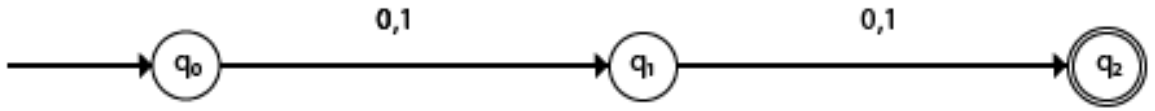


Fig: NFA

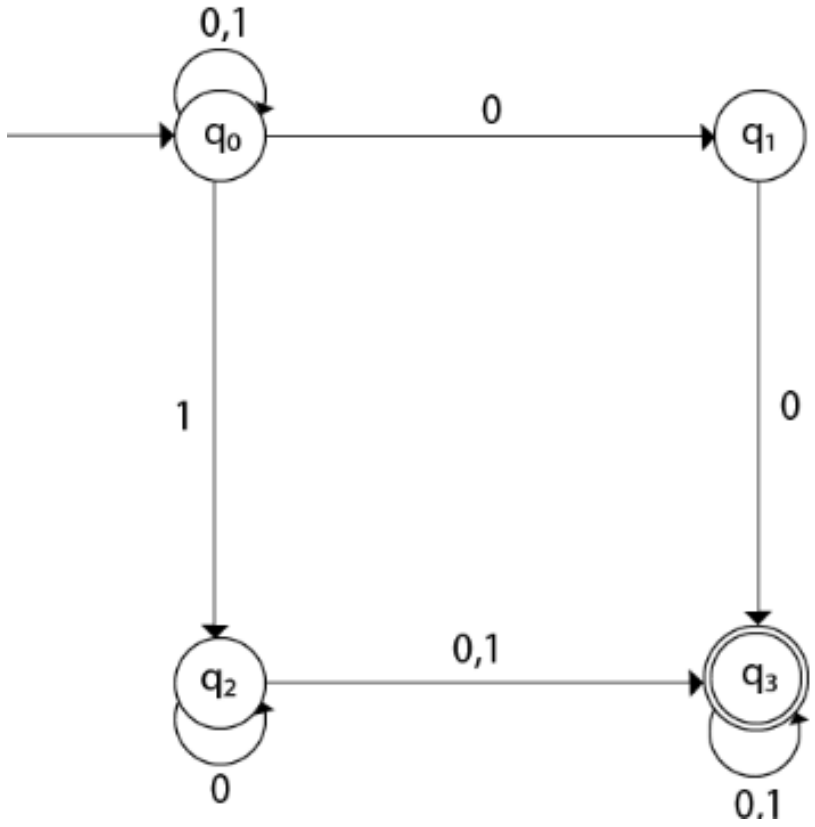
Transition Table:

Present State	Next state for Input 0	Next State of Input 1
→q0	q1	q1
q1	q2	q2
*q2	ε	ε

Examples of NFA

Design a NFA for the transition table as given below:

Present State	0	1
→q0	q0, q1	q0, q2
q1	q3	ε
q2	q2, q3	q3
→q3	q3	q3



δ(q0, 0) = {q0, q1}

δ(q0, 1) = {q0, q2}

Then, δ(q1, 0) = {q3}

Then, δ(q2, 0) = {q2, q3}

δ(q2, 1) = {q3}

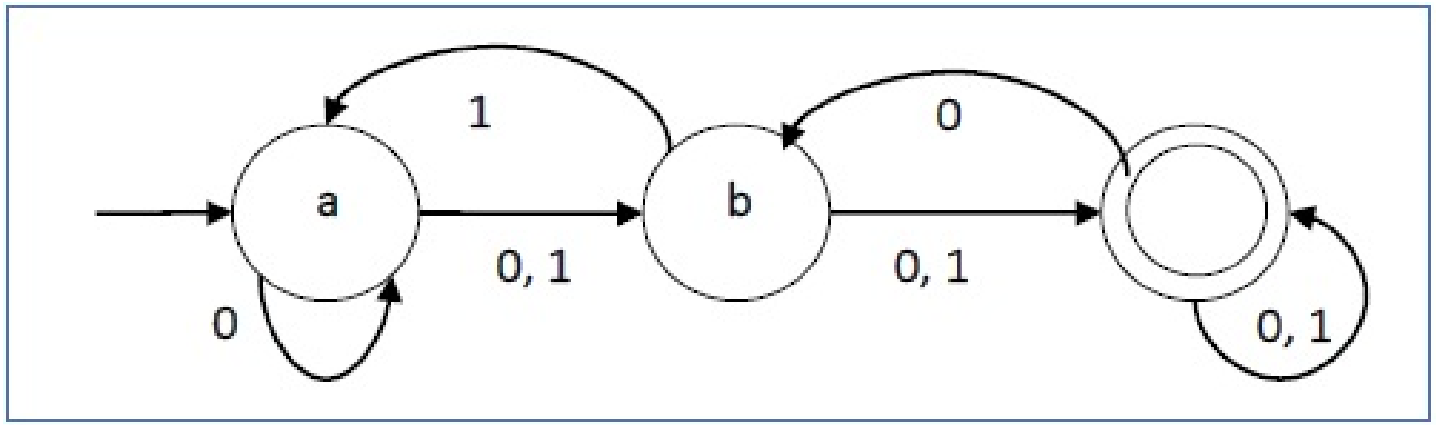
Then, δ(q3, 0) = {q3}

δ(q3, 1) = {q3}

Examples of NFA

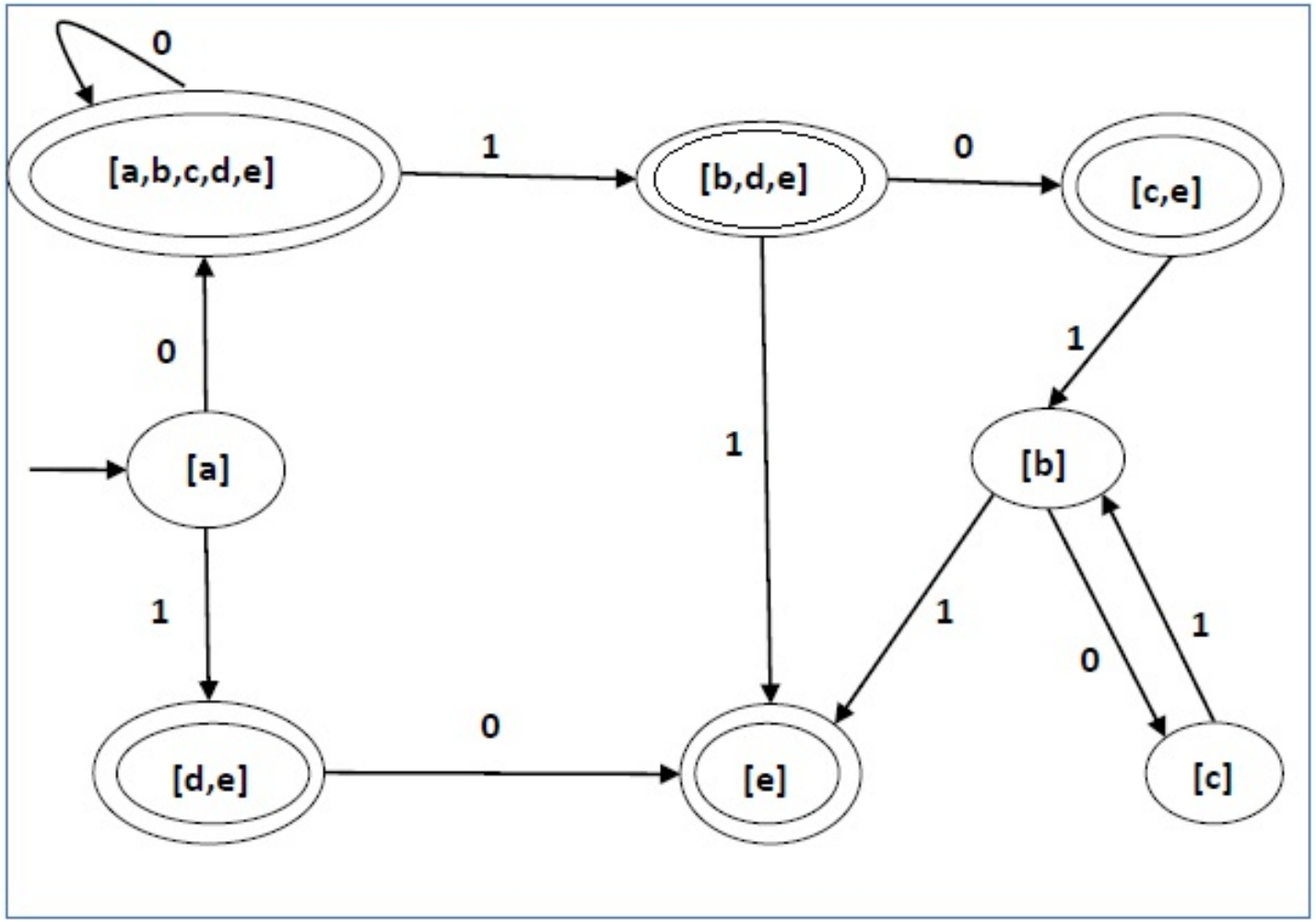
Present State	Next State for Input 0	Next State for Input 1
a	a, b	b
b	c	a, c
c	b, c	c

Its graphical representation would be as follows –



Examples of NFA

q	δ(q,0)	δ(q,1)
[a]	[a,b,c,d,e]	[d,e]
[a,b,c,d,e]	[a,b,c,d,e]	[b,d,e]
[d,e]	[e]	ø
[b,d,e]	[c,e]	[e]
[e]	ø	ø
[c, e]	ø	[b]
[b]	[c]	[e]
[c]	ø	[b]



THANKS