Cairo University
Faculty of Computers & Artificial Intelligence
Theory of Computations

Lab#5

NFA - Conversion

Non-deterministic Finite Automaton

For a particular input symbol, the machine can move to any combination of the states in the machine. In other words, the exact state to which the machine moves cannot be determined.
Hence, it is called Non-deterministic Automaton. As it has finite number of states, the machine is called Non-deterministic Finite Machine.
Can have ϵ -moves

Formal Definition of an NFA

An NFA can be represented by a 5-tuple (Q, Σ, δ, q0, F) where −

- Q is a finite set of states.
- Σ is a finite set of symbols called the alphabets.
- δ is the transition function where δ: Q × Σ → 2Q
  (Here the power set of Q (2Q) has been taken because in case of NDFA, from a state, transition can occur to any combination of Q states)
- q0 is the initial state from where any input is processed (q0 ∈ Q).
- F is a set of final state/states of Q (F ⊆ Q).

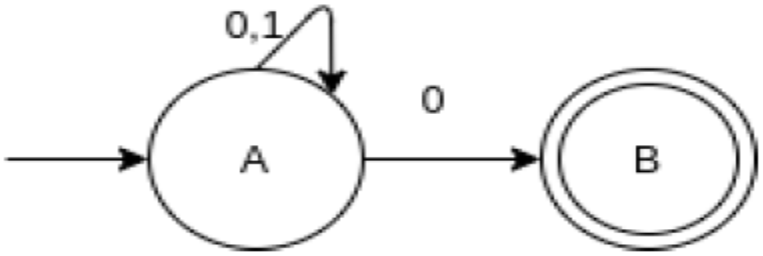
Graphical Representation of an NFA: same as DFA

Examples

1. Design an NFA that accepts all strings ending with 0
2. Design an NFA that accepts all strings starting with 10
3. Design an NFA that recognize (a+b)*abb
4. Design an NFA with ∑ = {0, 1} accepts all string in which the third symbol from the right end is always 0.
5. Design an NFA with ∑ = {0, 1} in which double '1' is followed by double '0'.

Solutions

1.



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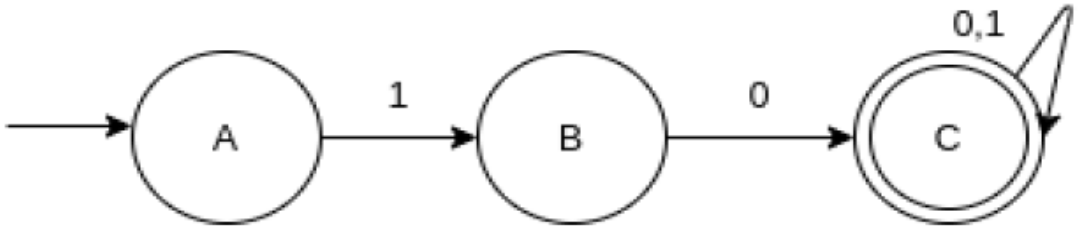

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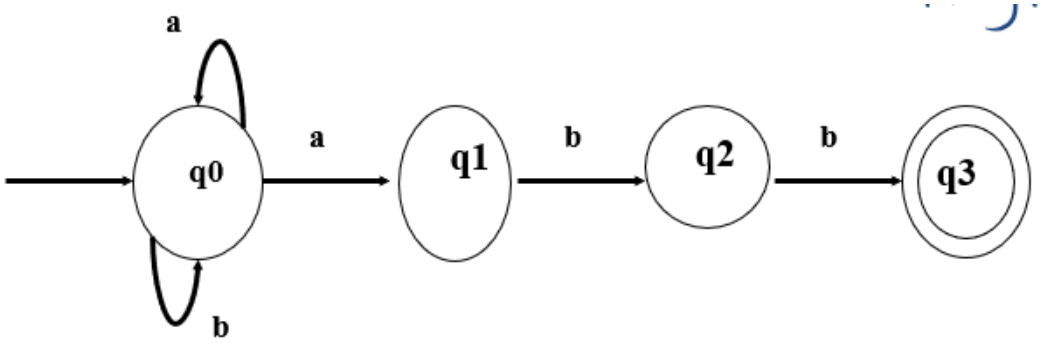

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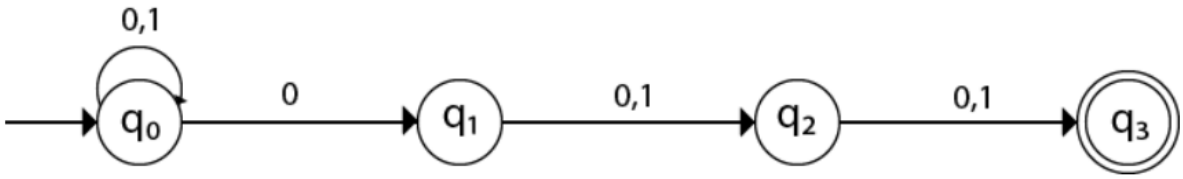
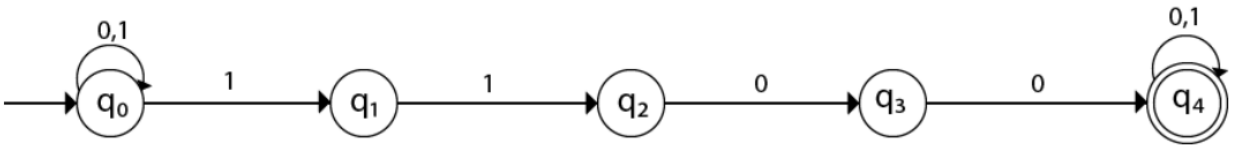


5.



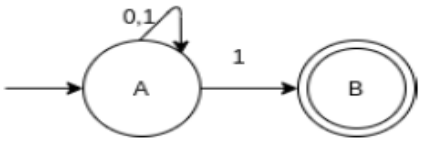
Conversion from NFA to DFA

Steps of converting NFA to DFA:

1. Create a state table from the given NDFA.
2. Mark the start state of the DFA by q0 (Same as the NDFA).
3. Find out the combination of States {Q0, Q1,... , Qn} for each possible input alphabet.
4. Each time a new DFA state is generated under the input alphabet columns, apply step 3 again, otherwise go to step 5.
5. The states which contain any of the final states of the NDFA are the final states of the equivalent DFA.

Examples:

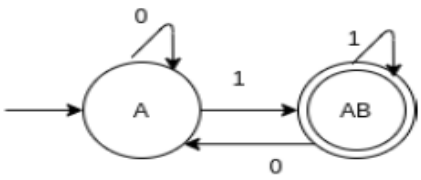
1. Design an NFA that accepts all strings ending with 1 over 0,1 then convert it to DFA



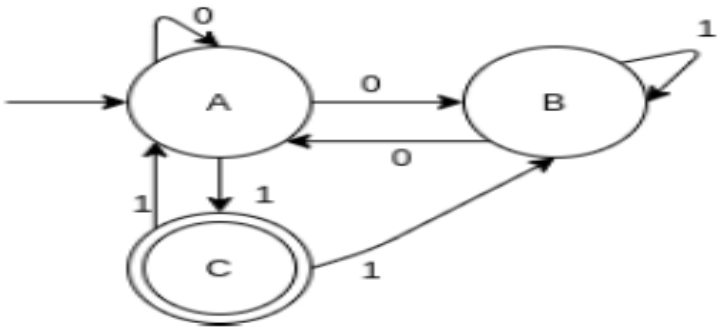
	0	1
A	{A}	{A,B}
B	Φ	Φ

To DFA

	0	1
A	{A}	{AB}
AB	{A}	{AB}

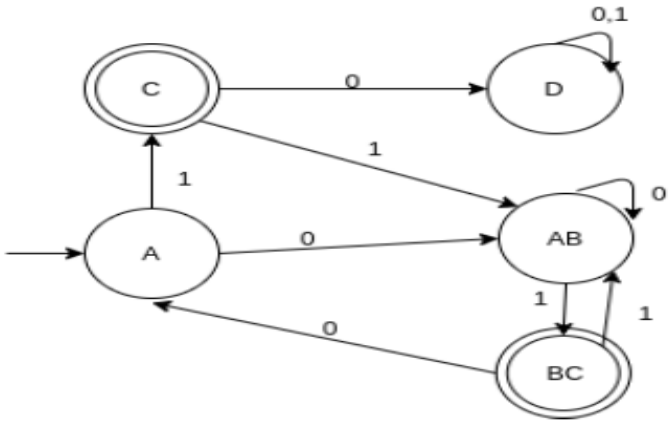


2. Convert the following NFA to DFA



	0	1
A	A,B	C
B	A	B
(C)	Φ	A,B

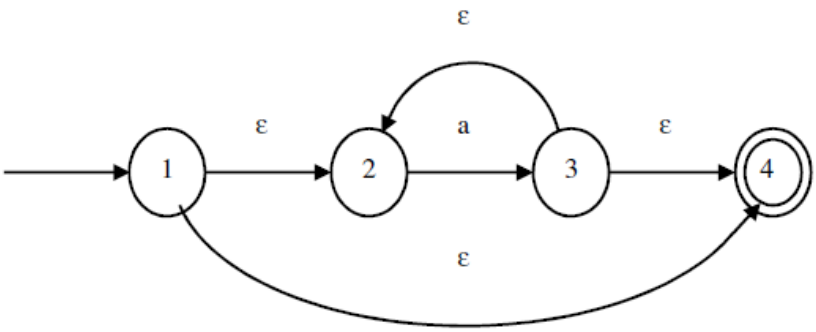
	0	1
A	AB	C
AB	AB	BC
BC	A	AB
C	D	AB
D	D	D



Note:

Having ε in NFA:

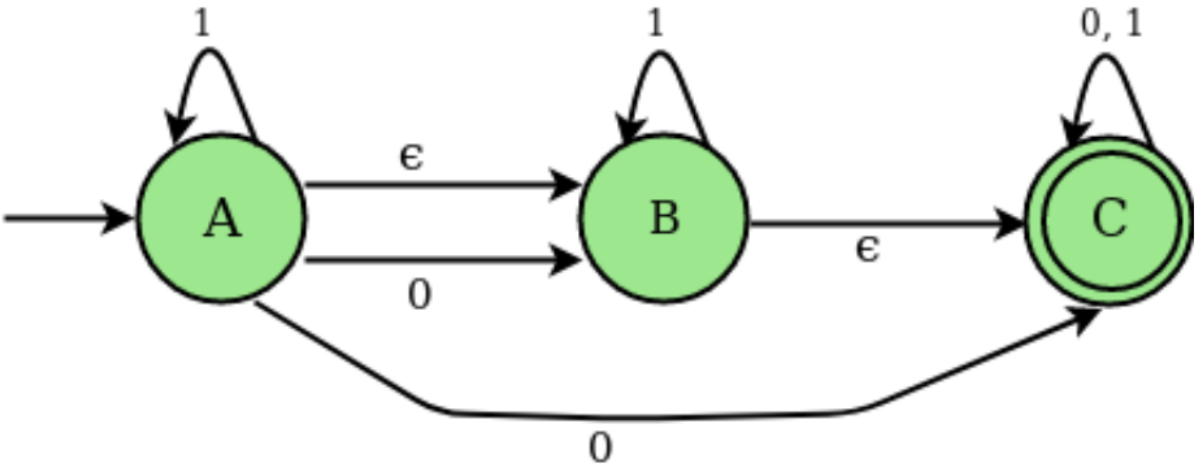
Eliminating ε transitions involves the construction of ε-closures .
ε–closure of a single state s : is the set of states reachable by a series of zero or more ε transitions.



$\bar{1} = \{1, 2, 4\}$, $\bar{2} = \{2\}$, $\bar{3} = \{2, 3, 4\}$, and $\bar{4} = \{4\}$.

Example :

Consider the following figure of NFA with ∈ move :



State	∈ closure
A	{A, B, C}
B	{B, C}
C	{C}

State	0	1
A	B,C	A
B		B
C	C	C

-> use the ∈ closure of the state instead of the state itself

State	**∈ closure**	0	1
A	**A,B,C**	B,C	A,B,C
B, C	**B,C**	C	B,C
C	**C**	C	C