Non Deterministic Finite Automata
To
Deterministic Finite Automata Construction

Course Name: Compiler Design
Course Code: CSE331
Level:3, Term:3
Department of Computer Science and Engineering
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Non Deterministic Features of NFA

There are three main cases of non- determinism in NFAs:

1. Transition to a state without consuming any input.
2. Multiple transitions on the same input symbol.
3. No transition on an input symbol.

To convert NFAs to DFAs we need to get rid of non-determinism from NFAs.

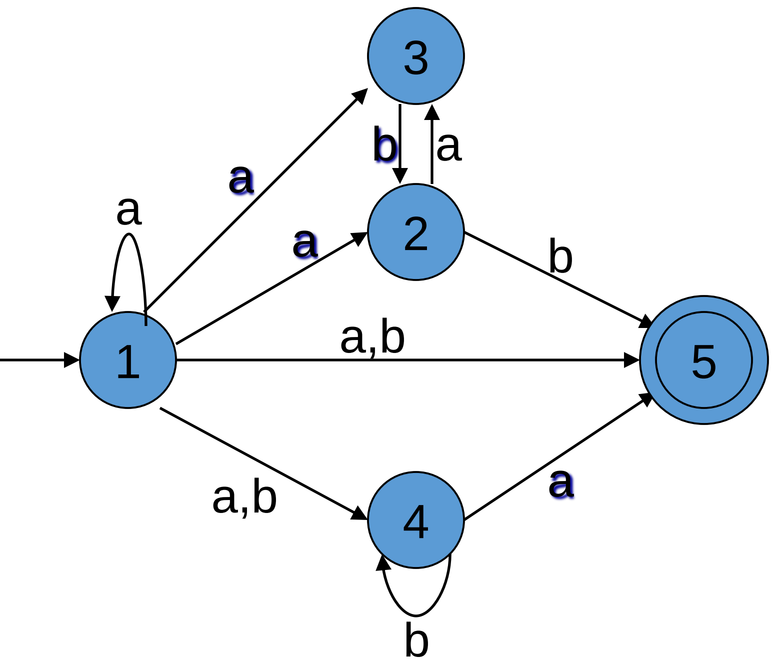
Subset Construction Method

Using Subset construction method to convert NFA to DFA involves the following steps:

- For every state in the NFA, determine all *reachable states* for every input symbol.
- The set of reachable states constitute a *single state* in the converted DFA (Each state in the DFA corresponds to a subset of states in the NFA).
- Find *reachable states* for each new DFA state, until no more new states can be found.

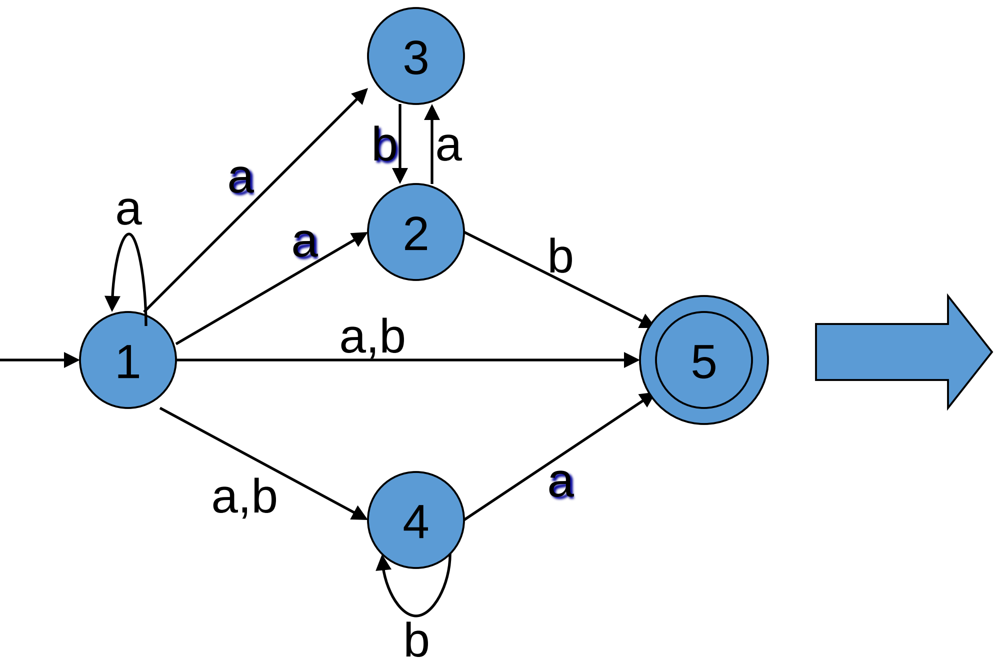
Subset Construction Method

Fig1. NFA without λ-transitions



Subset Construction Method

Fig1. NFA without λ-transitions



Step1

Construct a transition table showing all reachable states for every state for every input signal.

Subset Construction Method

Fig1. NFA without λ-transitions

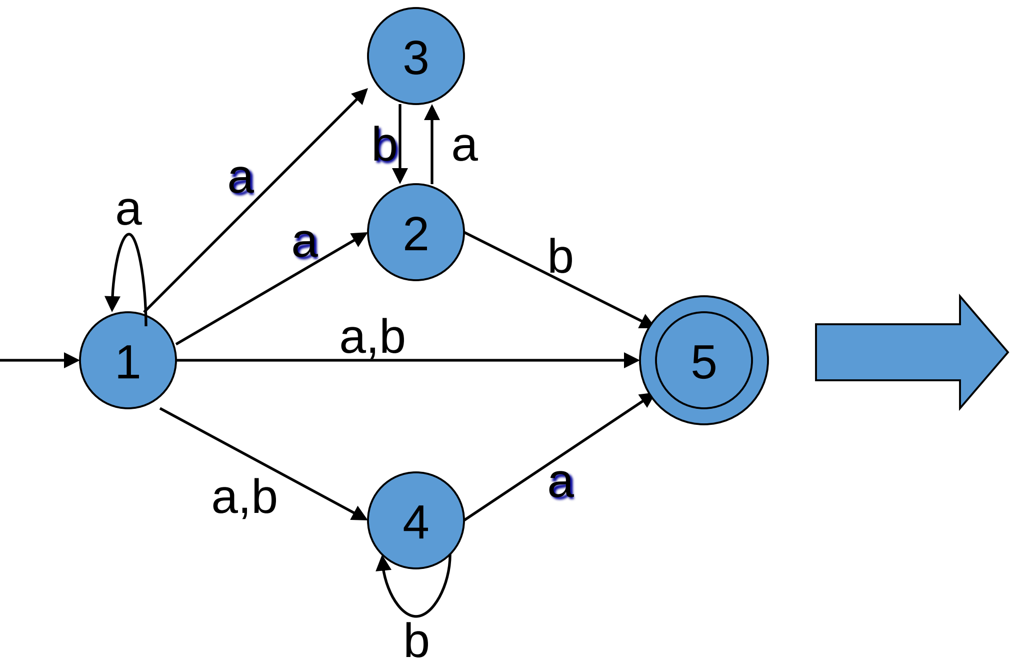


Fig2. Transition table

Subset Construction Method

Fig1. NFA without λ-transitions

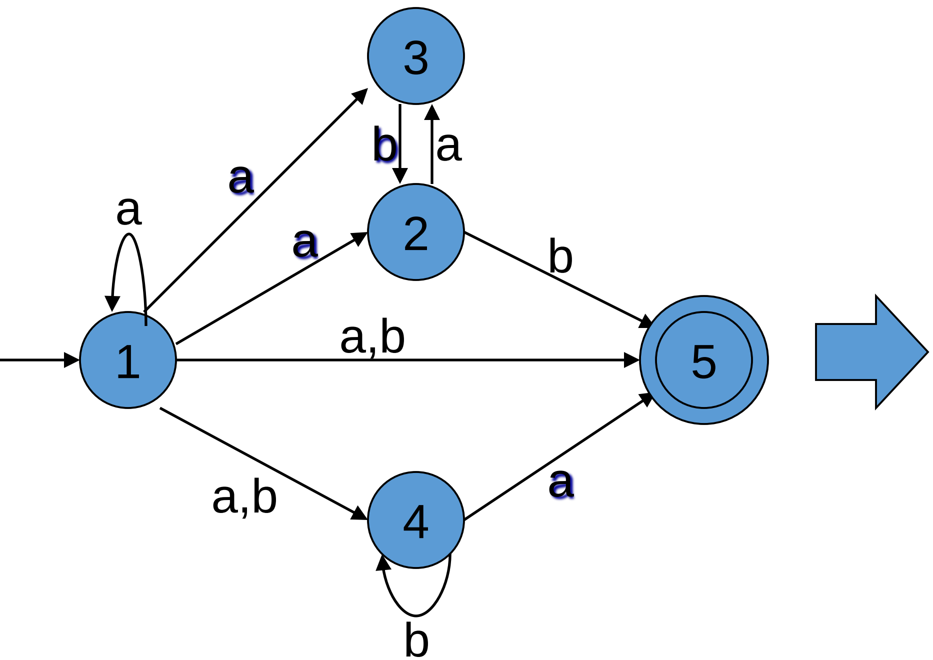
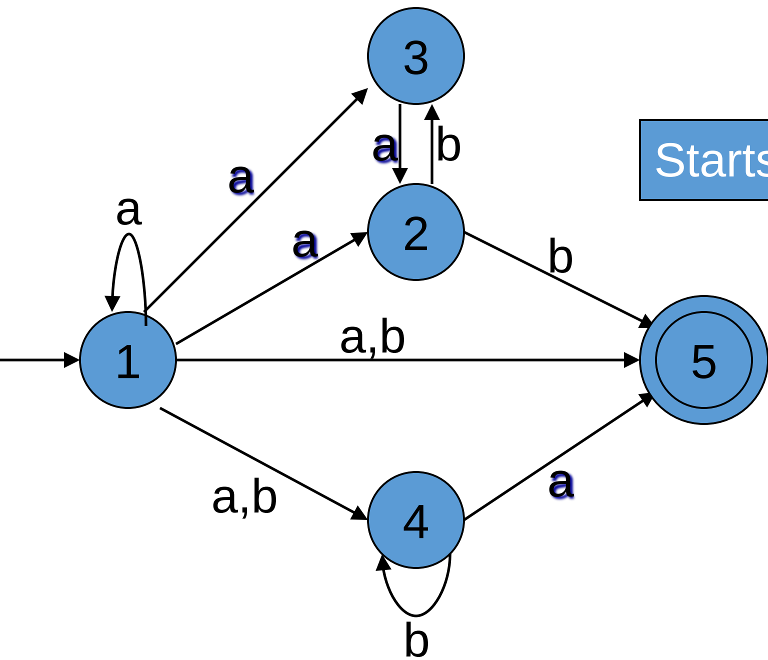


Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Subset Construction Method

Fig1. NFA without λ-transitions



Starts here

Transition from state q with input a

Transition from state q with input b

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Fig2. Transition table

Subset Construction Method

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Step2

The set of states resulting from every transition function constitutes a new state. Calculate all reachable states for every such state for every input signal.

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Fig3. Subset Construction table

Starts with Initial state

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Starts with Initial state

Fig3. Subset Construction table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}		
{4,5}		

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Starts with Initial state

Fig3. Subset Construction table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}		
{4,5}		

Step3

Repeat this process(step2) until no more new states are reachable.

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Fig3. Subset Construction table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}	{1,2,3,4,5}	{2,4,5}
{4,5}		
{2,4,5}		

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Fig3. Subset Construction table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}	{1,2,3,4,5}	{2,4,5}
{4,5}	5	4
{2,4,5}		
5		
4		

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Fig3. Subset Construction table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}	{1,2,3,4,5}	{2,4,5}
{4,5}	5	4
{2,4,5}	{3,5}	{4,5}
5		
4		
{3,5}		

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Fig3. Subset Construction table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}	{1,2,3,4,5}	{2,4,5}
{4,5}	5	4
{2,4,5}	{3,5}	{4,5}
5	∅	∅
4		
{3,5}		
∅		

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Fig3. Subset Construction table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}	{1,2,3,4,5}	{2,4,5}
{4,5}	5	4
{2,4,5}	{3,5}	{4,5}
5	∅	∅
4	5	4
{3,5}		

We already got 4 and 5.
So we don't add them again.

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	Ø	{2}
4	{5}	{4}
5	Ø	Ø

Fig3. Subset Construction table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}	{1,2,3,4,5}	{2,4,5}
{4,5}	5	4
{2,4,5}	{3,5}	{4,5}
5	Ø	Ø
4	5	4
{3,5}	Ø	2
Ø		
2		

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	Ø	{2}
4	{5}	{4}
5	Ø	Ø

Fig3. Subset Construction table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}	{1,2,3,4,5}	{2,4,5}
{4,5}	5	4
{2,4,5}	{3,5}	{4,5}
5	Ø	Ø
4	5	4
{3,5}	Ø	2
Ø	Ø	Ø
2		

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	Ø	{2}
4	{5}	{4}
5	Ø	Ø

Fig3. Subset Construction table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}	{1,2,3,4,5}	{2,4,5}
{4,5}	5	4
{2,4,5}	{3,5}	{4,5}
5	Ø	Ø
4	5	4
{3,5}	Ø	2
Ø	Ø	Ø
2	3	5
3		

Fig2. Transition table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
2	{3}	{5}
3	∅	{2}
4	{5}	{4}
5	∅	∅

Fig3. Subset Construction table

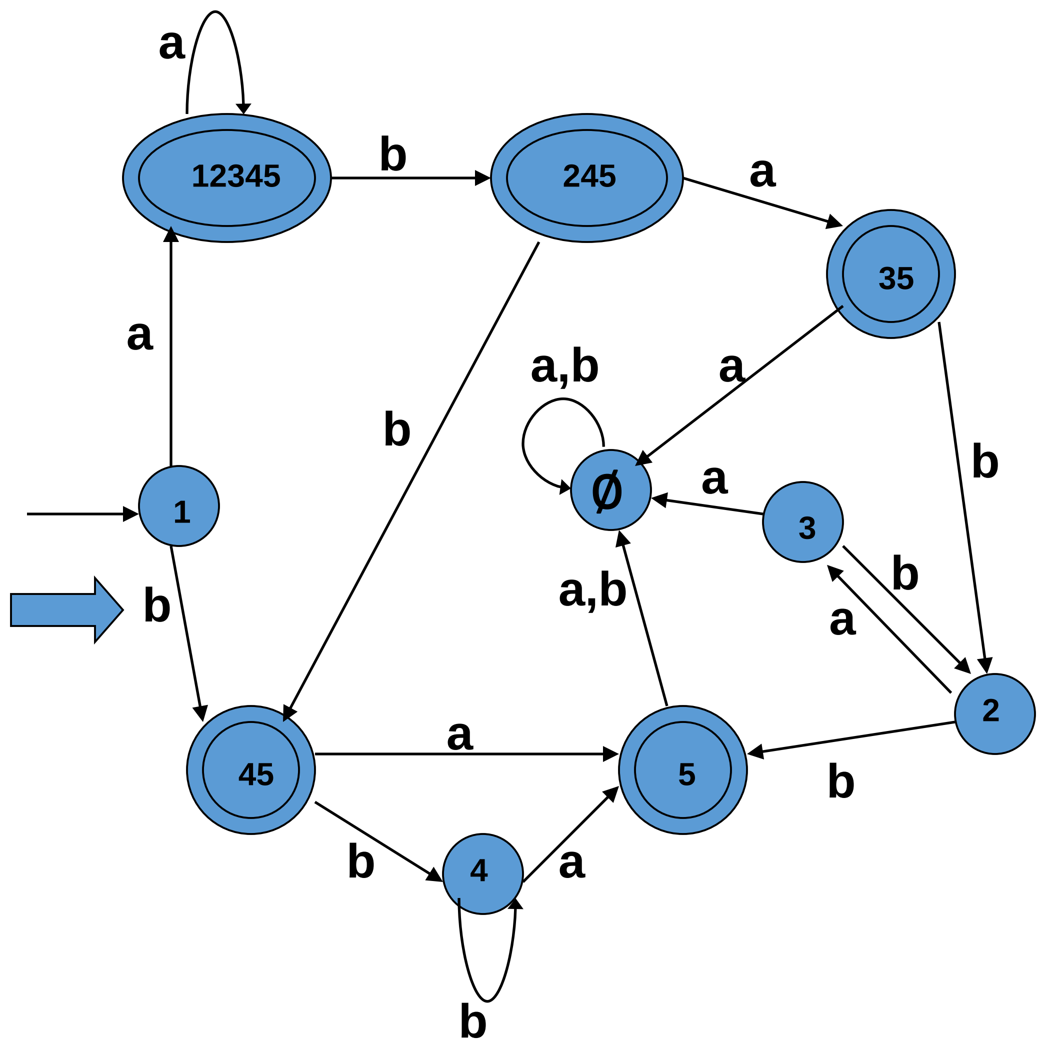
q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}	{1,2,3,4,5}	{2,4,5}
{4,5}	5	4
{2,4,5}	{3,5}	{4,5}
5	∅	∅
4	5	4
{3,5}	∅	2
∅	∅	∅
2	3	5
3	∅	2

Stops here as there are no more reachable states

Fig3. Subset Construction table

q	δ(q,a)	δ(q,b)
1	{1,2,3,4,5}	{4,5}
{1,2,3,4,5}	{1,2,3,4,5}	{2,4,5}
{4,5}	5	4
{2,4,5}	{3,5}	{4,5}
5	∅	∅
4	5	4
{3,5}	∅	2
∅	∅	∅
2	3	5
3	∅	2

Fig4. Resulting FA after applying Subset Construction to fig1



NFA to DFA Conversion

Let **$X = (Q_x, \sum, \delta_x, q_0, F_x)$** be an NFA which accepts the language L(X). We have to design an equivalent DFA **$Y = (Q_y, \sum, \delta_y, q_0, F_y)$** such that **L(Y) = L(X)**.
The following procedure converts the NFA to its equivalent DFA −

Algorithm:

Input − An NFA

Output − An equivalent DFA

Step 1 − Create state table from the given NFA.

Step 2 − Create a blank state table under possible input alphabets for the equivalent DFA.

Step 3 − Mark the start state of the DFA by q0 (Same as the NFA).

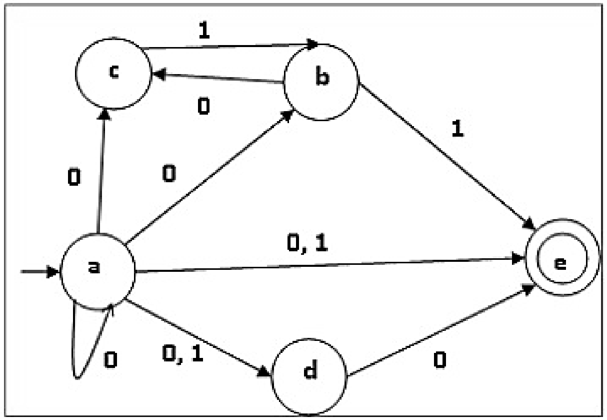
Step 4 − Find out the combination of States {Q0, Q1,... , Qn} for each possible input alphabet.

Step 5 − Each time we generate a new DFA state under the input alphabet columns, we have to apply step 4 again, otherwise go to step 6.

Step 6 − The states which contain any of the final states of the NFA are the final states of the equivalent DFA.

Example

Let us consider the NFA shown in the figure:



The state transition table of the NFA is:

q	δ(q,0)	δ(q,1)
a	{a,b,c,d,e}	{d,e}
b	{c}	{e}
c	∅	{b}
d	{e}	∅
e	∅	∅

Example...

The state transition table of the NFA is:

q	δ(q,0)	δ(q,1)
a	{a,b,c,d,e}	{d,e}
b	{c}	{e}
c	Ø	{b}
d	{e}	Ø
e	Ø	Ø

Using the algorithm, we find its equivalent DFA.
The state transition table of the DFA is:

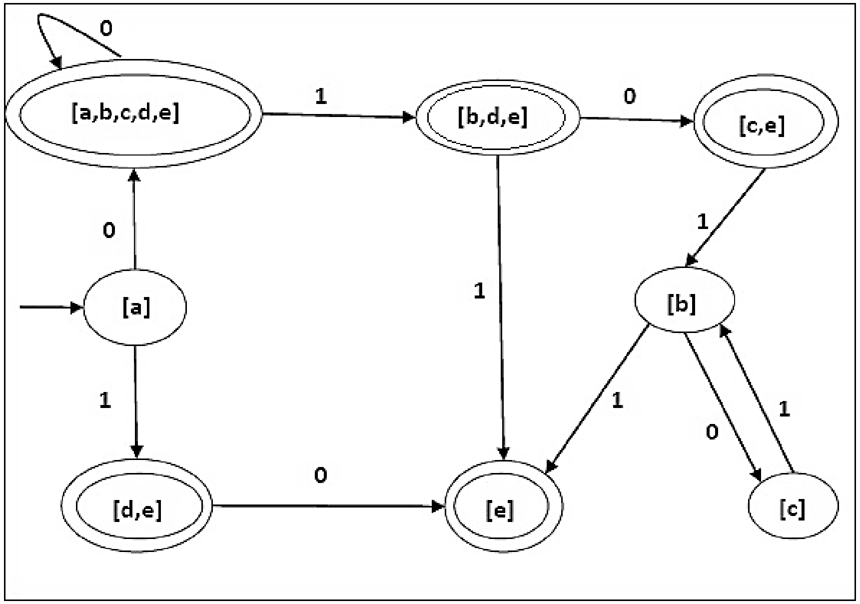
q	δ(q,0)	δ(q,1)
[a]	[a,b,c,d,e]	[d,e]
[a,b,c,d,e]	[a,b,c,d,e]	[b,d,e]
[d,e]	[e]	Ø
[b,d,e]	[c,e]	[e]
[e]	Ø	Ø
[c, e]	Ø	[b]
[b]	[c]	[e]
[c]	Ø	[b]

Example…

The state transition table of the DFA is:

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]

The state diagram of the DFA is as follows:



THANK YOU