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Date	<TO BE 16/8/24Y STUDENT>	Student Name	<T G.VG.Man

TUTORIAL SESSION 06:

DFA Minimization

Concept Building

Construct an automaton with the minimum number of states equivalent to a given a
With fewer states and transitions, the minimized DFA requires fewer computations and mem
resulting in faster execution.

Definition Two states $q_1$and $q_2$are equivalent (denoted by $q_1 \equiv q_2$) if both $\delta(q_{1,}x)$
final states. or both are nonfinal states for all $x \in \sum^*$.As it is difficult to construct $\delta(q_1,$
for all $x \in \sum^*$ (there are an infinite number of strings in $\sum^*$). we give one more definition.

Definition Two states q_1 and q_2 are k-equivalent $(k \geq 0)$ if both $\delta(q_1, x)$and $\delta(q_{2,}x)$
or both nonfinal states for all strings $|x| \leq k$.

Myhill-Nerode Theorem

It states that a regular language can be recognized by a deterministic finite automaton (DFA)
be recognized by a non-deterministic finite automaton (NFA) with a finite number of states. T
provides a method for minimizing a DFA by eliminating unnecessary states and transitions, re
efficient and simplified automaton.

Steps for Minimization:

Step 1: Create a Table: Create a table for all pairs of states in the DFA.

Step 2: Mark Pairs: Mark all pairs of states where one state is final and the other is no

Step 3: Repeat: Repeat Step 2 until no more pairs can be marked.

Step 4: Combine: Combine all unmarked pairs of states into a single state in the minir

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Date	6/8/24	Student Name	G.V.G. Maneesh

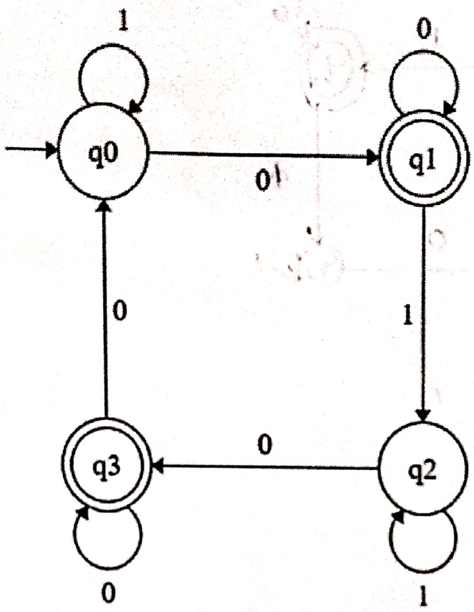
Pre-Tutorial (To be completed by student before attending tutorial session)

1.Find the equivalent states in the following automaton. Explain.

$Q = \{q_0, q_1, q_2, q_3\}$

$F = \{q_1, q_3\}$

$Q - F = \{q_0, q_2\}$



q_1	X		
q_2	X	X	
q_3	X	X	X
	q_0	q_1	q_2

After Iteration 1

$(q_2, q_0) \Rightarrow$ empty

After Iteration

No empty.

Solution:

(i) Equivalent States:

Reason: ~~There are no equivalent states in this DFA, Because the given DFA is treated as minimal DFA~~

(ii) Non-equivalent states:

Reason: All states $Q = \{q_0, q_1, q_2, q_3\}$ are non-equivalent states

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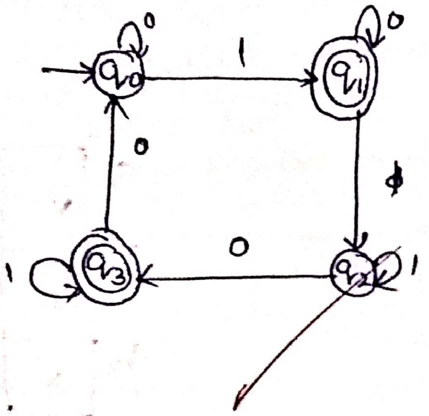
2. Construct a minimum state automaton of the automaton given in Q# 1.

Solution:



3. Differentiate between DFA and 2DFA.

DFA : A DFA processes input strictly left to right with a single pass, recognizing regular languages.

2DFA : It can move its head both left and right, offering more flexibility.

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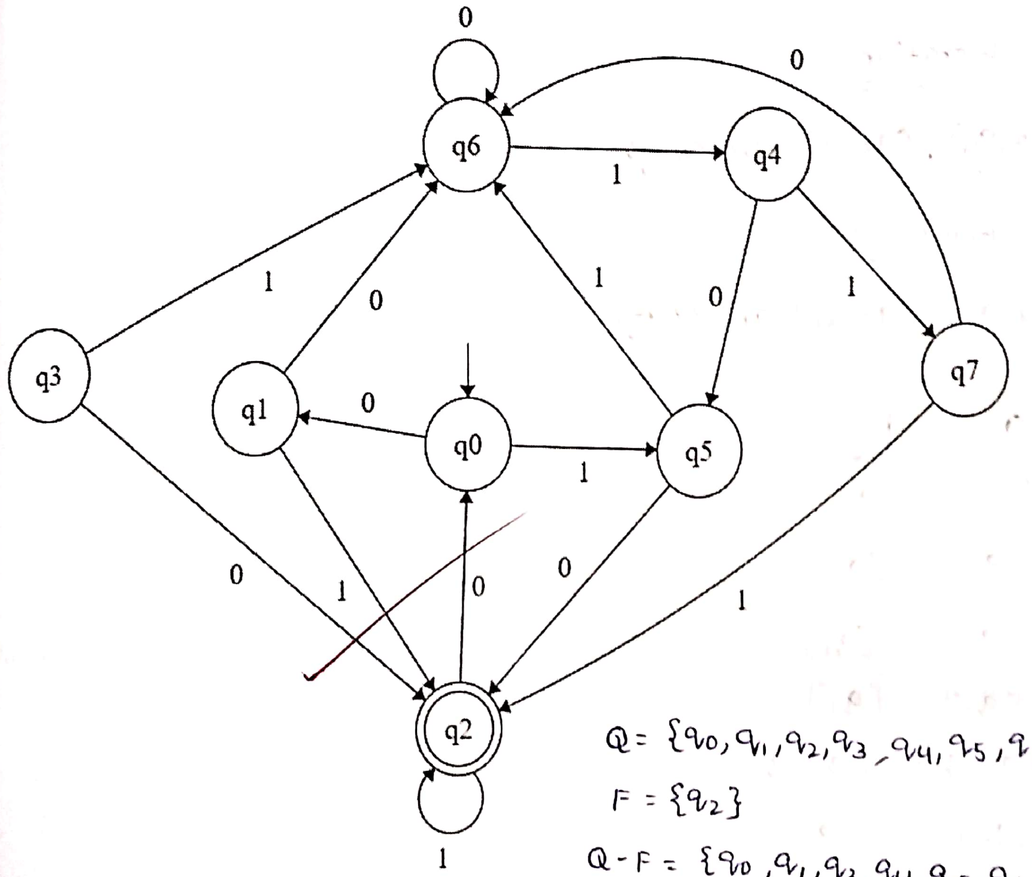
IN-TUTORIAL (To be carried out in presence of faculty in classroom)

. Construct a minimum state automaton equivalent to the finite automaton given below.



$Q = \{q_0, q_1, q_2, q_3, q_4, q_5, q_6\}$

$F = \{q_2\}$

$Q - F = \{q_0, q_1, q_3, q_4, q_5, q_6\}$

Solution:

q_1	X						
q_2	X	X					
q_3	X	X	X				
q_4	X	X	X	X			
q_5	X	X	X	O	X		
q_6	X	X	X	X	X	X	
q_7	X	O	X	X	X	X	X
	q_0	q_1	q_2	q_3	q_4	q_5	q_6

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After Iteration 1

$(q_3,q_0), (q_0,q_4), (q_0,q_5), (q_0,q_6), (q_5,q_3), (q_1,q_7),$

(q_6,q_4) are empty states

After Iteration 2

$(q_7,q_1), (q_5,q_3)$ are empty

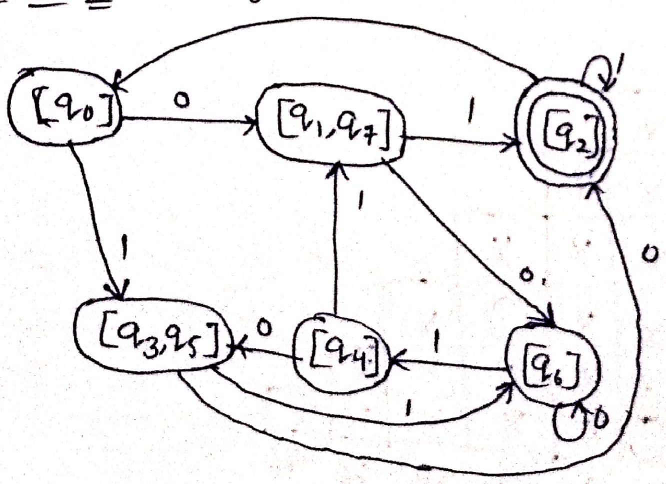
After Iteration 3

$(q_7,q_1), (q_5,q_3)$ are empty

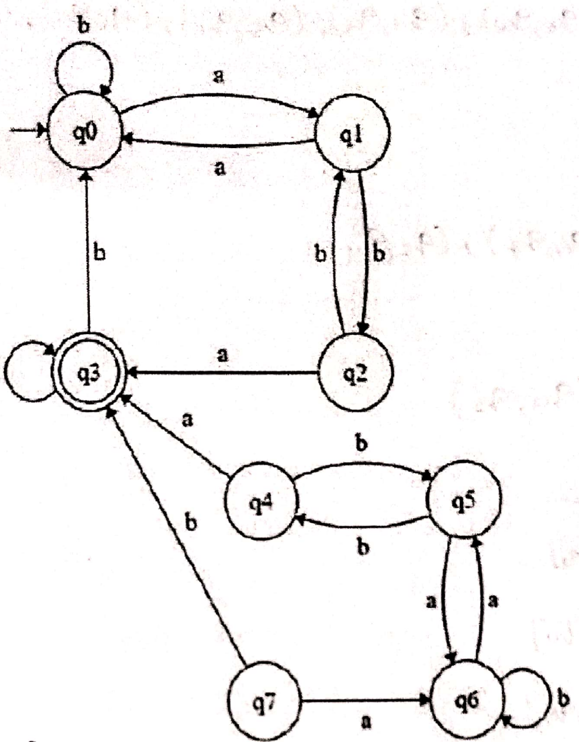
DFA δ'

δ'	0	1
$\rightarrow[q_0]$	$[q_1,q_7]$	$[q_5,q_3]$
$[q_1,q_7]$	$[q_6]$	$[q_2]$
$*[q_3]$	$[q_0]$	$[q_2]$
$[q_3,q_5]$	$[q_2]$	$[q_6]$
$[q_4]$	$[q_5,q_3]$	$[q_7,q_1]$
$[q_6]$	$[q_6]$	$[q_4]$

DFA minimized



. Construct a minimum state automaton equivalent to the transition diagram given below.



Solution:

$Q = \{q_0, q_1, q_2, q_3, q_4, q_5, q_6, q_7\}$

$F = \{q_3\}$

$Q - F = \{q_0, q_1, q_2, q_4, q_5, q_6, q_7\}$

q_1	X						
q_2	X	X					
q_3	X	X	X				
q_4	X	X	O	X			
q_5	X	X	X	X	X		
q_6	O	X	X	X	X	X	
q_7	X	X	X	X	X	X	X
	q_0	q_1	q_2	q_3	q_4	q_5	q_6

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After iteration 1 (empty state)

$(q_1,q_0), (q_5,q_0), (q_6,q_0), (q_4,q_2), (q_5,q_1), (q_6,q_1), (q_7,q_1)$

After iteration 2

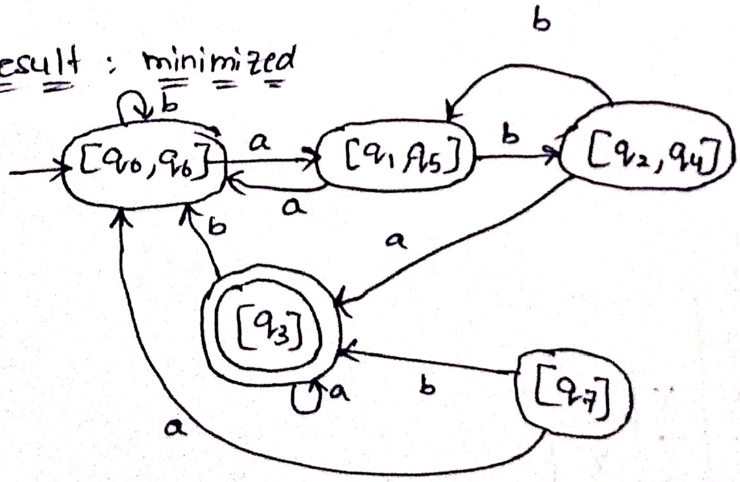
$(q_6,q_0), (q_1,q_5), (q_1,q_7), (q_2,q_4)$

After iteration 3

$(q_6,q_0), (q_5,q_1), (q_4,q_2)$

δ'	a	b
→ [q0, q6]	[q1, q5]	[q0, q6]
[q1, q5]	[q0, q6]	[q2, q4]
[q2, q4]	[q3]	[q1, q5]
* [q3]	[q3]	[q0, q6]
[q7]	[q0, q6]	[q3]

Result : minimized



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Post-Tutorial(To be carried out by student after attending tutorial session)

1. Construct a minimum state automaton equivalent to the given automaton whose transition table is given below. Initial state: q_0, Final State: q_6.

State	a	b
→ q_0	q_0	q_3
q_1	q_2	q_5
q_2	q_3	q_4
q_3	q_0	q_5
q_4	q_0	q_6
q_5	q_1	q_4
* q_6	q_1	q_3

Solution:

$Q = \{q_0, q_1, q_2, q_3, q_4, q_5, q_6\}$

$F = \{q_6\}$

$Q - F = \{q_0, q_1, q_2, q_3, q_4, q_5\}$

$= \{(q_6, q_0), (q_6, q_1), (q_6, q_2), (q_6, q_3), (q_6, q_4), (q_6, q_5)\}$

q_1	X					
q_2	X	X				
q_3	X	X	X			
q_4	X	X	X	X		
q_5	X	X	X	X	X	
q_6	X	X	X	X	X	X
	q_0	q_1	q_2	q_3	q_4	q_5

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After Iteration 1 : Empty states are

(q_0,q_1) (q_0,q_5) (q_1,q_5)

(q_0,q_2) (q_1,q_2) (q_2,q_3)

(q_0,q_3) (q_1,q_3) (q_3,q_5)

After Iteration 2 : Empty states are

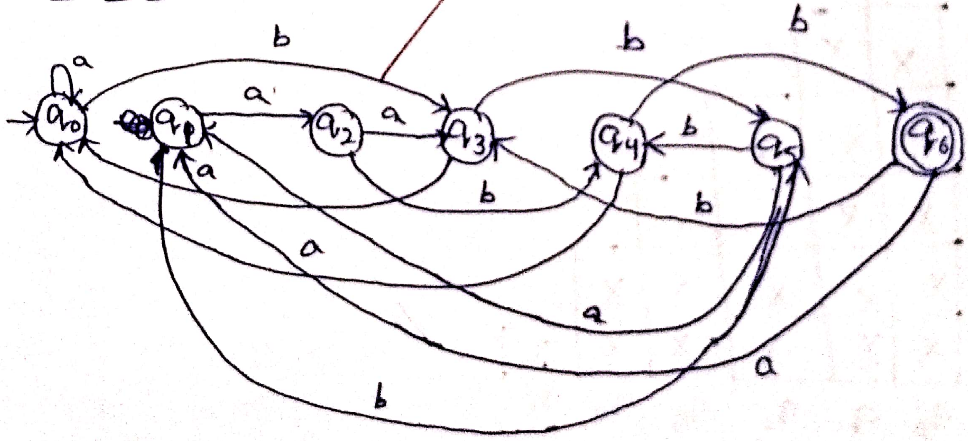
(q_0,q_1), (q_0,q_3)

After Iteration 3 .

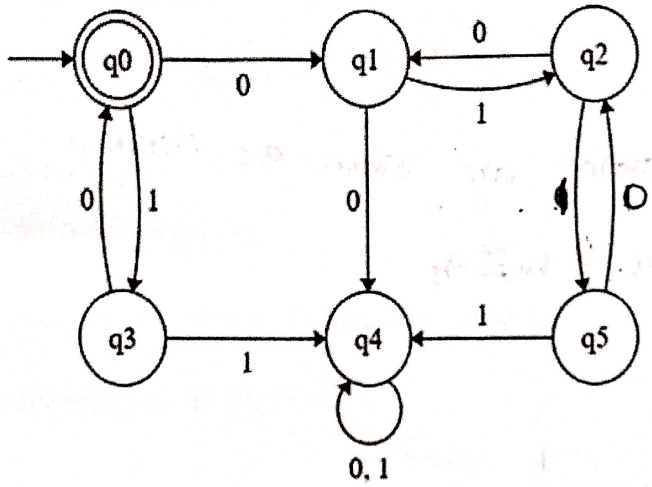
No empty states

So, the given DFA is minimal DFA

Minimized:



Construct a minimum state automaton equivalent to the DFA described in the following transition diagram.



Solution:

	q_0	q_1	q_2	q_3	q_4
q_1	X				
q_2	X				
q_3	X	X	X		
q_4	X			X	
q_5	X			X	

$Q = \{q_0, q_1, q_2, q_3, q_4, q_5\}$

$F = \{q_0\}$

$Q - F = \{q_1, q_2, q_3, q_4, q_5\}$

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After Iteration 1:

pending | Empty states are
$(q_1, q_2), (q_1, q_4), (q_1, q_5), (q_2, q_4), (q_2, q_5), (q_4, q_5)$

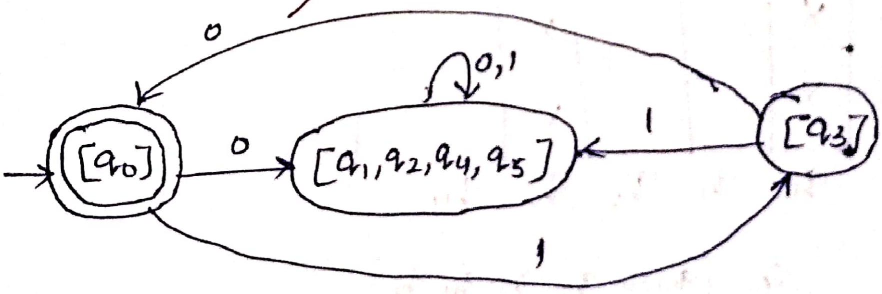
After Iteration 2:

pending | Empty states are same as Iteration

$\therefore\ q_1 \cong q_2 \cong q_4 \cong q_5$

Final DFA

δ'	0	1
$* \rightarrow [q_0]$	$[q_1, q_2, q_4, q_5]$	$[q_3]$
$[q_1, q_2, q_4, q_5]$	$[q_1, q_2, q_4, q_5]$	$[q_1, q_2, q_4, q_5]$
$[q_3]$	$[q_0]$	$[q_1, q_2, q_4, q_5]$



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Date	<TO BE FILLED BY STUDENT> 17/8/24	Student Name	<TO BE FILLED BY STUDENT> G.V.G. Maneesh

Viva Questions

1. What is the purpose of minimizing a DFA?

Answer:

→ It can be used to reduce the no. of States and transitions of the DFA given.

→ It is used to increase the efficiency of DFA

2. What is the difference between indistinguishable and distinguishable pairs of states in a DFA?

Answer:

Indistinguishable pairs ⇒ Indicates with 'X'
* different states

distingushable pairs ⇒ Indicates with 'O'
* equal states

(For Evaluator's use only)

Comment of the Evaluator (if Any)	Evaluator's Observation
	Marks Secured: 50 out of 50 Full Name of the Evaluator: Signature of the Evaluator Date of Evaluation: 19/8/2024