STATE REDUCTION/MINIMIZATION

The state reduction is used to avoid the redundant states in the sequential circuits. The reduction in redundant states reduces the number of required Flip-Flops and logic gates, reducing the cost of the final circuit.

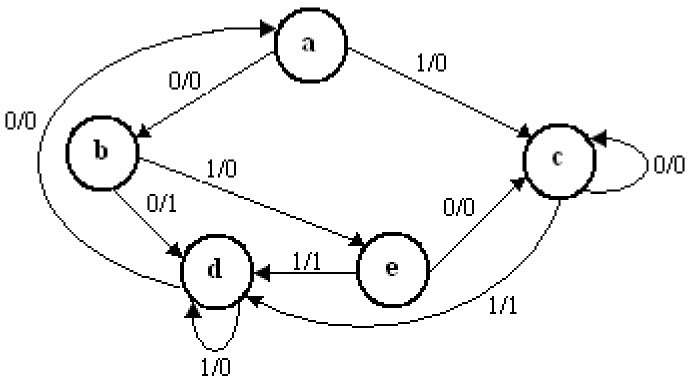
The two states are said to be redundant or equivalent, if every possible set of Inputs generate exactly same output and same next state. When two states are equivalent, one of them can be removed without altering the input-output relationship.

Since'n' Flip-flops produced 2^nstate, are duction in the number of states may result in are Reduction in the number of Flip-Flops.

The need for state reduction or state minimization is explained with one example.

Examples:

1. Reduce the number of states in the following state diagram and draw the reduced state diagram



State diagram

Step1:Determine the state table for given state diagram

Presentstate	Nextstate		Output	
	X=0	X=1	X=0	X=1
a	b	c	0	0
b	d	e	1	0
c	c	d	0	1
d	a	d	0	0
e	c	d	0	1

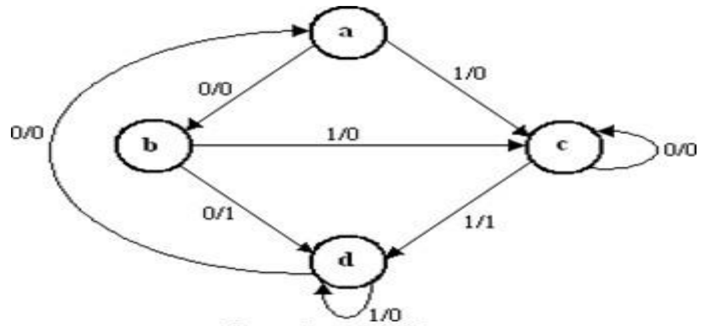
Step2:Find equivalent states
From the above state table **c**an d**e**generate exactly same next state and same

Output for every possible set of inputs.The state **c** and **e** go to next states **c** and **d** and have out puts 0 and 1 for x=0 and x=1 respectively. Therefore state **e** can be removed and replaced by **c**.The final reduced state table is shown below.

Presentstate	Nextstate		Output	
	X=0	X=1	X=0	X=1
a	b	c	0	0
b	d	c	1	0
c	c	d	0	1
d	a	d	0	0

Reduced state table

Step3:Draw state diagram



Reduced state diagram

2. Reducethenumberofstatesinthefollowingstatetableandtabulatethereduced statetable.

Presentstate	Nextstate		Output	
	X=0	X=1	X=0	X=1
a	a	b	0	0
b	c	d	0	0
c	a	d	0	0
d	e	f	0	1
e	a	f	0	1
f	g	f	0	1
g	a	f	0	1

Soln:

From the above state table **e** and **g** generate exactly same next state and same output for every possible set of inputs. The state **e** and **g** go to next states **a** and **f** and have outputs 0 and 1 for x=0 and x=1 respectively. Therefore state **g** can be removed and replaced by **e.**

The reduced state table-1 is shown below.

Present state	Next state		Output	
	X=0	X=1	X=0	X=1
a	A	b	0	0
b	C	d	0	0
c	A	d	0	0
d	E	f	0	1
e	A	f	0	1
f	**E**	f	0	1

Now states d and f are equivalent. Both states go to the same next state(e,f)and have same output(0,1).Therefore one state can be removed; **f** is replaced by **d.**

The final reduced state table-2 is shown below.

Present state	Next state		Output	
	X=0	X=1	X=0	X=1
a	a	b	0	0
b	c	d	0	0
c	a	**d**	0	0
d	e	**d**	0	1
e	a	**d**	0	1

Reducedstatetable-2

Thus 7 states are reduced into 5 states

3. Determine a minimal state table equivalent furnished below

Present state	Next state	
	X=0	X=1
1	1,0	1,0
2	1,1	6,1
3	4,0	5,0
4	1,1	7,0
5	2,0	3,0
6	4,0	5,0
7	2,0	3,0

Soln:

Present state	Next state		Output	
	X=0	X=1	X=0	X=1
1	1	1	0	0
2	1	6	1	1
3	4	5	0	0
4	1	7	1	0
5	2	3	0	0
6	4	5	0	0
7	2	3	0	0

From the above state table, **5** and **7** generate exactly same next state and same output for every possible set of inputs. The state **5** and **7** go to next states **2** and **3**and have outputs 0 and 0 for x=0 and x=1 respectively.Therefore state **7** can be removed and replaced by **5.**

Similarly,**3** and **6** generate exactly same next state and same output for every possible set of inputs. The state **3** and **6** go to next states **4** and **5** and have outputs 0 and for x=0 and x=1respectively. Therefore state **6** can be removed and replacedby**3**.Thefinal reduced state table is shown below.

Present state	**Next state**		**Output**	
	X=0	**X=1**	**X=0**	**X=1**
1	1	1	0	0
2	1	3	1	1
3	4	5	0	0
4	1	5	1	0
5	2	3	0	0

Reduced state table

Thus 7 states are reduced into 5 state

4. Minimize the following state table

Present state	Next state	
	X=0	X=1
A	D,0	C,1
B	E,1	A,1
C	H, 1	D,1
D	D,0	C,1
E	B,0	G, 1
F	H, 1	D,1
G	A,0	F,1
H	C,0	A,1
I	G, 1	H,1

Soln:

Present state	Next state		Output	
	X=0	X=1	X=0	X=1
A	D	C	0	1
B	E	A	1	1
C	H	D	1	1
D	D	C	0	1
E	B	G	0	1
F	H	D	1	1
G	A	F	0	1
H	C	A	0	1
I	G	H	1	1

From the above state table, **A** and **D** generate exactly same next state and same output for every possible set of inputs. The state **A** and **D** go to next states **D**and **C** and have outputs 0 and 1 forx=0 and x=1 respectively. Therefore state **D** can be removed and replaced by **A**. Similarly, **C** and **F** generate exactly same next state and same output for every possible set of inputs. The state **C** and **F** go to next states **H** and **D** and have outputs 1 and 1 for x=0 and x=1 respectively. Therefore state **F** can be removed and replaced By C

Presentstate	Nextstate		Output	
	X=0	X=1	X=0	X=1
A	A	C	0	1
B	E	A	1	1
C	H	A	1	1
E	B	G	0	1
G	A	C	0	1
H	C	A	0	1
I	G	H	1	1

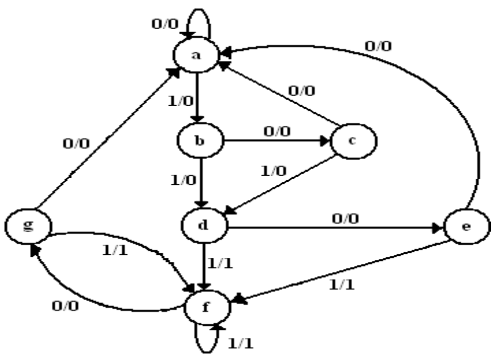
Reducedstatetable-1

From the above reduced state table-1, **A** and **G** generate exactly same next state and sameoutput for every possible set of inputs. The state **A** and **G** go to next states **A** and **C** and haveoutputs 0 and 1 for x=0 and x=1 respectively. Therefore state **G** can be removed and replaced by **A.** The final reduced state table-2 is shown below.

Present state	Next state		Output	
	X=0	X=1	X=0	X=1
A	A	C	0	1
B	E	A	1	1
C	H	A	1	1
E	B	A	0	1
H	C	A	0	1
I	A	H	1	1

Thus 9 states are reduced in to 6 states.

5.Reduce the following state diagram



SOLN:

Present state	Next state		Output	
	X=0	X=1	X=0	X=1
a	a	b	0	0
b	c	d	0	0
c	a	d	0	0
d	e	f	0	1
e	a	f	0	1
f	g	f	0	1
g	a	f	0	1

State table

From the above state table **e** and **g** generate exactly same next state and same output for every possible set of inputs.The state **e** and **g** go to next states **a** and **f** and have outputs 0 and 1 for x=0 and x=1 respectively.Therefore state **g** can be removed and replaced by **e**.The reduced state table-1 is shown below.

Present state	**Next state**		**Output**	
	X=0	**X=1**	**X=0**	**X=1**
a	a	b	0	0
b	c	d	0	0
c	a	d	0	0
d	e	f	0	1
e	a	f	0	1
f	**e**	f	0	1

Reducedstatetable-1

Now states d and f are equivalent. Both states go to the same next state(e,f)and have same output(0,1).Therefore one state can be removed; **f** is replaced by **d.**

The final reduced state table-2 is shown below.

Present state	Next state		Output	
	X=0	X=1	X=0	X=1
A	A	b	0	0
b	C	d	0	0
c	A	**d**	0	0
d	E	**d**	0	1
e	A	**d**	0	1

Reduced state table-2

Thus 7 states are reduced into 5 states.

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Reduced state