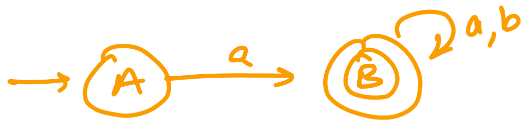
Conversion of NFA to DFA:

Both DFA & NFA equally powerful.

by default DFA is NFA

But NFA is not DFA.

Eg: NFA Starts with 'a' $\Sigma = \{a,b\}$



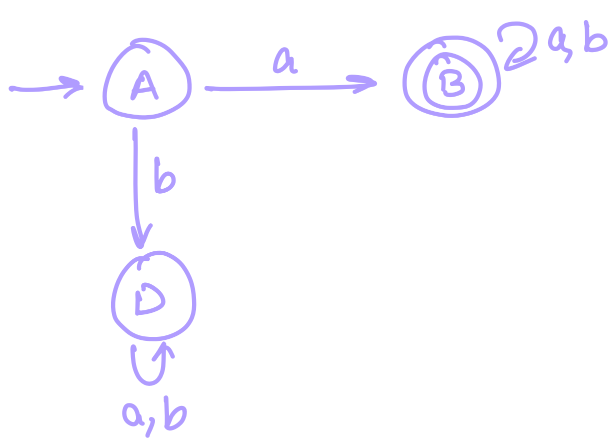
→ State Transition Diagram

State Transition Table:
(NFA)

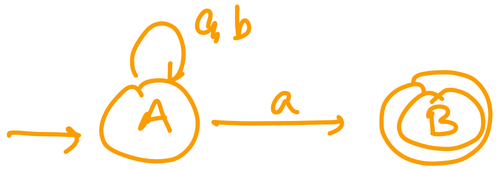
	a	b
→ A	B	ϕ → no move available
* B	B	B

State Transition Table:
(DFA)

	a	b
→ A	B	D (Dead State)
* B	B	B
D	D	D



Eg: NFA Ends with a



STT (NFA)

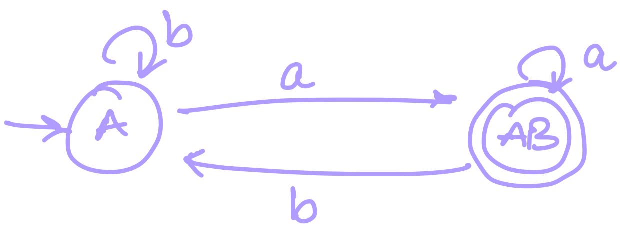
	a	b
→ A	AB	A
* B	ϕ	ϕ

no transition

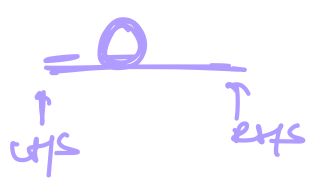
STT (DFA)

	a	b
→ A	AB	A
* AB	AB	A

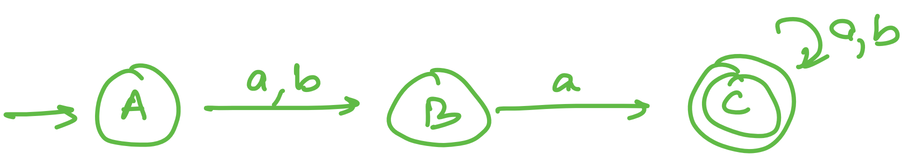
STD (DFA) :



Eg: NFA : 2^{nd} symbol from LHS is 'a'



STD (NFA)



STT (NFA)

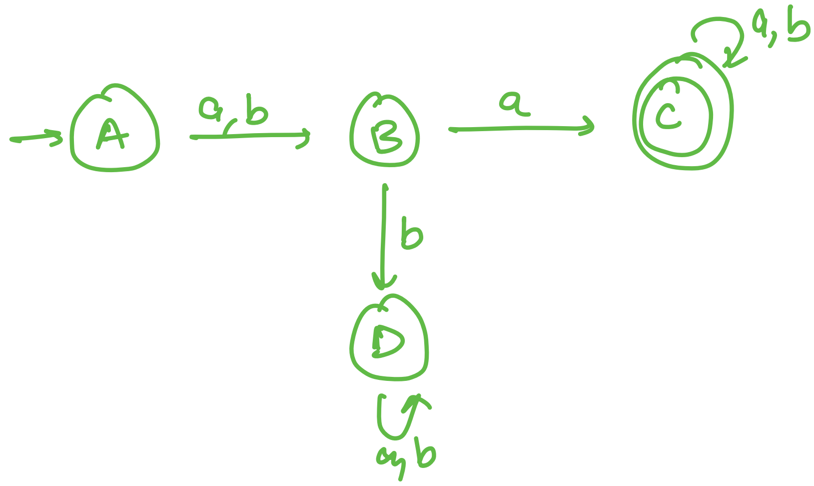
	a	b
→ A	B	B
B	C	ϕ
* C	C	C

$\phi \rightarrow$ Dead State

STT (DFA)

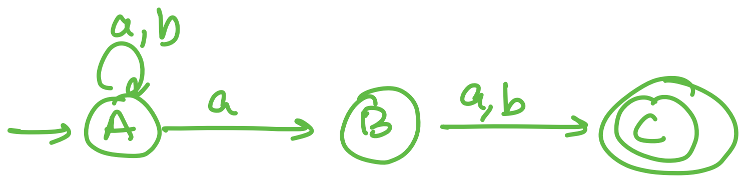
	a	b
→ A	B	B
B	C	D
→* C	C	C
D	D	D

STD (DFA)



Eg: Second symbol from RHS is 'a'

NFA (STD)



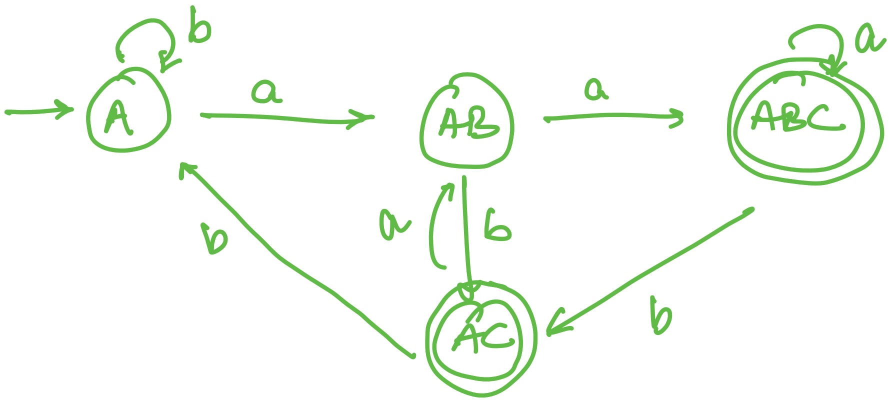
NFA (STT)

	a	b
→ A	AB	A
B	C	C
* C	ϕ	ϕ

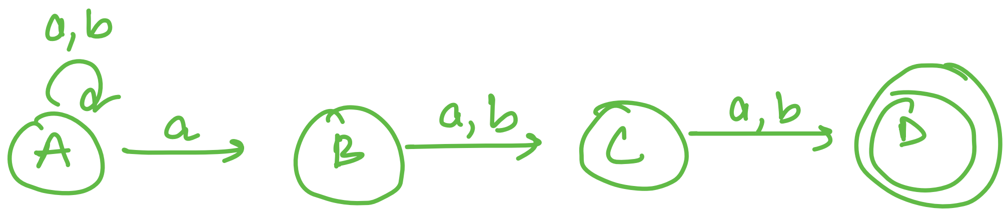
DFA (STT)

	a	b
→ A	AB	A
AB	ABC	AC

* ABC	ABC	AC
* AC	AB	A



Eg: 3rd symbol from RHS is 'a'



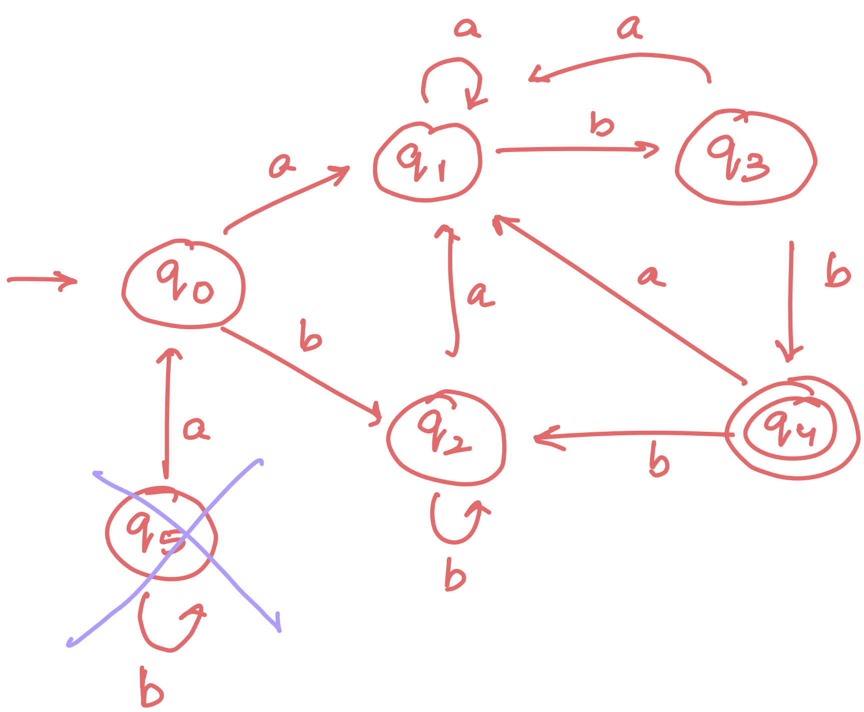
	a	b
→ A	AB	A
B	C	C
C	D	D
* D	ϕ	ϕ

	a	b
→ A	AB ✓	A ✓
AB	ABC ✓	AC ✓
ABC	ABCD ✓	ACD ✓
AC	ABD ✓	AD ✓
* ABCD	ABCD ✓	ACD ✓
* ACD	ABD ✓	AD ✓

* ABD	ABC ✓	AC ✓
* AD	ABD ✓	A ✓

Minimization of DFA:

Eg:



1. Unreachable states remove (q_5 remove)

2.

	a	b
$\rightarrow q_0$	q_1	q_2
q_1	q_1	q_3
q_2	q_1	q_2
q_3	q_1	q_4
$* q_4$	q_1	q_2

3. Find out 0 Equivalent states (final & non final separate)

0 Equivalent States: $[q_0 \ q_1 \ q_2 \ q_3]$ $[q_4]$

Find out 1 equivalent States:

$q_0 \ q_1$?

	a	b
q_0	q_1	q_2
q_1	q_1	q_2

same state

same set

$[q_0 q_1]$ $[q_4]$ q_2 ? q_3 ?

$q_0 q_2$?

	a	b
q_0	q_1	q_2
q_2	q_1	q_2

same state

same state

$[q_0 q_1 q_2]$ $[q_4]$ q_3 ?

$q_0 q_3$?

	a	b
q_0	q_1	q_2
q_3	q_1	q_4

same state

different state

$[q_0 q_1 q_2]$ $[q_4]$ $[q_3]$

2 Equivalence

[$q_0 q_1 q_2$] [q_4] [q_3]

$q_0 q_1$

	a	b
q_0	q_1	q_2
q_1	q_1	q_2

different set

[q_0] [q_1] [q_4] [q_3] q_2 ?

?

$q_0 q_2$

	a	b
q_0	q_1	q_2
q_2	q_1	q_2

[$q_0 q_2$] [q_1] [q_4] [q_3]

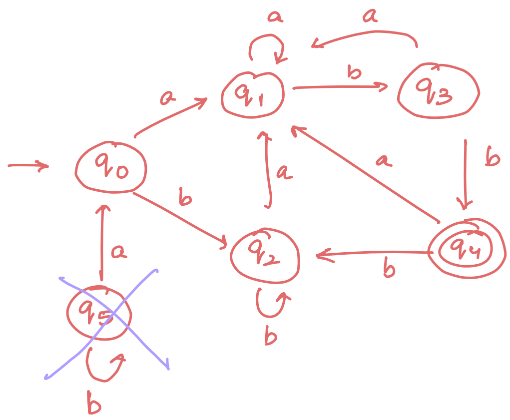
3 Equivalence

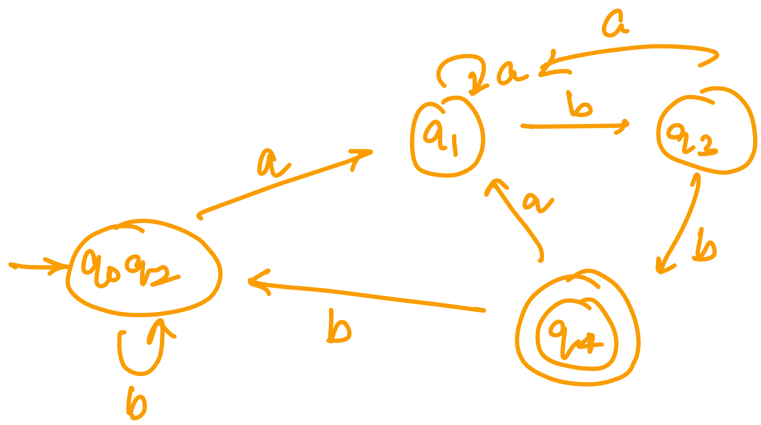
	a	b
q_0	q_1	q_2
q_2	q_1	q_2

same state

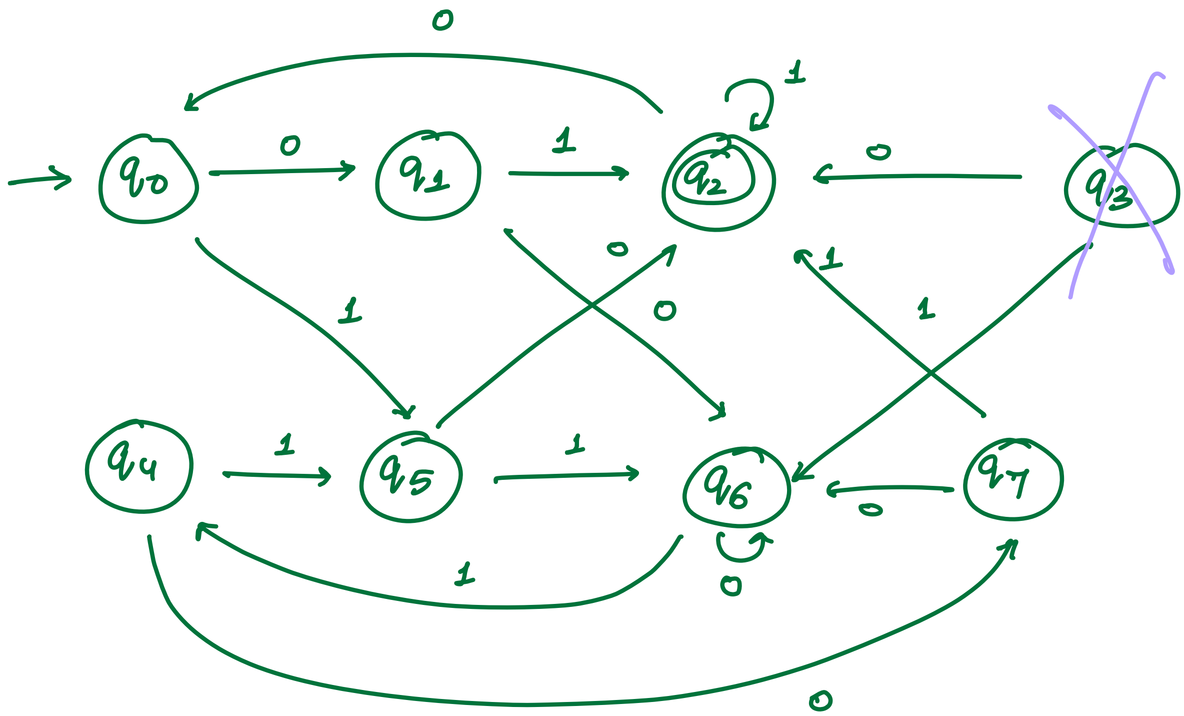
same state

[$q_0 q_2$] [q_1] [q_4] [q_3]





Eg:

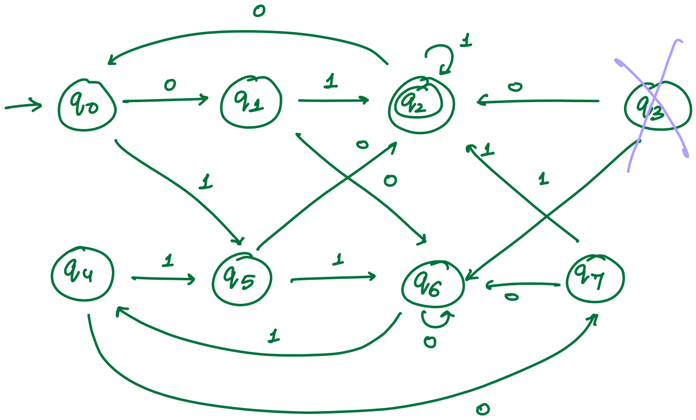


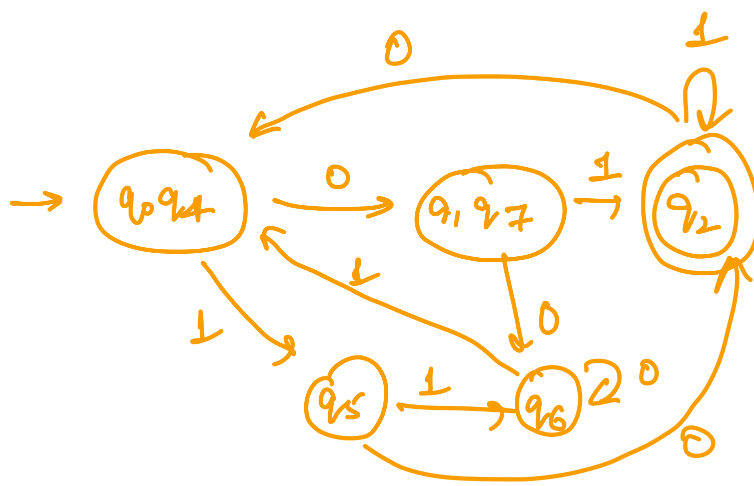
	0	1
→ q_0	q_1	q_5
q_1	q_6	q_2 *
* q_2	q_0	q_2 *
q_4	q_7	q_5
q_5	q_2 *	q_6
q_6	q_6	q_4
q_7	q_6	q_2 *

merge

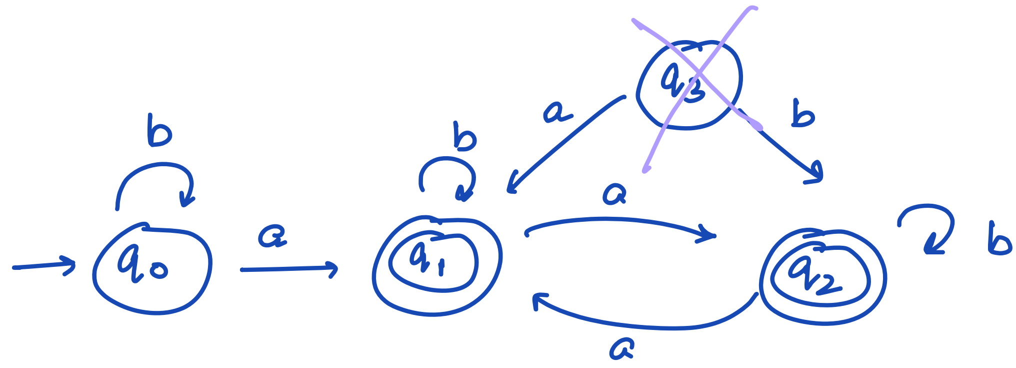
	0	1
→ q_0	q_1q_7	q_5
q_1q_7	q_6	q_2*
* q_2	q_0	q_2*
q_4	q_1q_7	q_5
q_5	q_2*	q_6
q_6	q_6	q_4

	0	1
→ q_0q_4	q_1q_7	q_5
q_1q_7	q_6	q_2*
* q_2	q_0q_4	q_2*
q_5	q_2*	q_6
q_6	q_6	q_0q_4

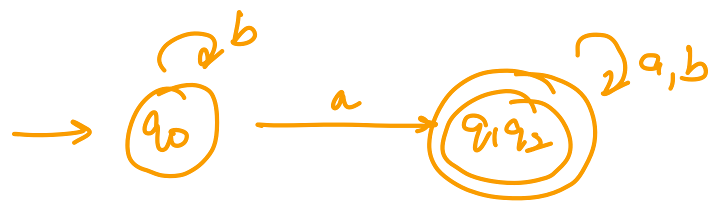




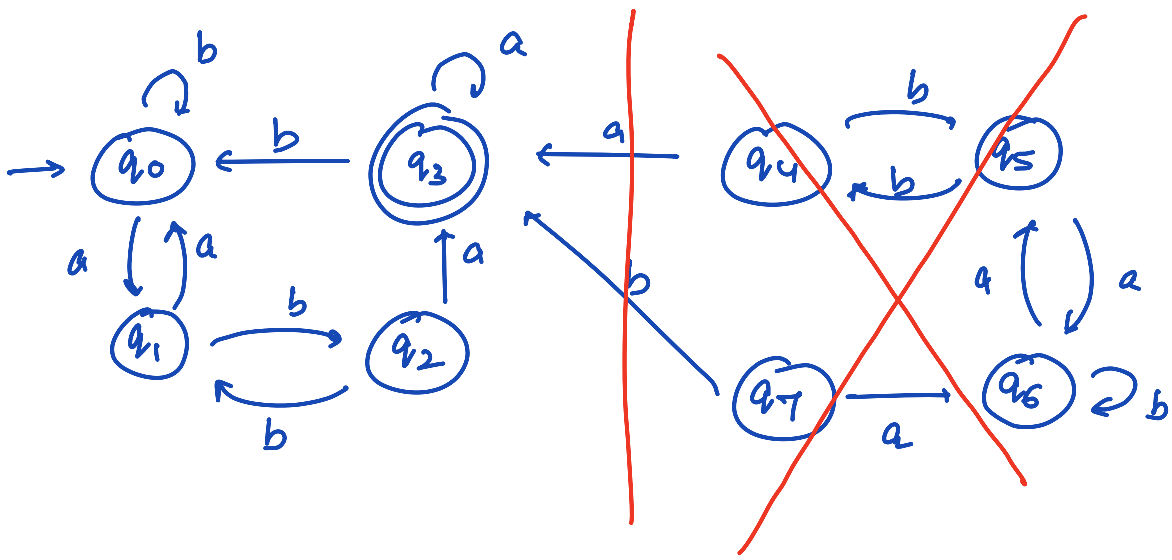
Eg:



	a	b
$\rightarrow q_0$	q_1 *	q_0
* q_1	q_2 *	q_1 *
* q_2	q_1 *	q_2 *



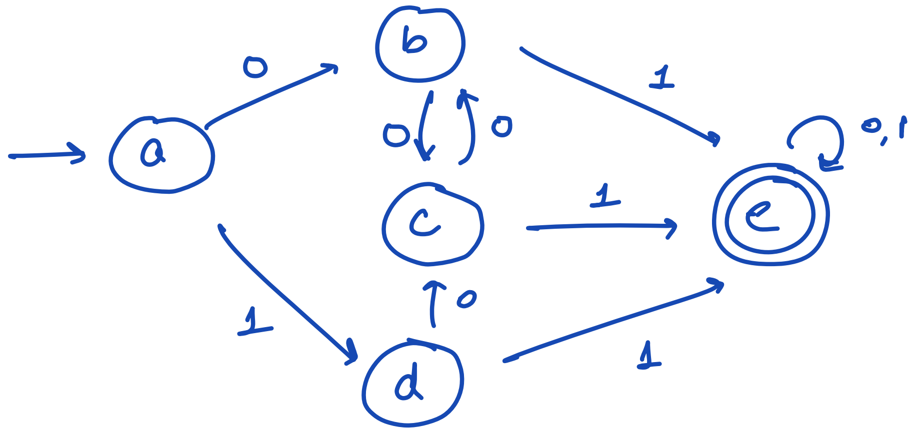
Q:



	a	b
$\rightarrow q_0$	q_1	q_0
q_1	q_0	q_2

q_2	q_3^*	q_1
$^*q_3$	q_3^*	q_0

eg:



	0	1
→ a	b	d
b	c	e*
c	b	e*
d	c	e*
* e	e*	e*

	0	1
→ a	bd	bd
bd	c	e*
c	bd	e*
* e	e*	e*

	0	1
→ a	bcd	bcd
bcd	bcd	e*
* e	e*	e*

Epsilon NFA

↳ NFA with epsilon moves

$\varepsilon \rightarrow$ length 0

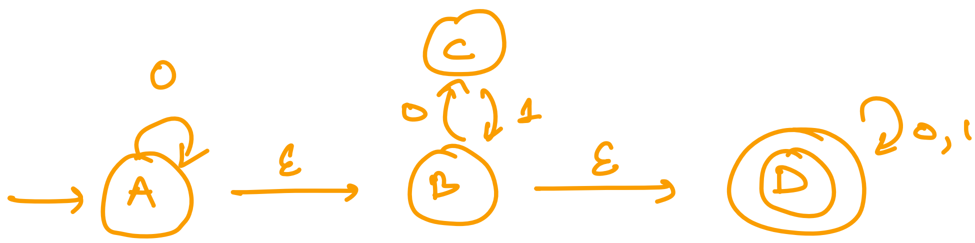
NFA : $Q, \Sigma, \delta, q_0, f$

$\delta : Q \times \Sigma \rightarrow 2^Q$

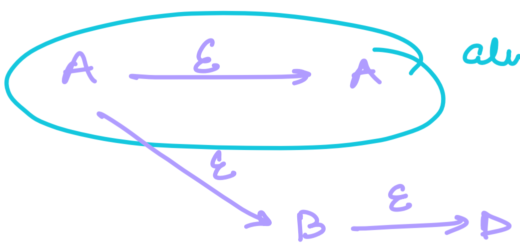
ε-NFA

$\delta : Q \times (\Sigma \cup \varepsilon) \rightarrow 2^Q$

without seeing anything transition is possible.



ε-closure (A) ⟶ ε closure of a state is what are the states that you can reach on seeing ε



always true

ε-closure (A) = {A, B, D}

DFA ≅ NFA   ε-NFA

equally powerful   equal in power

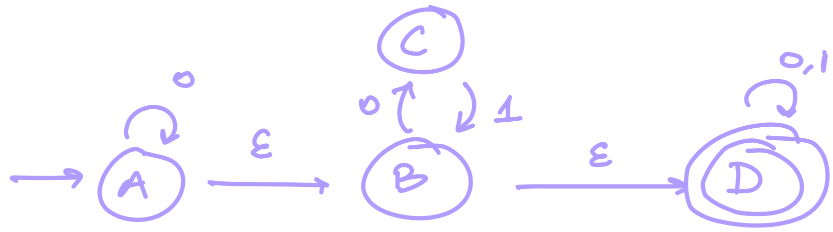
Every DFA is NFA   Every NFA is ε-NFA

Conversion NFA → DFA ✓   Conversion ε-NFA to NFA?

?

Convert ε-NFA to NFA?

Eg:



$\Sigma = \{0, 1\}$

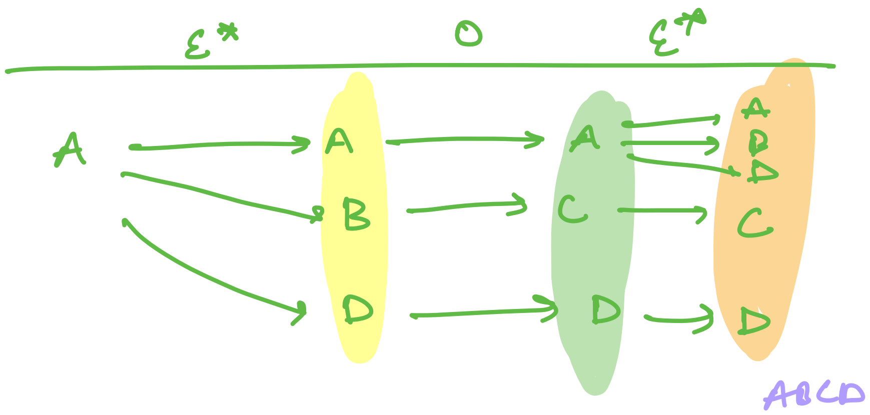
ε-closure(A) = ABD

ε-closure(B) = BD

ε-closure(D) = D

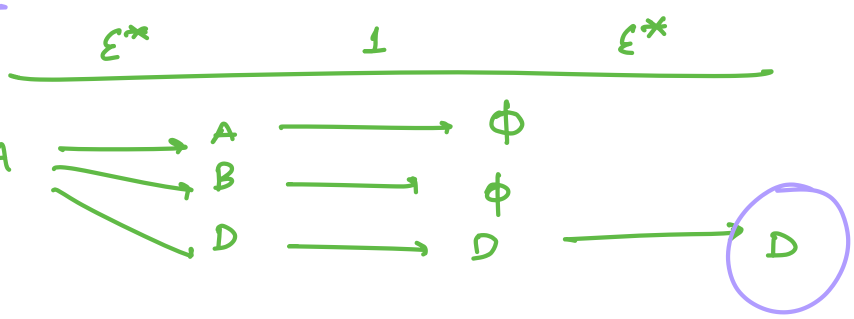
ε-closure(C) = C

Where does A goes on 0?

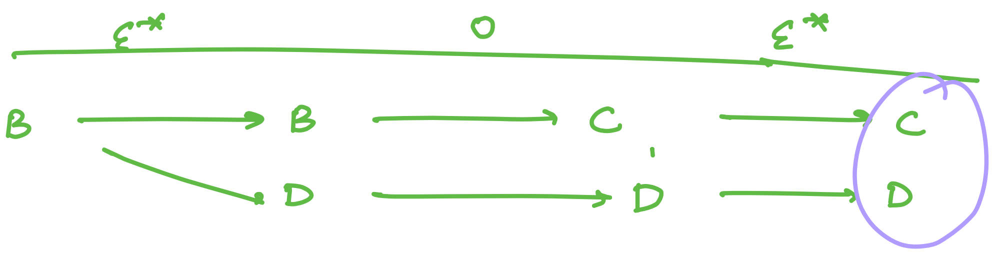


$\varepsilon\text{-closure}(\delta(\varepsilon\text{-closure}(A), 0))$

State A, 1



State B, 0



State B, 1

$$B \xrightarrow{\varepsilon^*} B \xrightarrow{1} \phi$$

$$B \xrightarrow{\varepsilon^*} D \xrightarrow{1} D \xrightarrow{\varepsilon^*} D$$

State C, 0

$$C \xrightarrow{\varepsilon^*} C \xrightarrow{0} \phi \qquad \varepsilon^*$$

State C, 1

$$C \xrightarrow{\varepsilon^*} C \xrightarrow{1} B \xrightarrow{\varepsilon^*} B, D$$

State D, 0

$$D \xrightarrow{\varepsilon^*} D \xrightarrow{0} D \xrightarrow{\varepsilon^*} D$$

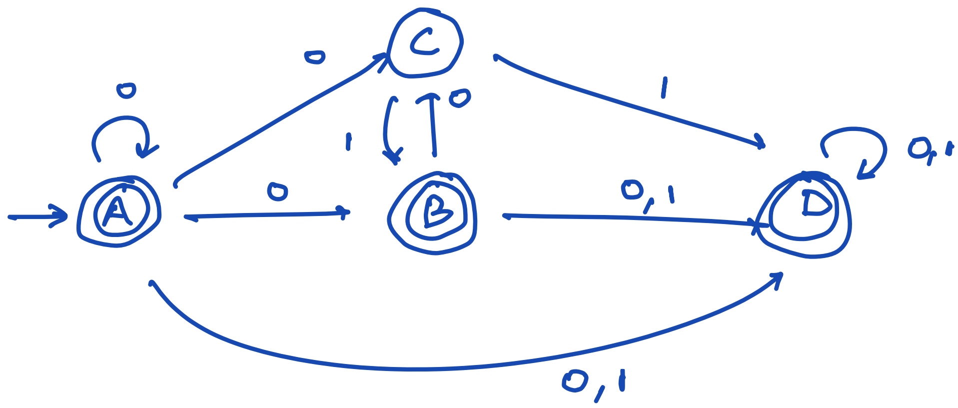
State D, 1

$$D \xrightarrow{\varepsilon^*} D \xrightarrow{1} D \xrightarrow{\varepsilon^*} D$$

State Transition Table (NFA)

	0	1
→ A	ABCD	D
B	CD	D
C	ϕ	BD
D	D	D

State Transition Diagram



States in whose ε-closure D was present : all those states will be your new final state.

NFA ⟶ DFA   no. of states same/increase

ENFA ⟶ NFA   states same
(final states will increase)