CSE211 – Formal Languages and Automata Theory

U1L11 – NFA to DFA Conversion

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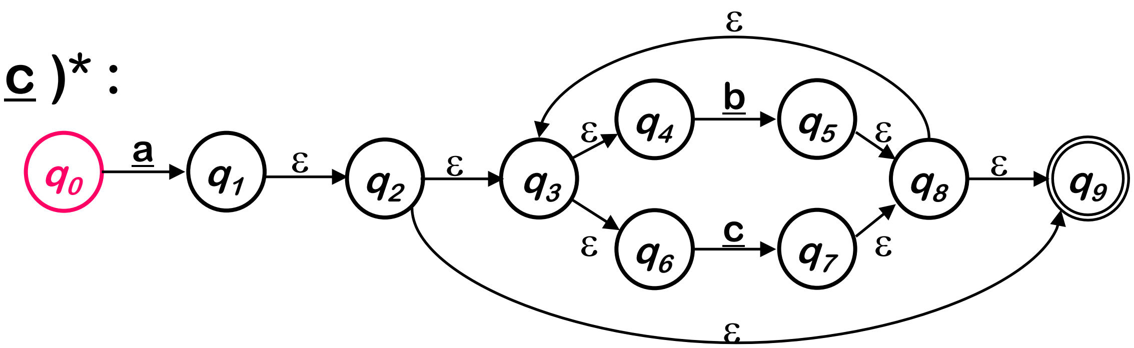
Agenda

- Recap of previous class
- Example for Converting e-NFA to DFA
- Example for Converting NFA to DFA
- Exercise for NFA to DFA conversion

NFA to DFA with Subset Construction

a (b | c)* :



States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0			

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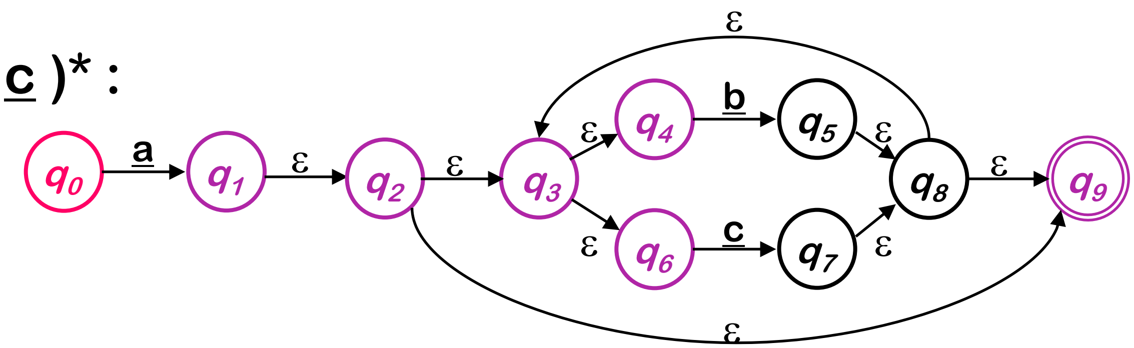
NFA to DFA with Subset Construction

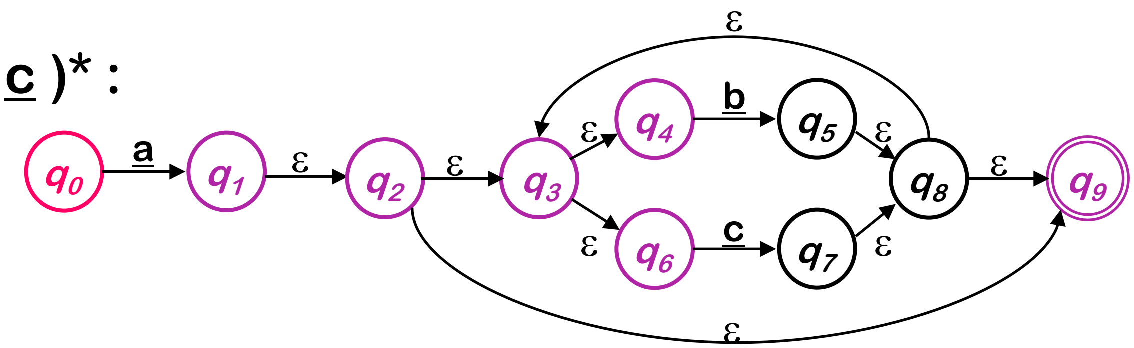
a (b | c)* :



States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$		

NFA to DFA with Subset Construction

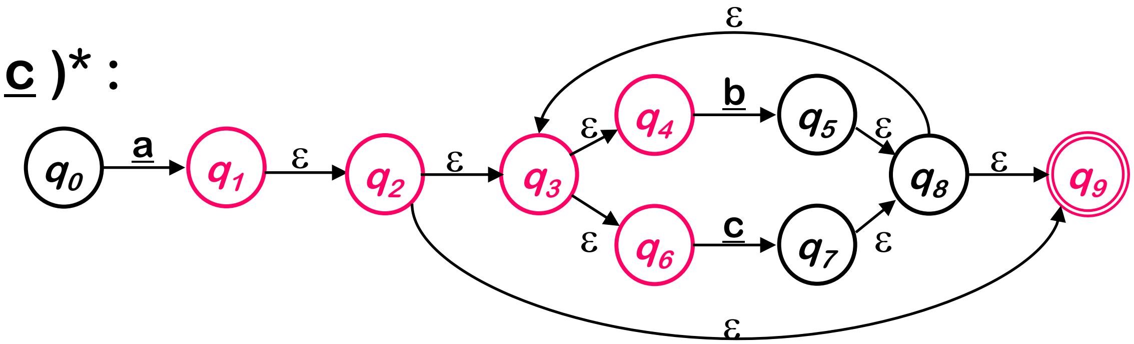
a (b | c)* :



States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$	none	none

NFA to DFA with Subset Construction

$a\,(\,b\,|\,c\,)^*$:



States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$	none	none
s_1	$q_1, q_2, q_3, q_4, q_6, q_9$			

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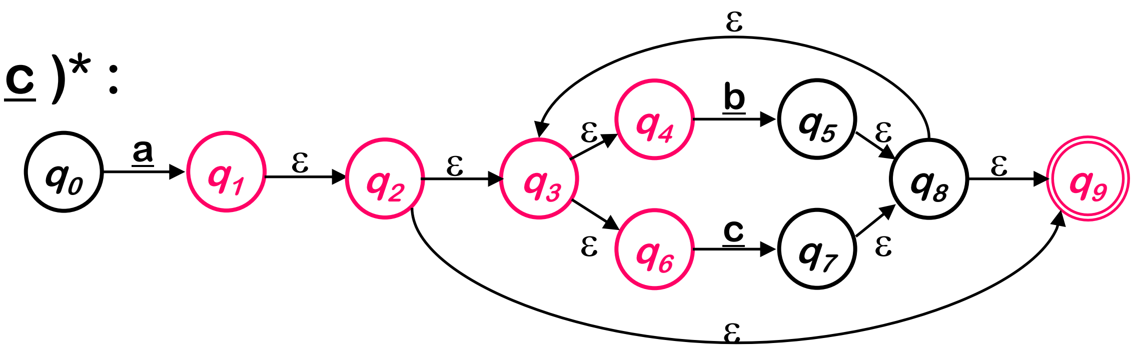
NFA →DFA with Subset Construction

a (b | c)* :



States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$	none	none
s_1	$q_1, q_2, q_3, q_4, q_6, q_9$	none		

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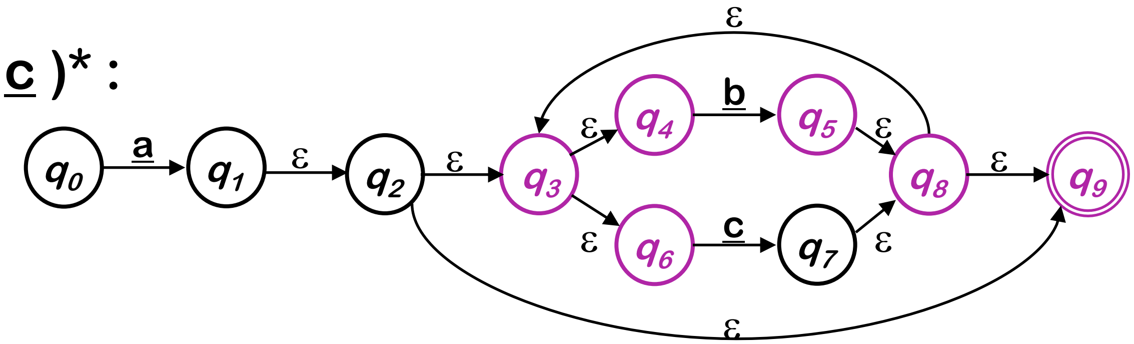
NFA →DFA with Subset Construction

a (b | c)* :



States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$	none	none
s_1	$q_1, q_2, q_3, q_4, q_6, q_9$	none	$q_5, q_8, q_9, q_3, q_4, q_6$	

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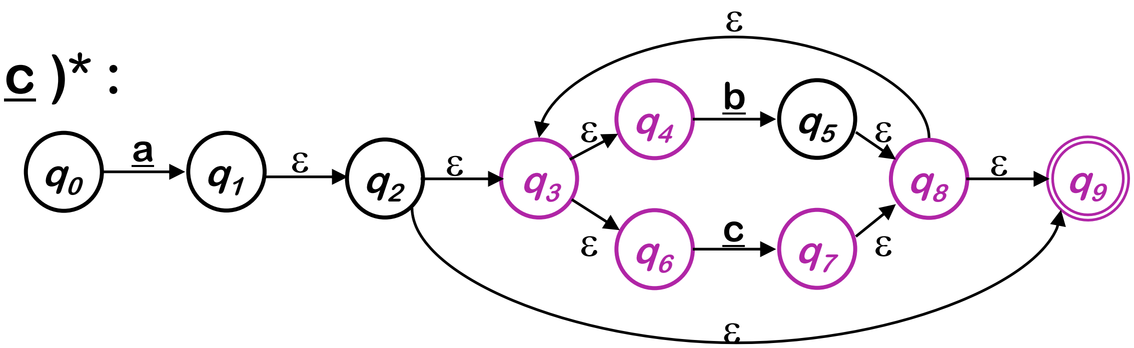
NFA →DFA with Subset Construction

a (b | c)* :



States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$	none	none
s_1	$q_1, q_2, q_3, q_4, q_6, q_9$	none	$q_5, q_8, q_9, q_3, q_4, q_6$	$q_7, q_8, q_9, q_3, q_4, q_6$

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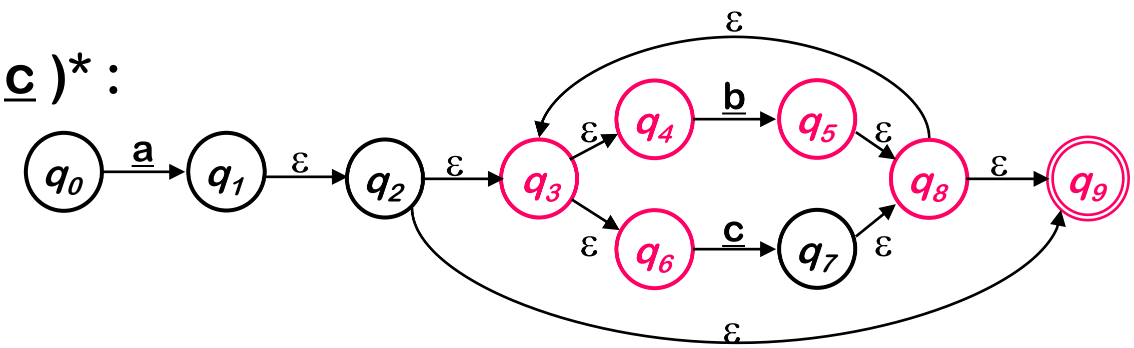
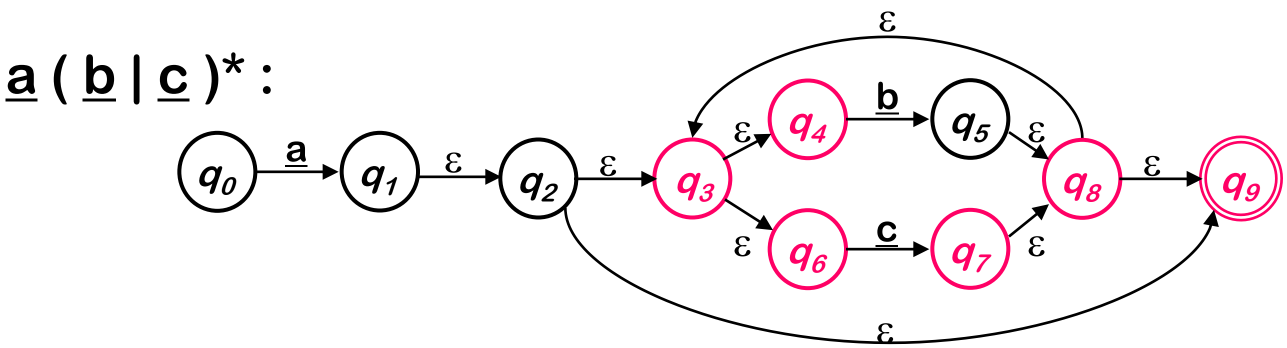
NFA to DFA with Subset Construction

a (b | c)* :



States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$	none	none
s_1	$q_1, q_2, q_3, q_4, q_6, q_9$	none	$q_5, q_8, q_9, q_3, q_4, q_6$	$q_7, q_8, q_9, q_3, q_4, q_6$
s_2	$q_5, q_8, q_9, q_3, q_4, q_6$			

NFA to DFA with Subset Construction



States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$	none	none
s_1	$q_1, q_2, q_3, q_4, q_6, q_9$	none	$q_5, q_8, q_9, q_3, q_4, q_6$	$q_7, q_8, q_9, q_3, q_4, q_6$
s_2	$q_5, q_8, q_9, q_3, q_4, q_6$			
s_3	$q_7, q_8, q_9, q_3, q_4, q_6$			

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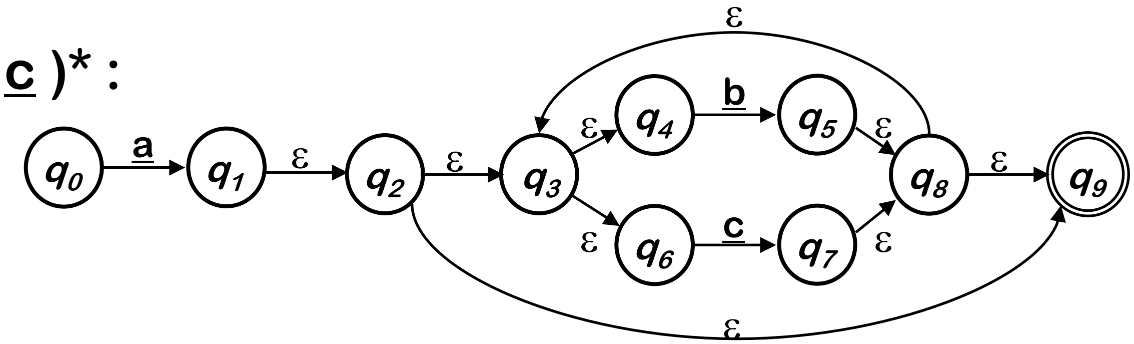
NFA to DFA with Subset Construction

a (b | c)* :



States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$	none	none
s_1	$q_1, q_2, q_3, q_4, q_6, q_9$	none	$q_5, q_8, q_9, q_3, q_4, q_6$	$q_7, q_8, q_9, q_3, q_4, q_6$
s_2	$q_5, q_8, q_9, q_3, q_4, q_6$	none		
s_3	$q_7, q_8, q_9, q_3, q_4, q_6$	none		

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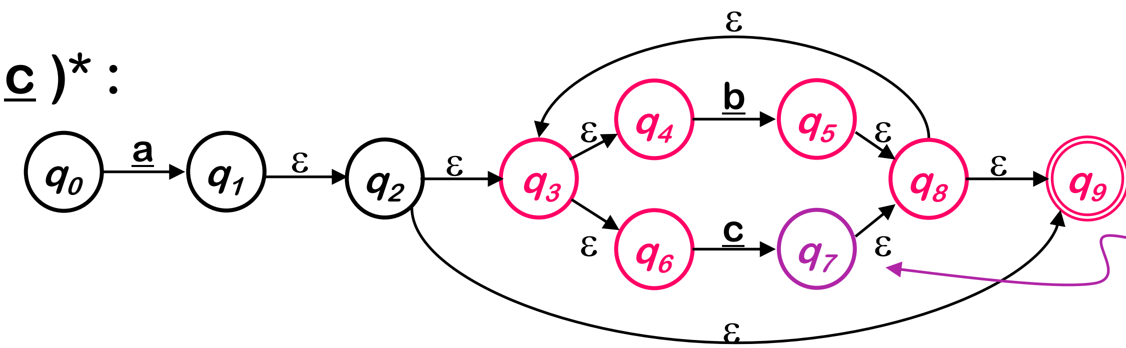
NFA →DFA with Subset Construction

a (b | c)* :



q_7 is the core state of s_3

States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$	none	none
s_1	$q_1, q_2, q_3, q_4, q_6, q_9$	none	$q_5, q_8, q_9, q_3, q_4, q_6$	$q_7, q_8, q_9, q_3, q_4, q_6$
s_2	$q_5, q_8, q_9, q_3, q_4, q_6$	none	s_2	s_3
s_3	$q_7, q_8, q_9, q_3, q_4, q_6$	none		

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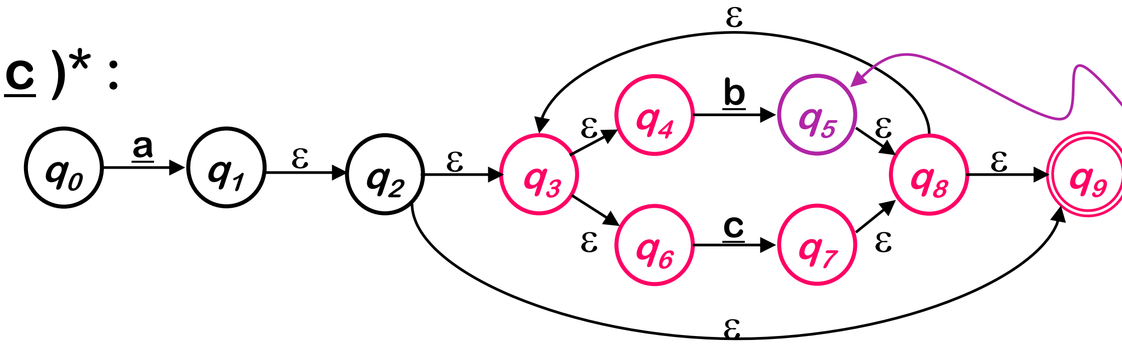
NFA →DFA with Subset Construction

a (b | c)* :

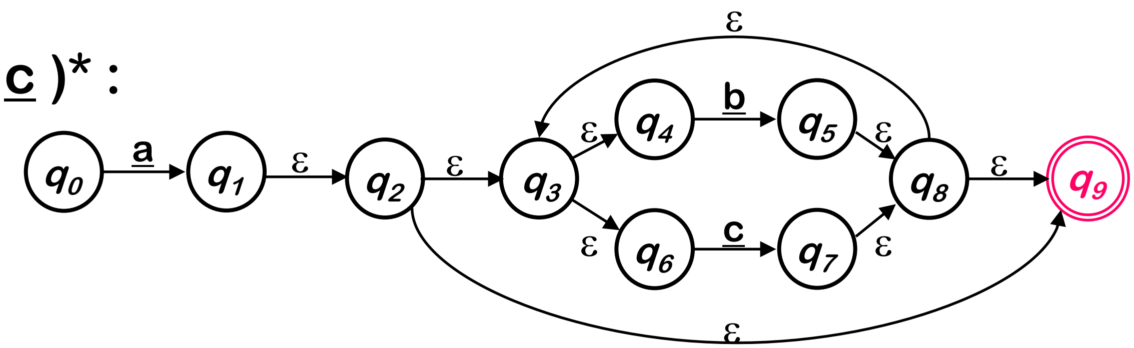


q_5 is the core state of s_2

States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$	none	none
s_1	$q_1, q_2, q_3, q_4, q_6, q_9$	none	$q_5, q_8, q_9, q_3, q_4, q_6$	$q_7, q_8, q_9, q_3, q_4, q_6$
s_2	$q_5, q_8, q_9, q_3, q_4, q_6$	none	s_2	s_3
s_3	$q_7, q_8, q_9, q_3, q_4, q_6$	none	s_2	s_3

NFA to DFA with Subset Construction

a (b | c)* :

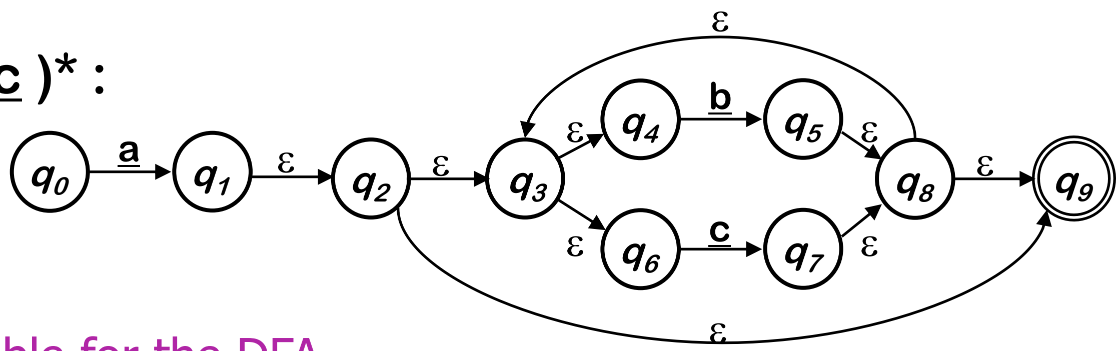


States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	$q_1, q_2, q_3, q_4, q_6, q_9$	none	none
s_1	$q_1, q_2, q_3, q_4, q_6, q_9$	none	$q_5, q_8, q_9, q_3, q_4, q_6$	$q_7, q_8, q_9, q_3, q_4, q_6$
s_2	$q_5, q_8, q_9, q_3, q_4, q_6$	none	s_2	s_3
s_3	$q_7, q_8, q_9, q_3, q_4, q_6$	none	s_2	s_3

Final states because of q_9

NFA to DFA with Subset Construction

$a\,(\,b \mid c\,)^*$:



Transition table for the DFA

States		ε-closure(Move(s,*))		
DFA	NFA	a	b	c
s_0	q_0	s_1	none	none
s_1	$q_1, q_2, q_3, q_4, q_6, q_9$	none	s_2	s_3
s_2	$q_5, q_8, q_9, q_3, q_4, q_6$	none	s_2	s_3
s_3	$q_7, q_8, q_9, q_3, q_4, q_6$	none	s_2	s_3

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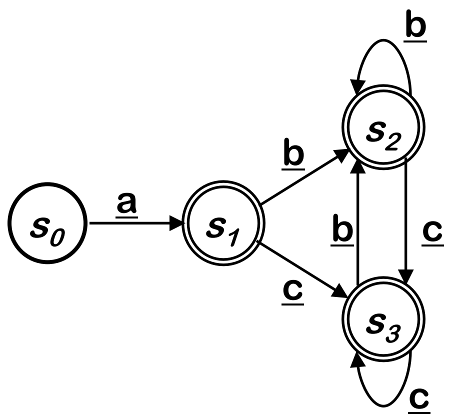
NFA to DFA with Subset Construction

The DFA for a (b | c)*



	a	b	c
s_0	s_1	none	none
s_1	none	s_2	s_3
s_2	none	s_2	s_3
s_3	none	s_2	s_3

Much smaller than the NFA (no ε-transitions)

- All transitions are deterministic

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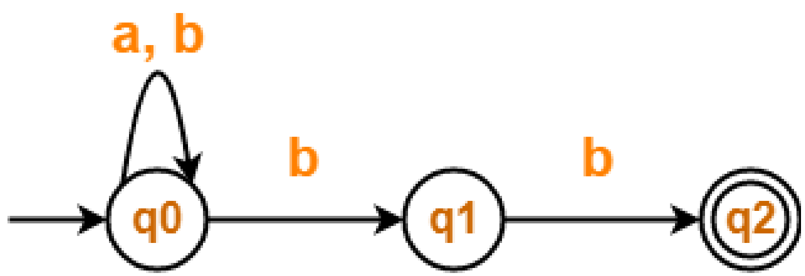
Example 3:

- Convert the following NFA to DFA



- NFA Transition table

State / Alphabet	a	b
→q0		
q1		
*q2		

DFA Transition table

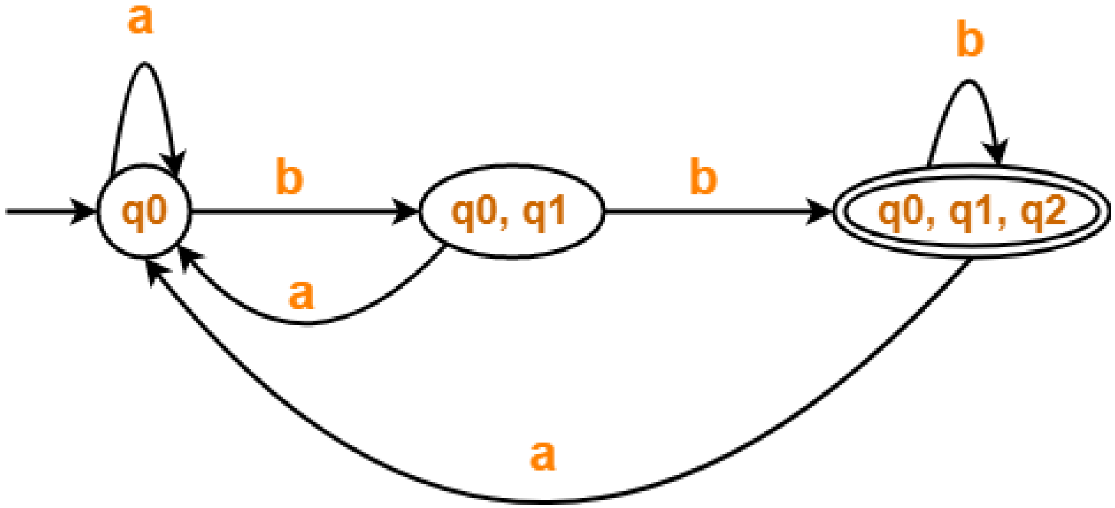
State / Alphabet	a	b

Equivalent DFA-Example 3

- DFA Transition Table

State / Alphabet	a	b
→q0	q0	{q0, q1}
{q0, q1}	q0	{q0, q1, q2}
*{q0, q1, q2}	q0	{q0, q1, q2}

- DFA



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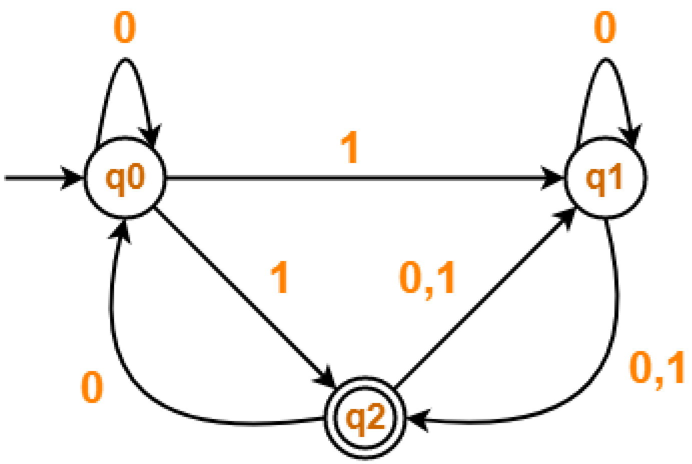
Example 4:

- Convert the following NFA into DFA



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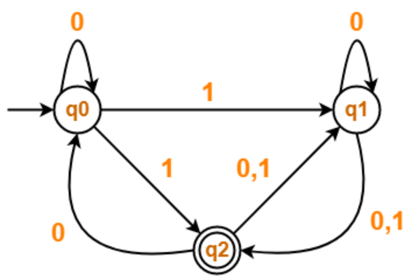
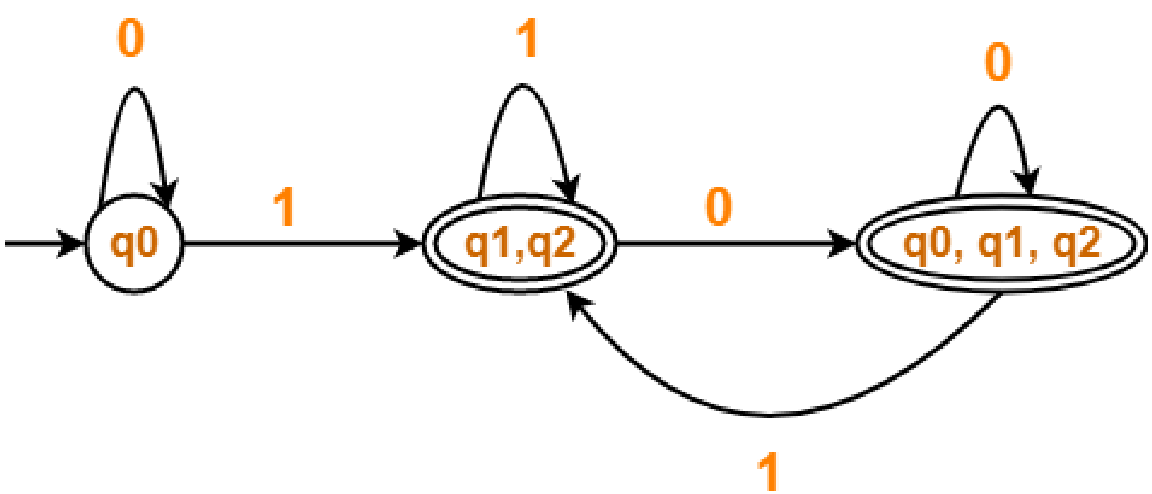
Equivalent DFA-Example 4

- DFA Transition Table



State / Alphabet	0	1
→q0	q0	*{q1, q2}
***{q1, q2}**	*{q0, q1, q2}	*{q1, q2}
***{q0, q1, q2}**	*{q0, q1, q2}	*{q1, q2}

- DFA



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References

- John E. Hopcroft, Rajeev Motwani and Jeffrey D. Ullman, *Introduction to Automata Theory*, Languages, and Computation, Pearson, 3rd Edition, 2011.
- Peter Linz, An Introduction to Formal Languages and Automata, Jones and Bartle Learning International, United Kingdom, 6th Edition, 2016.

Next Class:

Regular Expression

THANK YOU.