CS323 Compilers

Homework #2

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You are required to complete three exercises related to the following two regular languages. The alphabet contains three symbols: a, b, c.

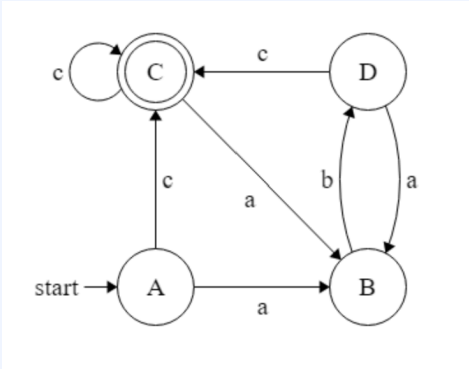
1. $L(((\epsilon|ab)*c)*)$
2. $L((a|b)*a(b|c)(a|b|c))$

Exercise 1

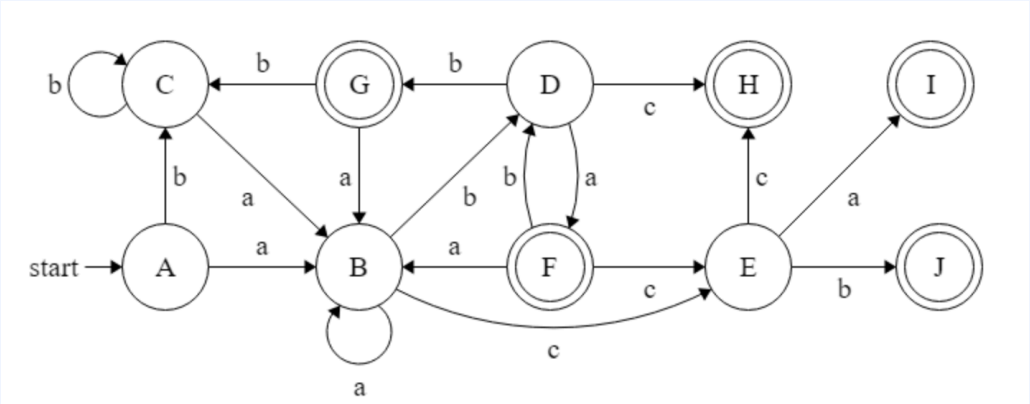
Design NFAs to recognize each of the above two regular languages. Is each of the NFAs designed by you also a DFA?

Solution

1. $L(((\epsilon|ab)*c)*)$



2. $L((a|b)*a(b|c)(a|b|c))$



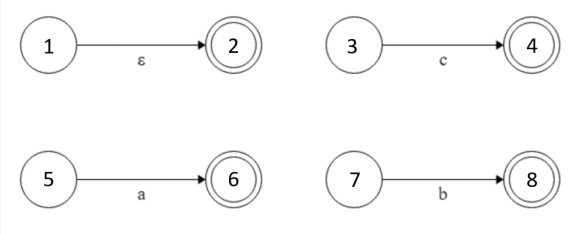
Both are DFAs.

Exercise 2

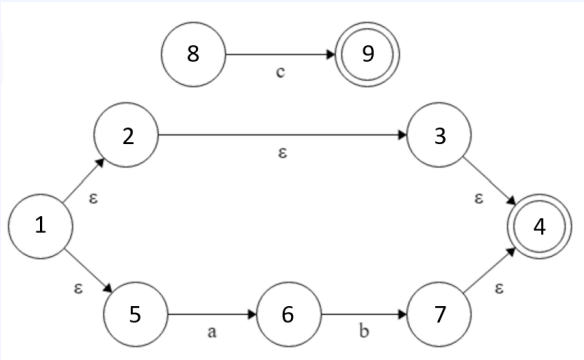
Convert the above two regular expressions to NFAs using the Thompson's Construction Algorithm (Algorithm 3.23 in the dragon book). Please put down the detailed steps and **DO NOT** optimize the NFAs.

Solution (1)

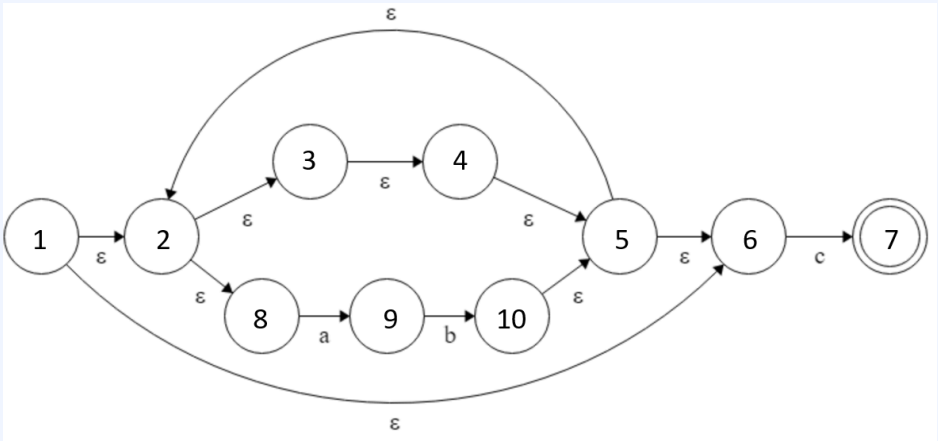
1. Basic rules for a, b, c, ε.



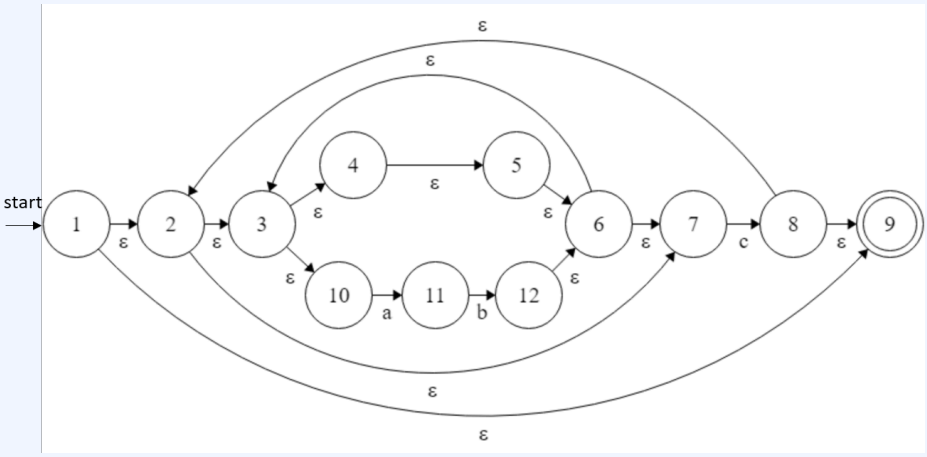
2. Concatenate ab, then union with ε.



3. Kleene closure for $(\varepsilon|ab)$, then concatenate c.



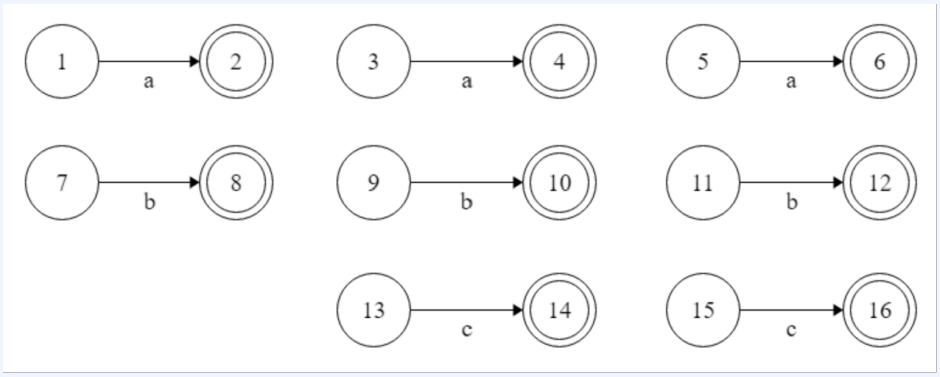
4. Kleene closure for $((\varepsilon|ab)*c)$.



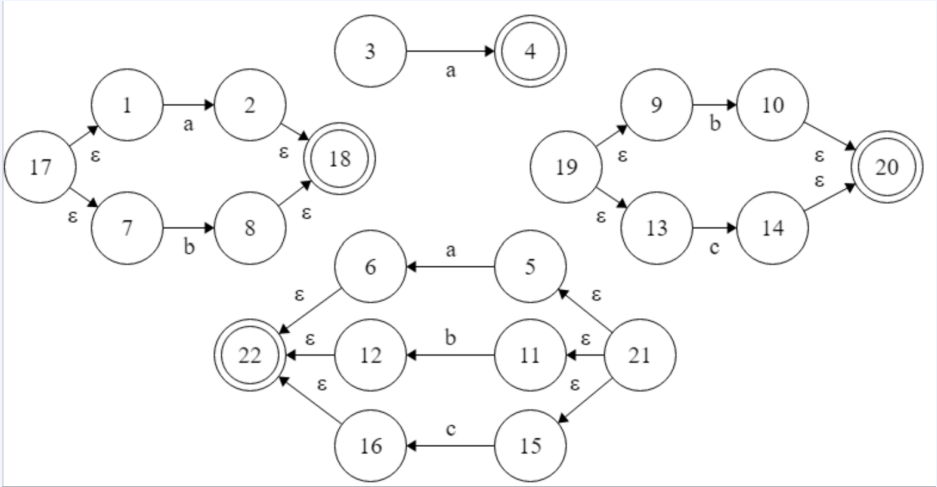
Now we get an NFA for regex #1.

Solution (2)

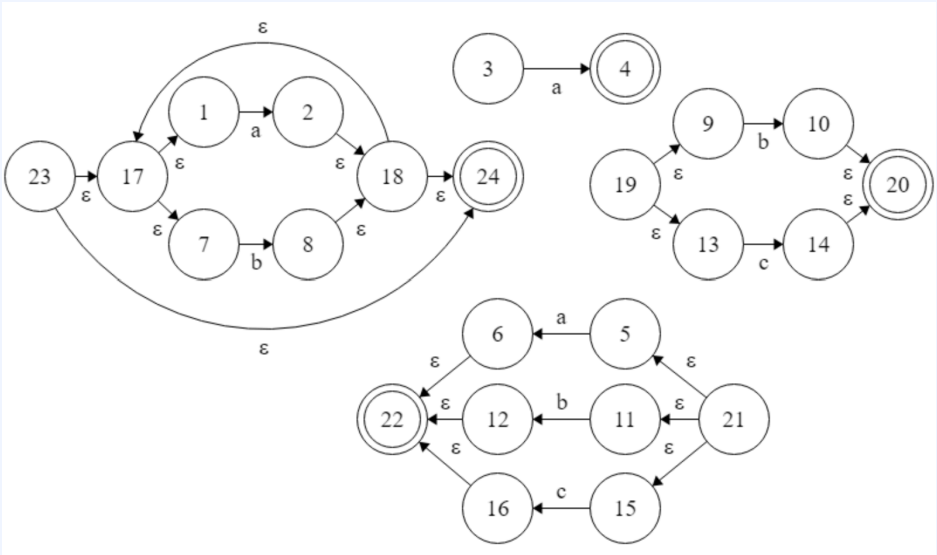
1. Basic rules for a, b, c.



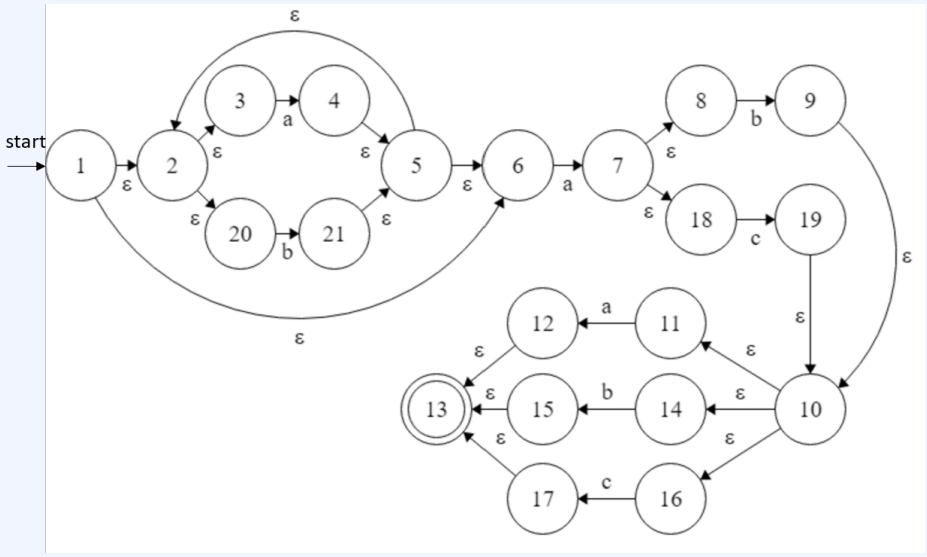
2. Union: $(a|b)$, $(b|c)$ and $(a|b|c)$.



3. Kleene closure for $(a|b)$.



4. Concatenate the 4 parts.

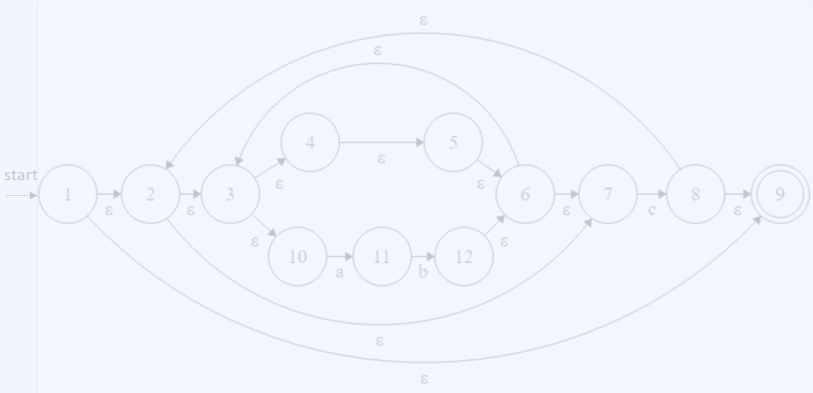


Now we get an NFA for regex #2.

Exercise 3

Convert the NFAs in Exercise 2 to DFAs using the Subset Construction Algorithm (Algorithm 3.20 in the dragon book). Please put down the detailed steps.

Solution (1)

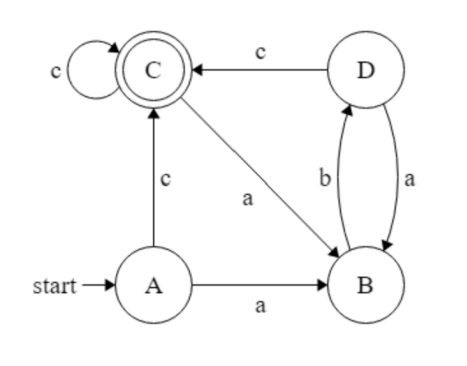


1. Calculate the ε-closure for state 1 in NFA, iteratively add new DFA states.
   *Closures that equal to empty set are omitted.
   ε-closure(1)={1,2,3,4,5,6,7,9,10}=A
   ε-closure(Move(A, a))={11}=B
   ε-closure(Move(A, c))={2,3,4,5,6,7,8,9,10}=C
   ε-closure(Move(B, b))={3,4,5,6,7,10,12}=D
   ε-closure(Move(C, a))={11}=B
   ε-closure(Move(C, c))={2,3,4,5,6,7,8,9,10}=C
   ε-closure(Move(D, a))={11}=B
   ε-closure(Move(D, c))={2,3,4,5,6,7,8,9,10}=C

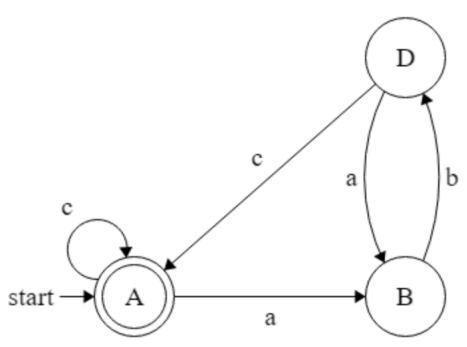
2. Calculate DFA transition table.

State S	ε-closure(Move(S, a))	ε-closure(Move(S, b))	ε-closure(Move(S, c))
A	B	/	C
B	/	D	/
C	B	/	C
D	B	/	C

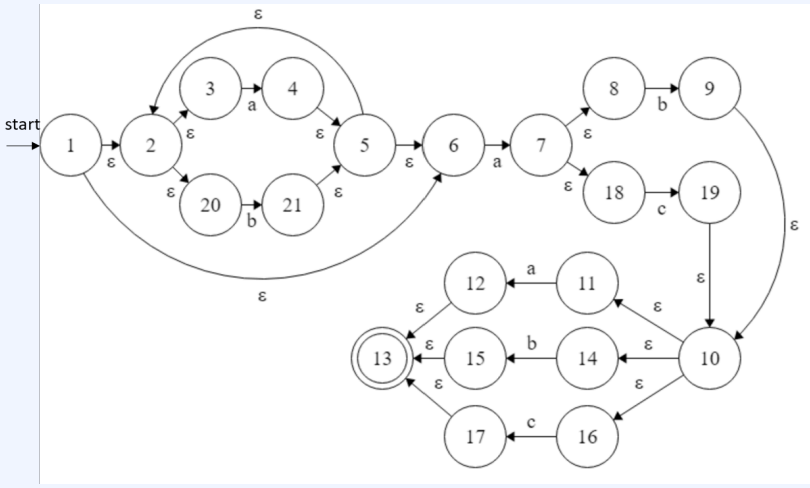
3. Draw the DFA diagram.



4. (Extra) Here A,C are both accpeting states since they contain state 9 of NFA, and they are equivalent therefore can be merged.



Solution(2)



1. Calculate the ε-closure for state 1 in NFA, iteratively add new DFA states.

*Closures that equal to empty set are omitted.

ε-closure(1)={1,2,3,6,20}=A

ε-closure(Move(A,a))={2,3,4,5,6,7,8,18,20}=B

ε-closure(Move(A,b))={2,3,5,6,20,21}=C

ε-closure(Move(B,a))={2,3,4,5,6,7,8,18,20}=B

ε-closure(Move(B,b))={2,3,5,6,9,10,11,14,16,20,21}=D

ε-closure(Move(B,c))={10,11,14,16,19}=E

ε-closure(Move(C,a))={2,3,4,5,6,7,8,18,20}=B

ε-closure(Move(C,b))={2,3,5,6,20,21}=C

ε-closure(Move(D,a))={2,3,4,5,6,7,8,12,13,18,20}=F

ε-closure(Move(D,b))={2,3,5,6,13,15,20,21}=G

ε-closure(Move(D,c))={13,17}=H

ε-closure(Move(E,a))={12,13}=I

ε-closure(Move(E,b))={13,15}=J

ε-closure(Move(E,c))={13,17}=H

ε-closure(Move(F,a))={2,3,4,5,6,7,8,18,20}=B

ε-closure(Move(F,b))={2,3,5,6,9,10,11,14,16,20,21}=D

ε-closure(Move(F,c))={10,11,14,16,19}=E

ε-closure(Move(G,a))={2,3,4,5,6,7,8,18,20}=B

ε-closure(Move(G,b))={2,3,5,6,20,21}=C

2. Calculate DFA transition table.

State S	ε-closure(Move(S, a))	ε-closure(Move(S, b))	ε-closure(Move(S, c))
A	B	C	/
B	B	D	E
C	B	C	/
D	F	G	H
E	I	J	H
F	B	D	E
G	B	C	/
H	/	/	/
I	/	/	/
J	/	/	/

3. Draw the DFA Diagram.

Here F, G, H, I, J are both accpeting states since they contain state 13 of NFA