

# HA601I - Exercices de révisions

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2022

# Construction d'un AFD à partir d'un AFN

## Enoncé

Donner l'automate fini déterministe (AFD) de certaines des expressions régulières de l'exercice précédent.

①  $ab$

④  $ab^*|c$

⑦  $abc$

②  $b^*$

⑤  $((a|b)|cc)^*$

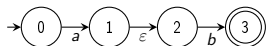
⑧  $(a|b)|c$

③  $a|b$

⑥  $b^*a^*(cb)^*$

⑨  $a|(b|c)$

Avec les AFD des expressions régulières  $(a|b)|c$  et  $a|(b|c)$ , que peut-on en déduire sur la règle  $|$  ?

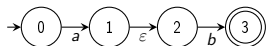


$\text{expr} = ab$

On rappelle que pour créer un AFD à partir d'un AFN, il faut créer des  $\varepsilon$ -fermetures d'ensemble d'états, en commençant par l'état de départ (ici l'état 0).

$$\text{EpsilonFermeture}(\{0\}) = \{0\}$$

En effet, l' $\varepsilon$ -fermeture comprend tous les états de l'ensemble (ici uniquement 0) et comprend également tous les états qui peuvent être atteint avec une  $\varepsilon$ -transition, il n'y en a aucune ici.



$\text{expr} = ab$



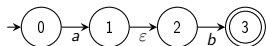
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Voici donc D, notre nouvel état de départ, on l'ajoute à notre AFD :

$$D = \{0\}$$



$\text{expr} = ab$



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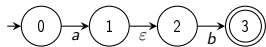
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Voici donc D, notre nouvel état de départ, on l'ajoute à notre AFD :

$$D = \{0\}$$

On part maintenant de D, pour créer notre AFD.

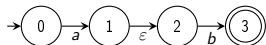


$\text{expr} = ab$



$D = \{0\}$

Etat actuel :  $D = \{0\}$ .



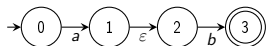
$\text{expr} = ab$



$D = \{0\}$

Etat actuel :  $D = \{0\}$ .

On va parcourir tout l'alphabet de notre vocabulaire et regarder les transitions depuis  $D$ .



$\text{expr} = ab$



$D = \{0\}$

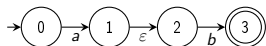
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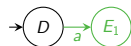
Pour  $x = a$ , la seule transition de l'AFN est  $0a1$ . On calcul donc l' $\varepsilon$ -fermeture de 1.

$$\text{EpsilonFermeture}(\{1\}) = E_1 = \{1, 2\}$$





expr = ab



$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

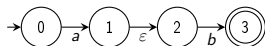
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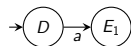
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On ajoute ensuite l'état  $E_1$  et la transition  $DaE_1$  dans notre AFD.



expr = ab



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$$E_1 = \{1, 2\}$$

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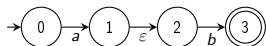
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Pour  $x = b$ , il n'y a aucune transition depuis l'état 0.



expr = ab



$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

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On va parcourir tout l'alphabet de notre vocabulaire et regarder les transitions depuis  $D$ .

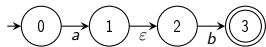
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Pour  $x = b$ , il n'y a aucune transition depuis l'état 0.

On marque maintenant  $D$  et on regarde s'il reste des états non marqués, c'est le cas donc on continue.



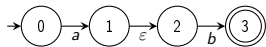
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$D = \{0\}$

$E_1 = \{1, 2\}$

Etat actuel :  $E_1 = \{1, 2\}$ .



expr = ab

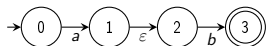


$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

Etat actuel :  $E_1 = \{1, 2\}$ .

On va parcourir tout l'alphabet de notre vocabulaire et regarder les transitions depuis  $E_1$ .



expr = ab



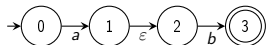
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expr = ab



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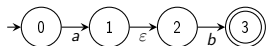
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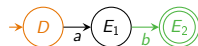
Pour  $x = a$ , il n'y a aucune transition.

Pour  $x = b$ , il y a la transition 2b3, on calcule donc l' $\varepsilon$ -fermeture de 3.

$$\text{EpsilonFermeture}(\{3\}) = E_2 = \{3\}$$



expr = ab



$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

$$E_2 = \{3\}$$

Etat actuel :  $E_1 = \{1, 2\}$ .

On va parcourir tout l'alphabet de notre vocabulaire et regarder les transitions depuis  $E_1$ .

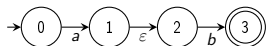
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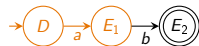
$$\text{EpsilonFermeture}(\{3\}) = E_2 = \{3\}$$

On ajoute ensuite l'état  $E_2$  et la transition  $E_1 b E_2$  dans notre AFD. Comme  $3 \in E_2$  et que 3 est un état final de l'AFN alors  $E_2$  est également final.





expr = ab



$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

$$E_2 = \{3\}$$

Etat actuel :  $E_1 = \{1, 2\}$ .

On va parcourir tout l'alphabet de notre vocabulaire et regarder les transitions depuis  $E_1$ .

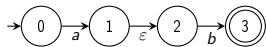
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On marque maintenant  $E_1$  et on regarde s'il reste des états non marqués, c'est le cas donc on continue.



expr = ab

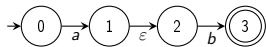


$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

$$E_2 = \{3\}$$

Etat actuel :  $E_2 = \{3\}$ .



expr = ab



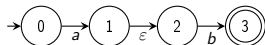
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$$E_1 = \{1, 2\}$$

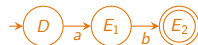
$$E_2 = \{3\}$$

Etat actuel :  $E_2 = \{3\}$ .

Il n'y a aucune transition depuis l'état 3 donc on marque directement l'état  $E_2$ .



expr = ab



$$D = \{0\}$$

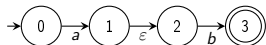
$$E_1 = \{1, 2\}$$

$$E_2 = \{3\}$$

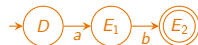
Etat actuel :  $E_2 = \{3\}$ .

Il n'y a aucune transition depuis l'état 3 donc on marque directement l'état  $E_2$ .

Tous les états sont maintenant marqués, l'AFD est terminé.



expr = ab



$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

$$E_2 = \{3\}$$

Etat actuel :  $E_2 = \{3\}$ .

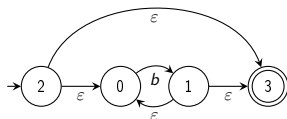
Il n'y a aucune transition depuis l'état 3 donc on marque directement l'état  $E_2$ .

Notez que la correction a été expliquée pour cet exemple mais ne le sera pas pour les prochains.

expr =  $b^*$



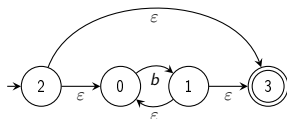
$$D = \{0, 2, 3\}$$



Calcul de l'état de départ :

$$D = \text{EpsilonFermeture}(\{2\}) = \{0, 2, 3\}$$

expr =  $b^*$

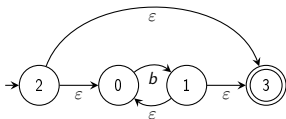


$D = \{0, 2, 3\}$

$E_1 = \{0, 1, 3\}$

Etat actuel :  $D$

- $x = b$
- transitions : 0b1
- $EpsilonFermeture(\{1\}) = \{0, 1, 3\} = E_1$
- etat final : oui



expr =  $b^*$



$D = \{0, 2, 3\}$

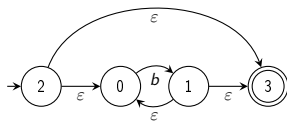
$E_1 = \{0, 1, 3\}$

Etat actuel :  $E_1$

- $x = b$
- transitions : 0b1
- $EpsilonFermeture(\{1\}) = \{0, 1, 3\} = E_1$
- etat final : oui



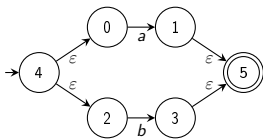
expr =  $b^*$



$D = \{0, 2, 3\}$

$E_1 = \{0, 1, 3\}$

AFD terminé, nombre d'états : 2



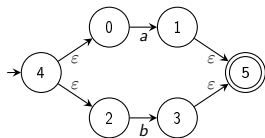
expr = a|b



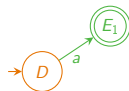
$$D = \{0, 2, 4\}$$

Calcul de l'état de départ :

$$D = \text{EpsilonFermeture}(\{4\}) = \{0, 2, 4\}$$



expr = a|b

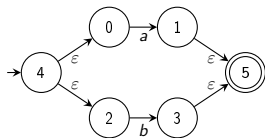


$D = \{0, 2, 4\}$

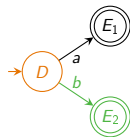
$E_1 = \{1, 5\}$

Etat actuel :  $D$

- $x = a$
- transitions : 0a1
- $EpsilonFermeture(\{1\}) = \{1, 5\} = E_1$
- etat final : oui



expr = a|b



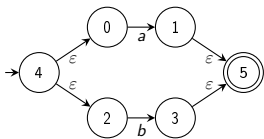
$D = \{0, 2, 4\}$

$E_1 = \{1, 5\}$

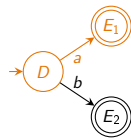
$E_2 = \{3, 5\}$

Etat actuel :  $D$

- $x = b$
- transitions : 2b3
- $EpsilonFermeture(\{3\}) = \{3, 5\} = E_2$
- etat final : oui



$\text{expr} = a|b$



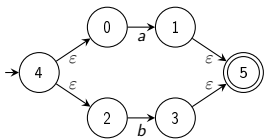
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$E_1 = \{1, 5\}$

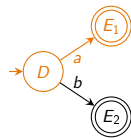
$E_2 = \{3, 5\}$

Etat actuel :  $E_1$

- $x = a$
- transitions : aucune



expr = a|b



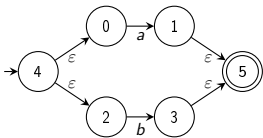
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$E_1 = \{1, 5\}$

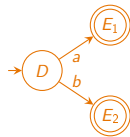
$E_2 = \{3, 5\}$

Etat actuel :  $E_1$

- $x = b$
- transitions : aucune



expr = a|b



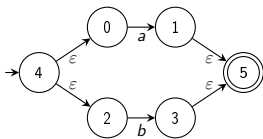
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$E_1 = \{1, 5\}$

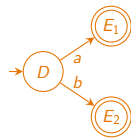
$E_2 = \{3, 5\}$

Etat actuel :  $E_2$

- $x = a$
- transitions : aucune



expr = a|b



$D = \{0, 2, 4\}$

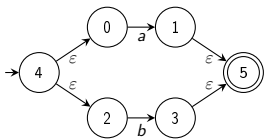
$E_1 = \{1, 5\}$

$E_2 = \{3, 5\}$

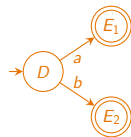
Etat actuel :  $E_2$

- $x = b$
- transitions : aucune





expr = a|b



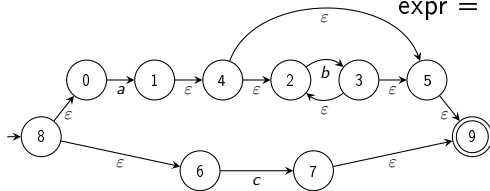
$D = \{0, 2, 4\}$

$E_1 = \{1, 5\}$

$E_2 = \{3, 5\}$

AFD terminé, nombre d'états : 3

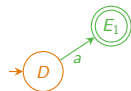
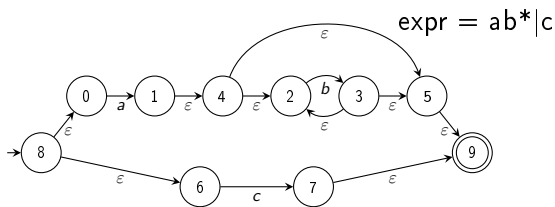
expr =  $ab^*|c$



$$D = \{0, 6, 8\}$$

Calcul de l'état de départ :

$$D = \text{EpsilonFermeture}(\{8\}) = \{0, 6, 8\}$$



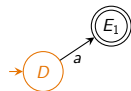
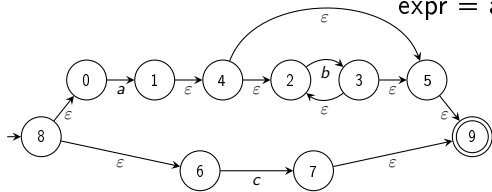
$$D = \{0, 6, 8\}$$

$$E_1 = \{1, 2, 4, 5, 9\}$$

Etat actuel :  $D$

- $x = a$
- transitions :  $0a1$
- $EpsilonFermeture(\{1\}) = \{1, 2, 4, 5, 9\} = E_1$
- etat final : oui

expr =  $ab^*|c$

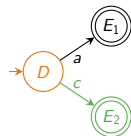
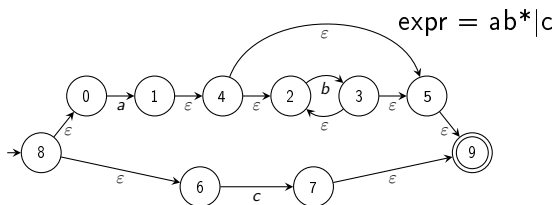


$D = \{0, 6, 8\}$

$E_1 = \{1, 2, 4, 5, 9\}$

Etat actuel :  $D$

- $x = b$
- transitions : aucune



$$D = \{0, 6, 8\}$$

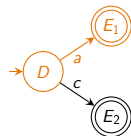
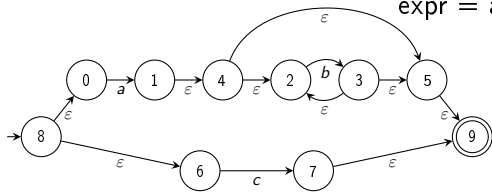
$$E_1 = \{1, 2, 4, 5, 9\}$$

$$E_2 = \{7, 9\}$$

Etat actuel :  $D$

- $x = c$
- transitions :  $6c7$
- $Epsilon\text{Fermeture}(\{7\}) = \{7, 9\} = E_2$
- etat final : oui

expr =  $ab^*|c$



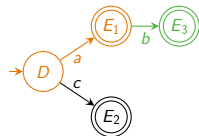
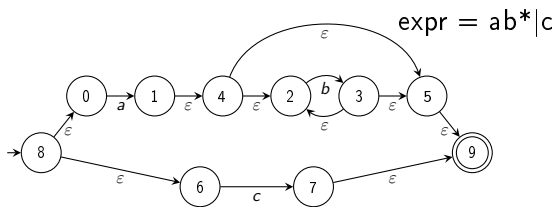
$D = \{0, 6, 8\}$

$E_1 = \{1, 2, 4, 5, 9\}$

$E_2 = \{7, 9\}$

Etat actuel :  $E_1$

- $x = a$
- transitions : aucune



$$D = \{0, 6, 8\}$$

$$E_1 = \{1, 2, 4, 5, 9\}$$

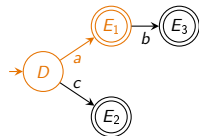
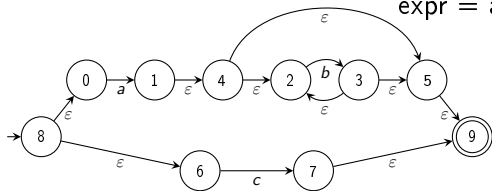
$$E_2 = \{7, 9\}$$

$$E_3 = \{2, 3, 5, 9\}$$

Etat actuel :  $E_1$

- $x = b$
- transitions : 2b3
- $EpsilonFermeture(\{3\}) = \{2, 3, 5, 9\} = E_3$
- etat final : oui

expr =  $ab^*|c$



$$D = \{0, 6, 8\}$$

$$E_1 = \{1, 2, 4, 5, 9\}$$

$$E_2 = \{7, 9\}$$

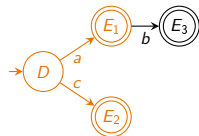
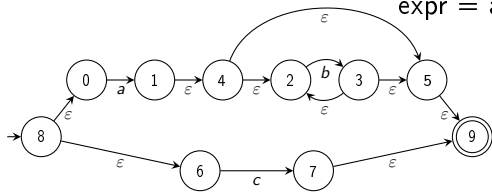
$$E_3 = \{2, 3, 5, 9\}$$

Etat actuel :  $E_1$

- $x = c$
- transitions : aucune



expr =  $ab^*|c$



$$D = \{0, 6, 8\}$$

$$E_1 = \{1, 2, 4, 5, 9\}$$

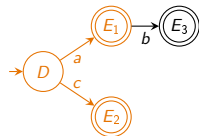
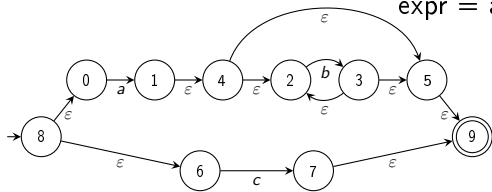
$$E_2 = \{7, 9\}$$

$$E_3 = \{2, 3, 5, 9\}$$

Etat actuel :  $E_2$

- $x = a$
- transitions : aucune

expr =  $ab^*|c$



$$D = \{0, 6, 8\}$$

$$E_1 = \{1, 2, 4, 5, 9\}$$

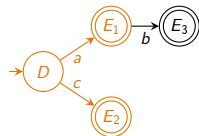
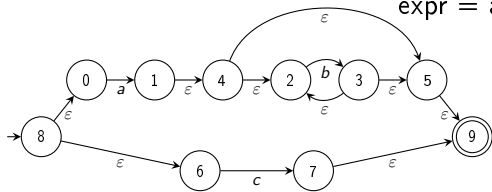
$$E_2 = \{7, 9\}$$

$$E_3 = \{2, 3, 5, 9\}$$

Etat actuel :  $E_2$

- $x = b$
- transitions : aucune

expr =  $ab^*|c$



$$D = \{0, 6, 8\}$$

$$E_1 = \{1, 2, 4, 5, 9\}$$

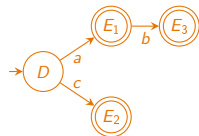
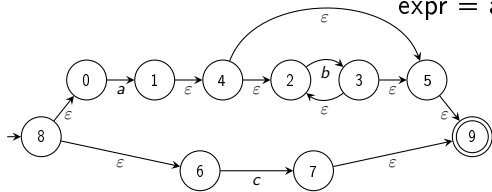
$$E_2 = \{7, 9\}$$

$$E_3 = \{2, 3, 5, 9\}$$

Etat actuel :  $E_2$

- $x = c$
- transitions : aucune

expr =  $ab^*|c$



$$D = \{0, 6, 8\}$$

$$E_1 = \{1, 2, 4, 5, 9\}$$

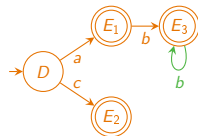
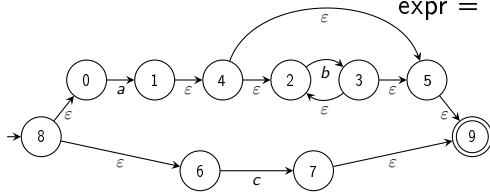
$$E_2 = \{7, 9\}$$

$$E_3 = \{2, 3, 5, 9\}$$

Etat actuel :  $E_3$

- $x = a$
- transitions : aucune

expr =  $ab^*|c$



$$D = \{0, 6, 8\}$$

$$E_1 = \{1, 2, 4, 5, 9\}$$

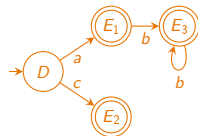
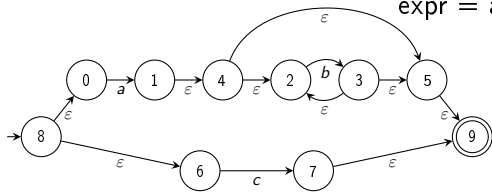
$$E_2 = \{7, 9\}$$

$$E_3 = \{2, 3, 5, 9\}$$

Etat actuel :  $E_3$

- $x = b$
- transitions : 2b3
- $EpsilonFermeture(\{3\}) = \{2, 3, 5, 9\} = E_3$
- etat final : oui

expr =  $ab^*|c$



$D = \{0, 6, 8\}$

$E_1 = \{1, 2, 4, 5, 9\}$

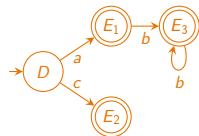
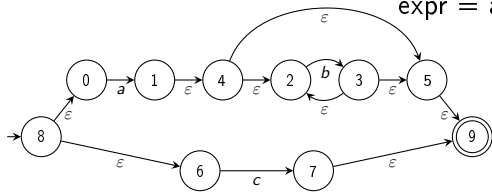
$E_2 = \{7, 9\}$

$E_3 = \{2, 3, 5, 9\}$

Etat actuel :  $E_3$

- $x = c$
- transitions : aucune

expr =  $ab^*|c$



$$D = \{0, 6, 8\}$$

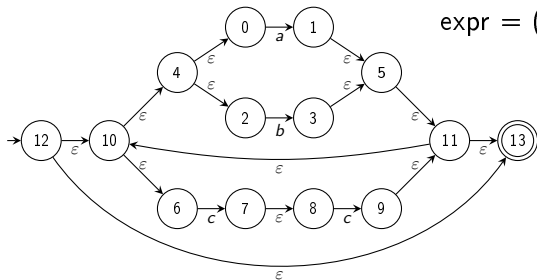
$$E_1 = \{1, 2, 4, 5, 9\}$$

$$E_2 = \{7, 9\}$$

$$E_3 = \{2, 3, 5, 9\}$$

AFD terminé, nombre d'états : 4

expr = ((a|b)|cc)\*



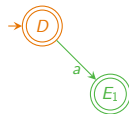
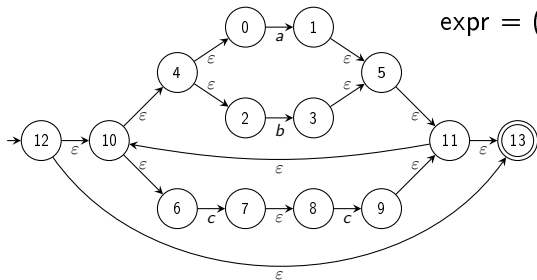
$$D = \{0, 2, 4, 6, 10, 12, 13\}$$

Calcul de l'état de départ :

$$D = \text{EpsilonFermeture}(\{12\}) = \{0, 2, 4, 6, 10, 12, 13\}$$



expr = ((a|b)|cc)\*



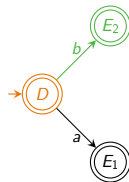
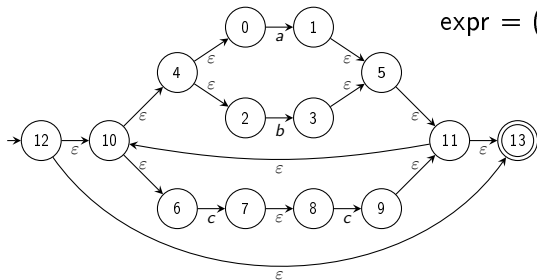
Etat actuel :  $D$

$D = \{0, 2, 4, 6, 10, 12, 13\}$

$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$

- $x = a$
- transitions : 0a1
- $EpsilonFermeture(\{1\}) = \{0, 1, 2, 4, 6, 5, 10, 11, 13\} = E_1$
- etat final : oui

expr = ((a|b)|cc)\*



Etat actuel :  $D$

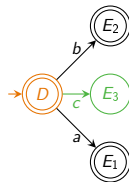
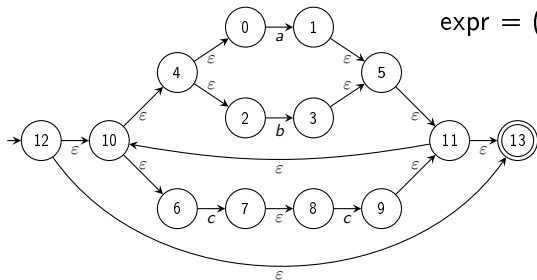
$$D = \{0, 2, 4, 6, 10, 12, 13\}$$

$$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$$

$$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$$

- $x = b$
- transitions : 2b3
- $EpsilonFermeture(\{3\}) = \{0, 2, 3, 4, 6, 5, 10, 11, 13\} = E_2$
- etat final : oui

expr = ((a|b)|cc)\*



Etat actuel :  $D$

$$D = \{0, 2, 4, 6, 10, 12, 13\}$$

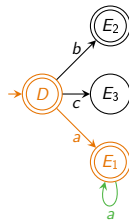
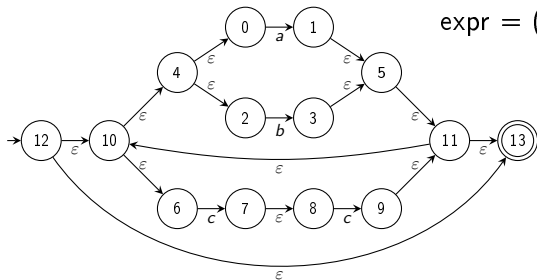
$$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$$

$$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$$

$$E_3 = \{7, 8\}$$

- $x = c$
- transitions : 6c7
- $EpsilonFermeture(\{7\}) = \{7, 8\} = E_3$
- etat final : non

expr = ((a|b)|cc)\*



Etat actuel :  $E_1$

$D = \{0, 2, 4, 6, 10, 12, 13\}$

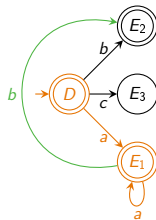
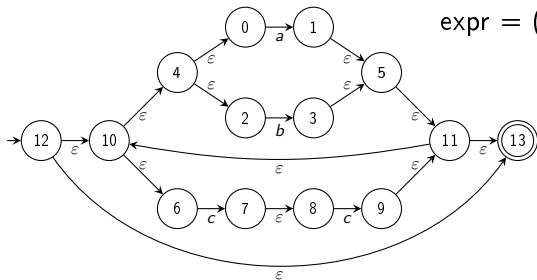
$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$

$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$

$E_3 = \{7, 8\}$

- $x = a$
- transitions : 0a1
- $EpsilonFermeture(\{1\}) = \{0, 1, 2, 4, 6, 5, 10, 11, 13\} = E_1$
- etat final : oui

expr = ((a|b)|cc)\*



Etat actuel :  $E_1$

$$D = \{0, 2, 4, 6, 10, 12, 13\}$$

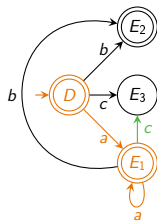
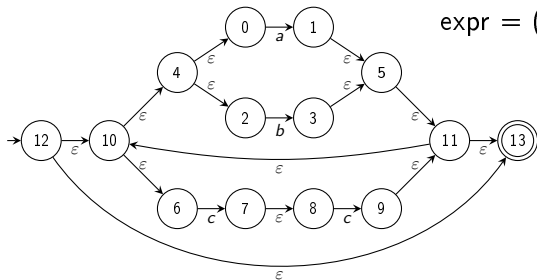
$$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$$

$$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$$

$$E_3 = \{7, 8\}$$

- $x = b$
- transitions : 2b3
- $Epsilon\text{Fermeture}(\{3\}) = \{0, 2, 3, 4, 6, 5, 10, 11, 13\} = E_2$
- etat final : oui

expr = ((a|b)|cc)\*



Etat actuel :  $E_1$

- $x = c$
- transitions : 6c7
- $EpsilonFermeture(\{7\}) = \{7, 8\} = E_3$
- etat final : non

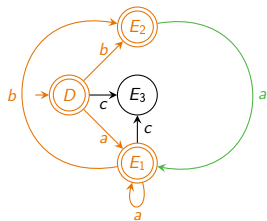
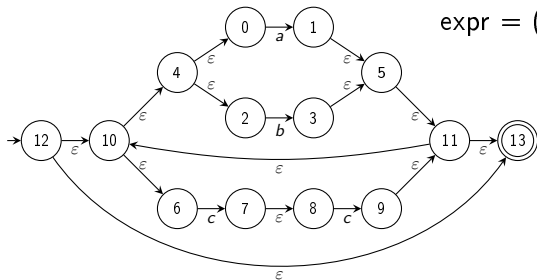
$$D = \{0, 2, 4, 6, 10, 12, 13\}$$

$$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$$

$$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$$

$$E_3 = \{7, 8\}$$

expr = ((a|b)|cc)\*



Etat actuel :  $E_2$

$$D = \{0, 2, 4, 6, 10, 12, 13\}$$

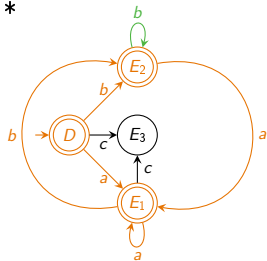
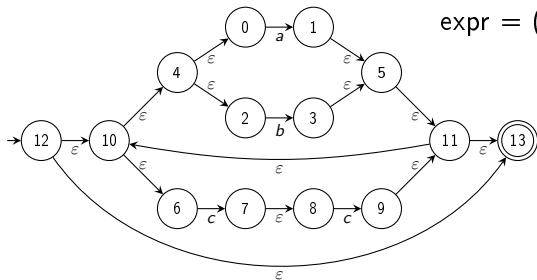
$$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$$

$$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$$

$$E_3 = \{7, 8\}$$

- $x = a$
- transitions : 0a1
- $EpsilonFermeture(\{1\}) = \{0, 1, 2, 4, 6, 5, 10, 11, 13\} = E_1$
- etat final : oui

expr = ((a|b)|cc)\*



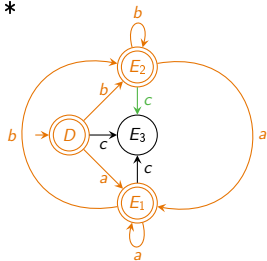
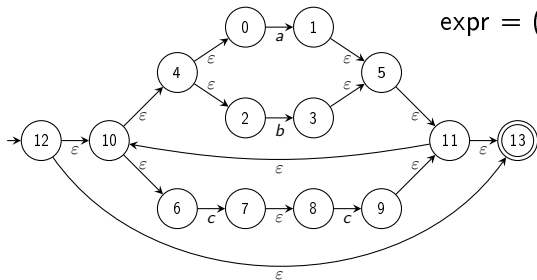
Etat actuel :  $E_2$

$$\begin{aligned} D &= \{0, 2, 4, 6, 10, 12, 13\} \\ E_1 &= \{0, 1, 2, 4, 5, 6, 10, 11, 13\} \\ E_2 &= \{0, 2, 3, 4, 5, 6, 10, 11, 13\} \\ E_3 &= \{7, 8\} \end{aligned}$$

- $x = b$
- transitions : 2b3
- $EpsilonFermeture(\{3\}) = \{0, 2, 3, 4, 6, 5, 10, 11, 13\} = E_2$
- etat final : oui



expr = ((a|b)|cc)\*

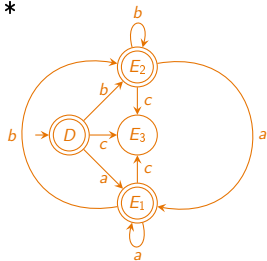
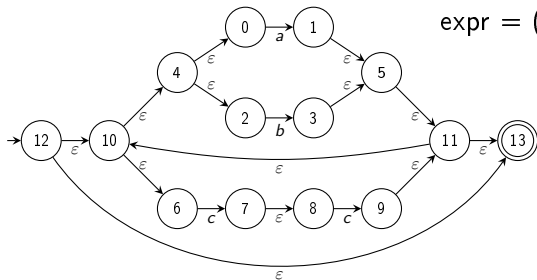


Etat actuel :  $E_2$

$D = \{0, 2, 4, 6, 10, 12, 13\}$   
 $E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$   
 $E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$   
 $E_3 = \{7, 8\}$

- $x = c$
- transitions : 6c7
- $EpsilonFermeture(\{7\}) = \{7, 8\} = E_3$
- etat final : non

expr = ((a|b)|cc)\*

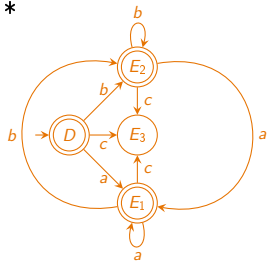
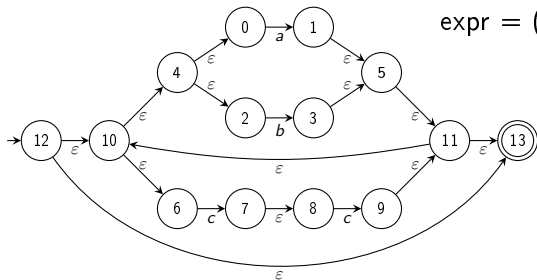


Etat actuel :  $E_3$

$D = \{0, 2, 4, 6, 10, 12, 13\}$   
 $E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$   
 $E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$   
 $E_3 = \{7, 8\}$

- $x = a$
- transitions : aucune

expr = ((a|b)|cc)\*

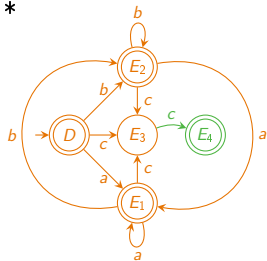
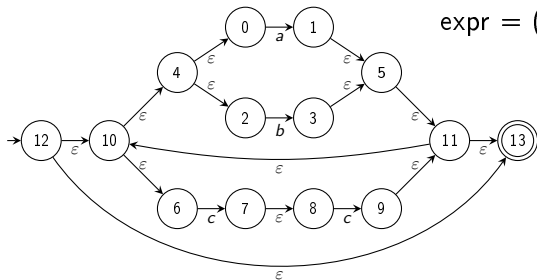


Etat actuel :  $E_3$

$D = \{0, 2, 4, 6, 10, 12, 13\}$   
 $E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$   
 $E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$   
 $E_3 = \{7, 8\}$

- $x = b$
- transitions : aucune

expr = ((a|b)|cc)\*



Etat actuel :  $E_3$

- $x = c$
- transitions : 8c9
- $EpsilonFermeture(\{9\}) = \{0, 2, 4, 6, 9, 10, 11, 13\} = E_4$
- etat final : non

$$D = \{0, 2, 4, 6, 10, 12, 13\}$$

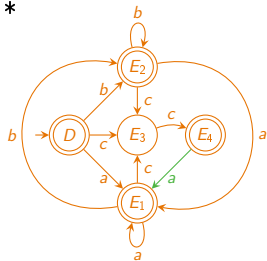
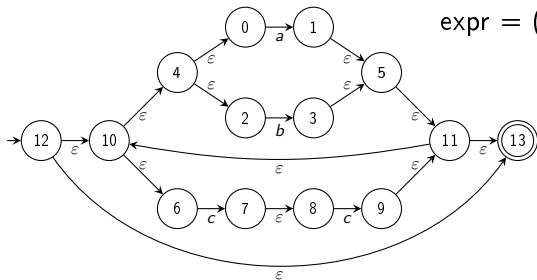
$$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$$

$$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$$

$$E_3 = \{7, 8\}$$

$$E_4 = \{0, 2, 4, 6, 9, 10, 11, 13\}$$

expr = ((a|b)|cc)\*



Etat actuel :  $E_4$

- $x = a$
- transitions : 0a1
- $EpsilonFermeture(\{1\}) = \{0, 1, 2, 4, 6, 5, 10, 11, 13\} = E_1$
- etat final : oui

$$D = \{0, 2, 4, 6, 10, 12, 13\}$$

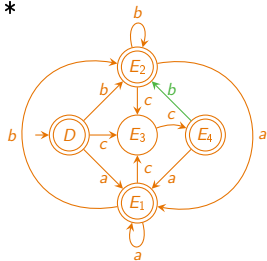
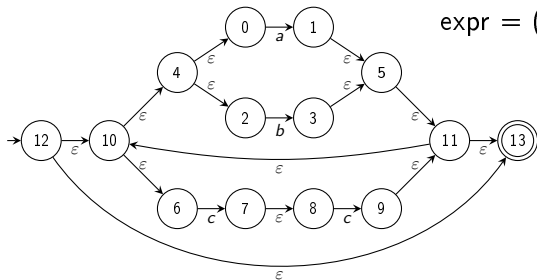
$$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$$

$$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$$

$$E_3 = \{7, 8\}$$

$$E_4 = \{0, 2, 4, 6, 9, 10, 11, 13\}$$

expr = ((a|b)|cc)\*



Etat actuel :  $E_4$

- $x = b$
- transitions : 2b3
- $EpsilonFermeture(\{3\}) = \{0, 2, 3, 4, 6, 5, 10, 11, 13\} = E_2$
- etat final : oui

$$D = \{0, 2, 4, 6, 10, 12, 13\}$$

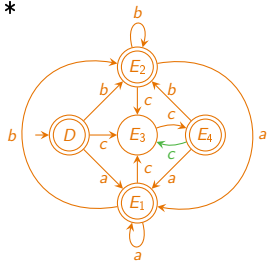
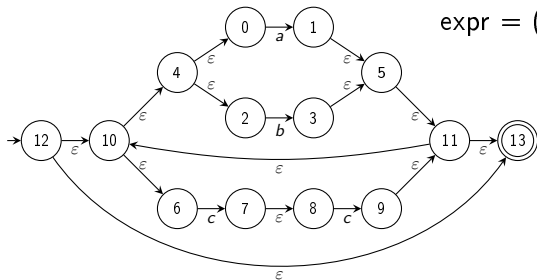
$$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$$

$$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$$

$$E_3 = \{7, 8\}$$

$$E_4 = \{0, 2, 4, 6, 9, 10, 11, 13\}$$

expr = ((a|b)|cc)\*

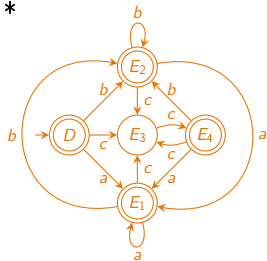
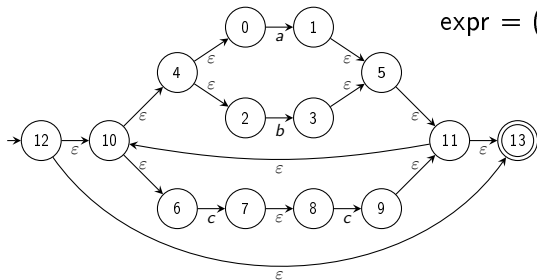


Etat actuel :  $E_4$

- $x = c$
- transitions :  $6c7$
- $EpsilonFermeture(\{7\}) = \{7, 8\} = E_3$
- etat final : non

$D = \{0, 2, 4, 6, 10, 12, 13\}$   
 $E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$   
 $E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$   
 $E_3 = \{7, 8\}$   
 $E_4 = \{0, 2, 4, 6, 9, 10, 11, 13\}$

expr = ((a|b)|cc)\*



AFD terminé, nombre d'états : 5

$$D = \{0, 2, 4, 6, 10, 12, 13\}$$

$$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$$

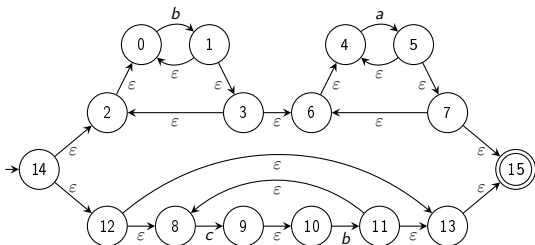
$$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$$

$$E_3 = \{7, 8\}$$

$$E_4 = \{0, 2, 4, 6, 9, 10, 11, 13\}$$



expr = b\*a\*|(cb)\*

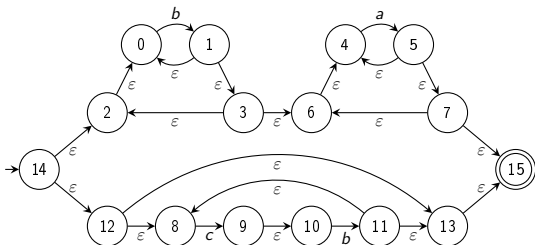


$D = \{0, 2, 8, 12, 13, 14, 15\}$

Calcul de l'état de départ :

$$D = \text{EpsilonFermeture}(\{14\}) = \{0, 2, 8, 12, 13, 14, 15\}$$

$\text{expr} = b^*a^*(cb)^*$

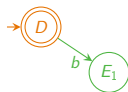
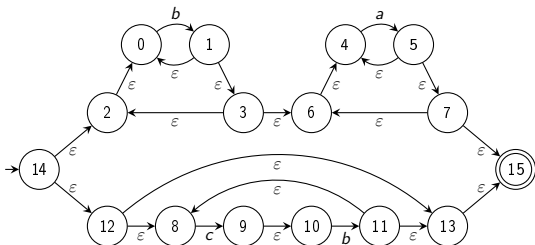


$D = \{0, 2, 8, 12, 13, 14, 15\}$

Etat actuel :  $D$

- $x = a$
- transitions : aucune

expr = b\*a\*|(cb)\*



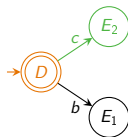
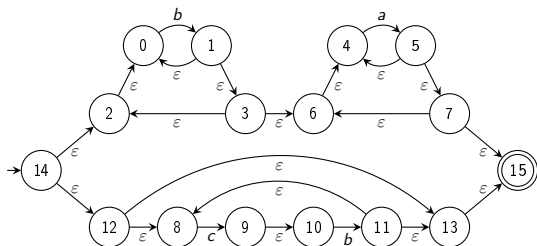
$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

Etat actuel :  $D$

- $x = b$
- transitions : 0b1
- $EpsilonFermeture(\{1\}) = \{0, 1, 2, 3, 4, 6\} = E_1$
- etat final : non

expr = b\*a\*|(cb)\*



$D = \{0, 2, 8, 12, 13, 14, 15\}$

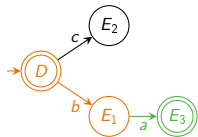
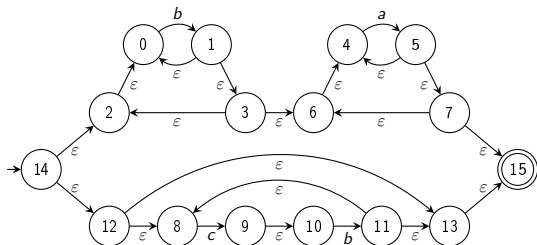
$E_1 = \{0, 1, 2, 3, 4, 6\}$

$E_2 = \{9, 10\}$

Etat actuel :  $D$

- $x = c$
- transitions : 8c9
- $EpsilonFermeture(\{9\}) = \{9, 10\} = E_2$
- etat final : non

expr = b\*a\*|(cb)\*



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

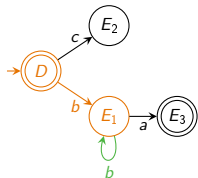
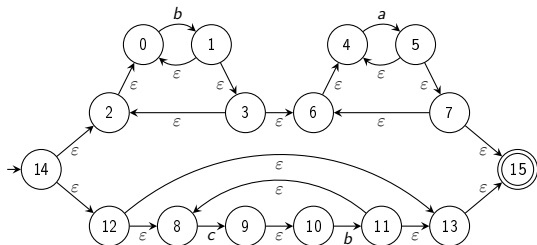
$E_2 = \{9, 10\}$

$E_3 = \{4, 5, 6, 7, 15\}$

Etat actuel :  $E_1$

- $x = a$
- transitions : 4a5
- $EpsilonFermeture(\{5\}) = \{4, 5, 6, 7, 15\} = E_3$
- etat final : oui

expr = b\*a\*|(cb)\*



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

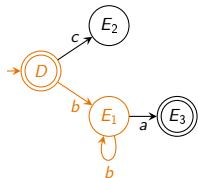
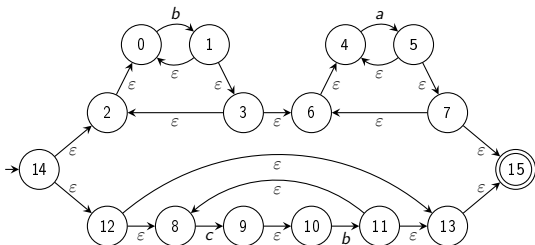
$E_2 = \{9, 10\}$

$E_3 = \{4, 5, 6, 7, 15\}$

Etat actuel :  $E_1$

- $x = b$
- transitions : 0b1
- $EpsilonFermeture(\{1\}) = \{0, 1, 2, 3, 4, 6\} = E_1$
- etat final : non

expr = b\*a\*|(cb)\*



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

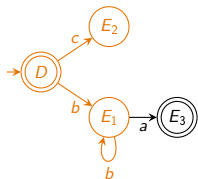
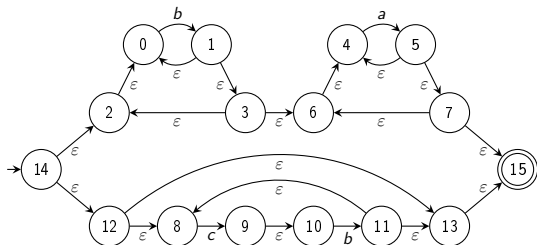
$E_2 = \{9, 10\}$

$E_3 = \{4, 5, 6, 7, 15\}$

Etat actuel :  $E_1$

- $x = c$
- transitions : aucune

$\text{expr} = b^*a^*(cb)^*$



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

$E_2 = \{9, 10\}$

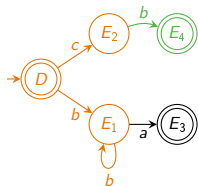
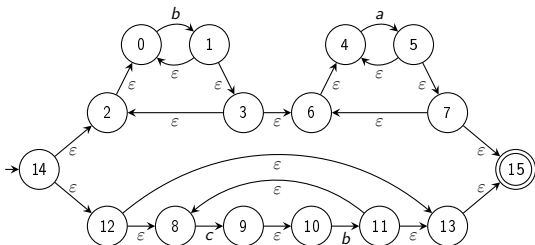
$E_3 = \{4, 5, 6, 7, 15\}$

Etat actuel :  $E_2$

- $x = a$
- transitions : aucune



expr = b\*a\*|(cb)\*



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

$E_2 = \{9, 10\}$

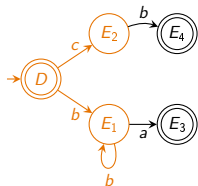
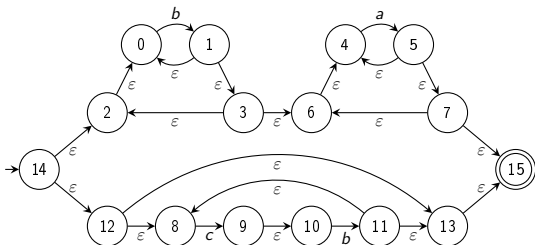
$E_3 = \{4, 5, 6, 7, 15\}$

$E_4 = \{8, 10, 11, 13, 15\}$

Etat actuel :  $E_2$

- $x = b$
- transitions : 10b11
- $EpsilonFermeture(\{11\}) = \{8, 10, 11, 13, 15\} = E_4$
- etat final : oui

expr = b\*a\*|(cb)\*



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

$E_2 = \{9, 10\}$

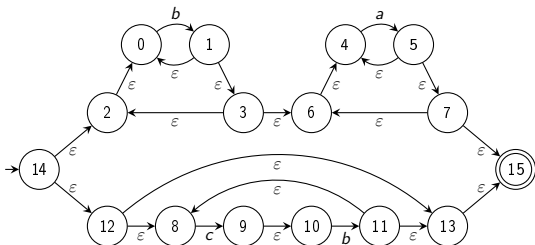
$E_3 = \{4, 5, 6, 7, 15\}$

$E_4 = \{8, 10, 11, 13, 15\}$

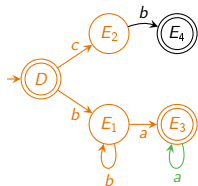
Etat actuel :  $E_2$

- $x = c$
- transitions : aucune

expr =  $b^*a^*(cb)^*$



Etat actuel :  $E_3$



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

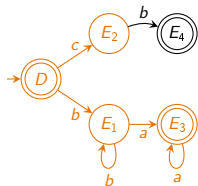
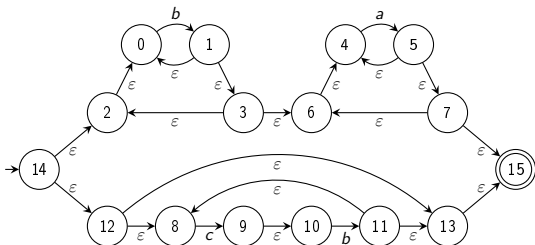
$E_2 = \{9, 10\}$

$E_3 = \{4, 5, 6, 7, 15\}$

$E_4 = \{8, 10, 11, 13, 15\}$

- $x = a$
- transitions : 4c5
- $EpsilonFermeture(\{5\}) = \{4, 5, 6, 7, 15\} = E_3$
- etat final : oui

$\text{expr} = b^*a^*(cb)^*$



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

$E_2 = \{9, 10\}$

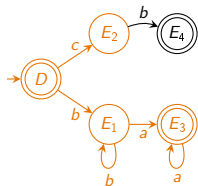
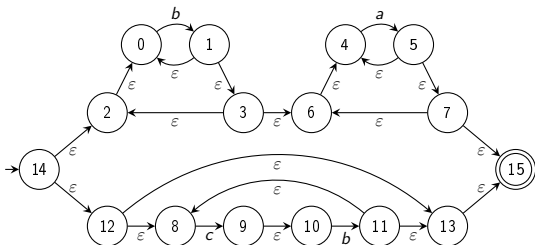
$E_3 = \{4, 5, 6, 7, 15\}$

$E_4 = \{8, 10, 11, 13, 15\}$

Etat actuel :  $E_3$

- $x = b$
- transitions : aucune

expr = b\*a\*|(cb)\*



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

$E_2 = \{9, 10\}$

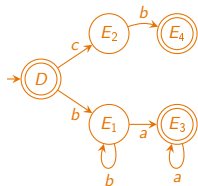
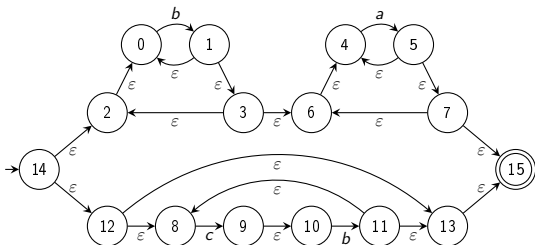
$E_3 = \{4, 5, 6, 7, 15\}$

$E_4 = \{8, 10, 11, 13, 15\}$

Etat actuel :  $E_3$

- $x = c$
- transitions : aucune

expr = b\*a\*|(cb)\*



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

$E_2 = \{9, 10\}$

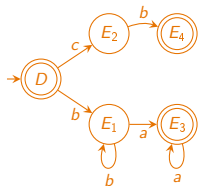
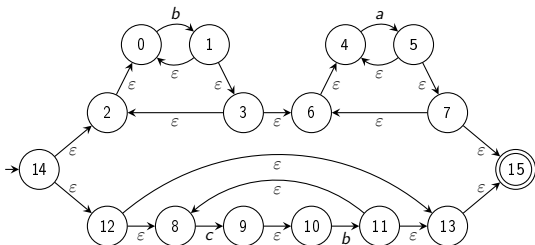
$E_3 = \{4, 5, 6, 7, 15\}$

$E_4 = \{8, 10, 11, 13, 15\}$

Etat actuel :  $E_4$

- $x = a$
- transitions : aucune

expr = b\*a\*|(cb)\*



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

$E_2 = \{9, 10\}$

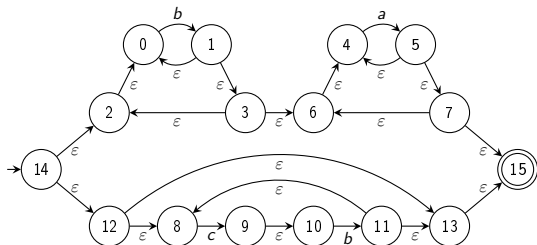
$E_3 = \{4, 5, 6, 7, 15\}$

$E_4 = \{8, 10, 11, 13, 15\}$

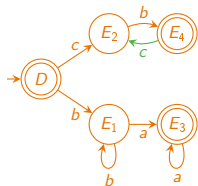
Etat actuel :  $E_4$

- $x = b$
- transitions : aucune

expr = b\*a\*|(cb)\*



Etat actuel :  $E_4$



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

$E_2 = \{9, 10\}$

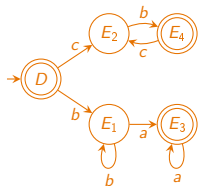
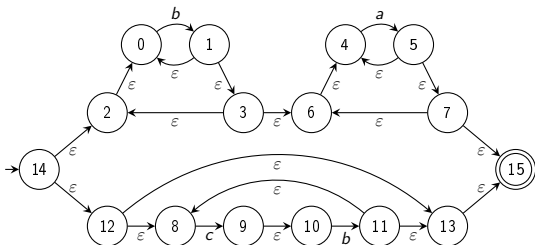
$E_3 = \{4, 5, 6, 7, 15\}$

$E_4 = \{8, 10, 11, 13, 15\}$

- $x = c$
- transitions : 8c9
- $EpsilonFermeture(\{9\}) = \{9, 10\} = E_2$
- etat final : non



$\text{expr} = b^*a^*(cb)^*$



$D = \{0, 2, 8, 12, 13, 14, 15\}$

$E_1 = \{0, 1, 2, 3, 4, 6\}$

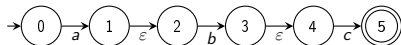
$E_2 = \{9, 10\}$

$E_3 = \{4, 5, 6, 7, 15\}$

$E_4 = \{8, 10, 11, 13, 15\}$

AFD terminé, nombre d'états : 5

expr = abc

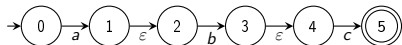


$$D = \{0\}$$

Calcul de l'état de départ :

$$D = \text{EpsilonFermeture}(\{0\}) = \{0\}$$

expr = abc



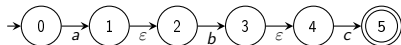
$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

Etat actuel :  $D$

- $x = a$
- transitions : 0a1
- $EpsilonFermeture(\{1\}) = \{1, 2\} = E_1$
- etat final : non

expr = abc



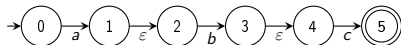
$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

Etat actuel :  $D$

- $x = b$
- transitions : aucune

expr = abc



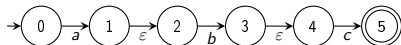
$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

Etat actuel :  $D$

- $x = c$
- transitions : aucune

expr = abc



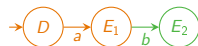
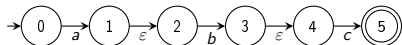
$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

Etat actuel :  $E_1$

- $x = a$
- transitions : aucune

expr = abc



$$D = \{0\}$$

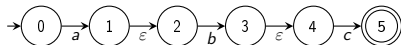
$$E_1 = \{1, 2\}$$

$$E_2 = \{3, 4\}$$

Etat actuel :  $E_1$

- $x = b$
- transitions : 2b3
- $EpsilonFermeture(\{3\}) = \{3, 4\} = E_2$
- etat final : non

expr = abc



$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

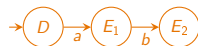
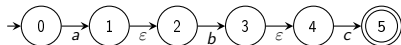
$$E_2 = \{3, 4\}$$

Etat actuel :  $E_1$

- $x = c$
- transitions : aucune



expr = abc



$$D = \{0\}$$

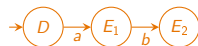
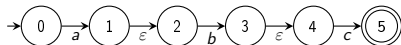
$$E_1 = \{1, 2\}$$

$$E_2 = \{3, 4\}$$

Etat actuel :  $E_2$

- $x = a$
- transitions : aucune

expr = abc



$$D = \{0\}$$

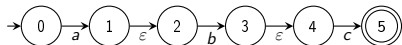
$$E_1 = \{1, 2\}$$

$$E_2 = \{3, 4\}$$

Etat actuel :  $E_2$

- $x = b$
- transitions : aucune

expr = abc



Etat actuel :  $E_2$

- $x = c$
- transitions : 4c5
- $EpsilonFermeture(\{5\}) = \{5\} = E_3$
- etat final : oui



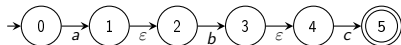
$D = \{0\}$

$E_1 = \{1, 2\}$

$E_2 = \{3, 4\}$

$E_3 = \{5\}$

expr = abc



$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

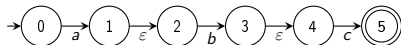
$$E_2 = \{3, 4\}$$

$$E_3 = \{5\}$$

Etat actuel :  $E_3$

- $x = a$
- transitions : aucune

expr = abc



Etat actuel :  $E_3$

- $x = b$
- transitions : aucune



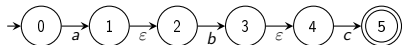
$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

$$E_2 = \{3, 4\}$$

$$E_3 = \{5\}$$

expr = abc



$$D = \{0\}$$

$$E_1 = \{1, 2\}$$

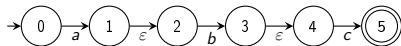
$$E_2 = \{3, 4\}$$

$$E_3 = \{5\}$$

Etat actuel :  $E_3$

- $x = c$
- transitions : aucune

expr = abc



$$D = \{0\}$$

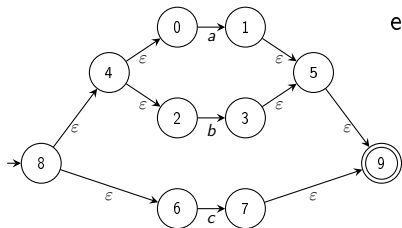
$$E_1 = \{1, 2\}$$

$$E_2 = \{3, 4\}$$

$$E_3 = \{5\}$$

AFD terminé, nombre d'états : 4

expr = (a|b)|c

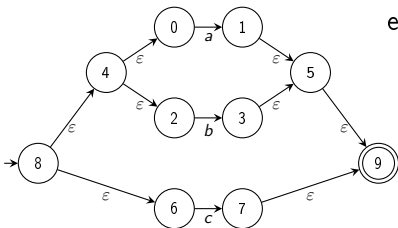


$$D = \{0, 2, 4, 6, 8\}$$

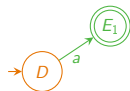
Calcul de l'état de départ :

$$D = \text{EpsilonFermeture}(\{8\}) = \{0, 2, 4, 6, 8\}$$





expr = (a|b)|c



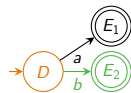
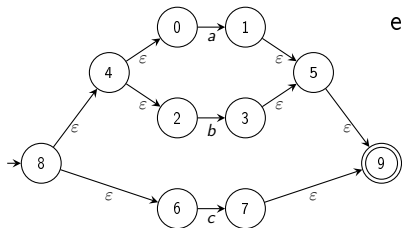
$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 5, 9\}$

Etat actuel :  $D$

- $x = a$
- transitions : 0a1
- $EpsilonFermeture(\{1\}) = \{1, 5, 9\} = E_1$
- etat final : oui

expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

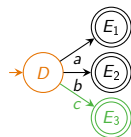
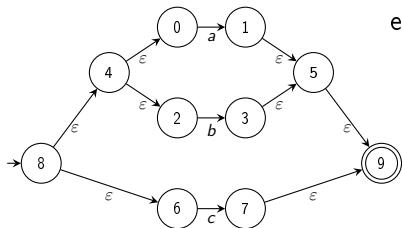
$E_1 = \{1, 5, 9\}$

$E_2 = \{3, 5, 9\}$

Etat actuel :  $D$

- $x = b$
- transitions : 2b3
- $EpsilonFermeture(\{3\}) = \{3, 5, 9\} = E_2$
- etat final : oui

expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 5, 9\}$

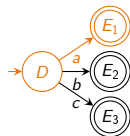
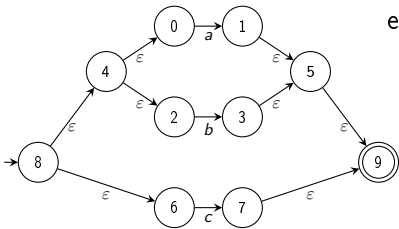
$E_2 = \{3, 5, 9\}$

$E_3 = \{7, 9\}$

Etat actuel :  $D$

- $x = c$
- transitions : 6c7
- $EpsilonFermeture(\{5\}) = \{7, 9\} = E_3$
- etat final : oui

expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 5, 9\}$

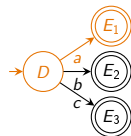
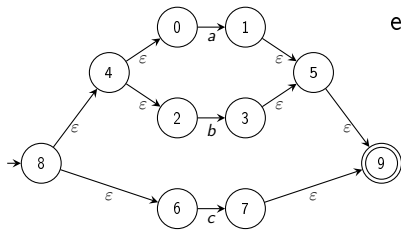
$E_2 = \{3, 5, 9\}$

$E_3 = \{7, 9\}$

Etat actuel :  $E_1$

- $x = a$
- transitions : aucune

expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 5, 9\}$

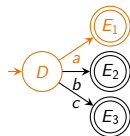
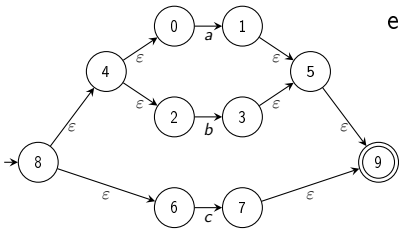
$E_2 = \{3, 5, 9\}$

$E_3 = \{7, 9\}$

Etat actuel :  $E_1$

- $x = b$
- transitions : aucune

expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 5, 9\}$

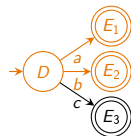
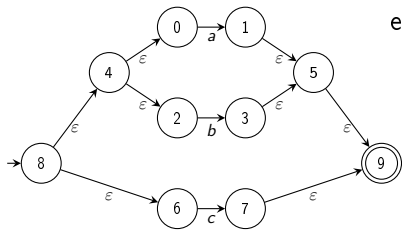
$E_2 = \{3, 5, 9\}$

$E_3 = \{7, 9\}$

Etat actuel :  $E_1$

- $x = c$
- transitions : aucune

expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 5, 9\}$

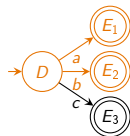
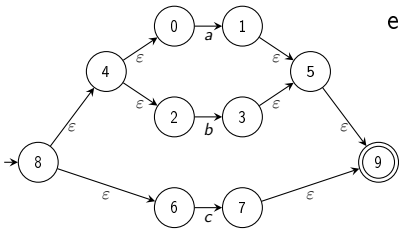
$E_2 = \{3, 5, 9\}$

$E_3 = \{7, 9\}$

Etat actuel :  $E_2$

- $x = a$
- transitions : aucune

expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 5, 9\}$

$E_2 = \{3, 5, 9\}$

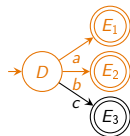
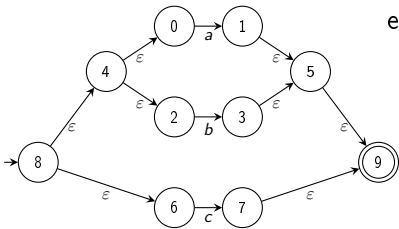
$E_3 = \{7, 9\}$

Etat actuel :  $E_2$

- $x = b$
- transitions : aucune



expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 5, 9\}$

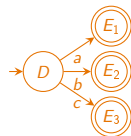
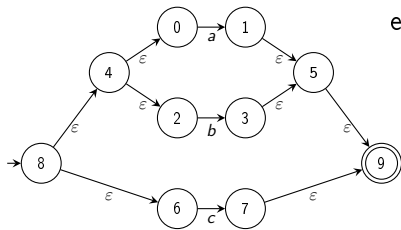
$E_2 = \{3, 5, 9\}$

$E_3 = \{7, 9\}$

Etat actuel :  $E_2$

- $x = c$
- transitions : aucune

expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 5, 9\}$

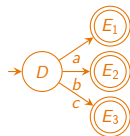
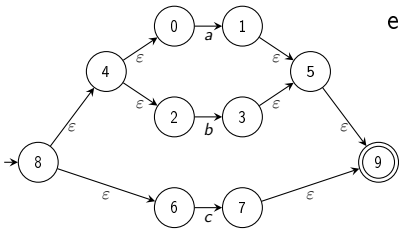
$E_2 = \{3, 5, 9\}$

$E_3 = \{7, 9\}$

Etat actuel :  $E_3$

- $x = a$
- transitions : aucune

expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 5, 9\}$

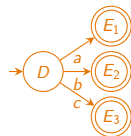
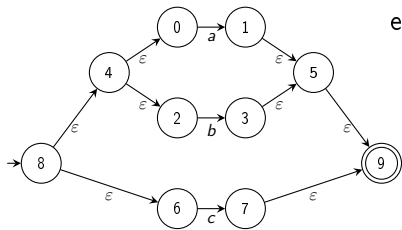
$E_2 = \{3, 5, 9\}$

$E_3 = \{7, 9\}$

Etat actuel :  $E_3$

- $x = b$
- transitions : aucune

expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 5, 9\}$

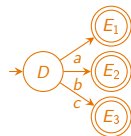
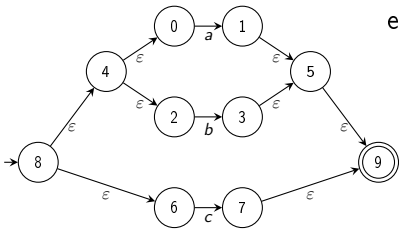
$E_2 = \{3, 5, 9\}$

$E_3 = \{7, 9\}$

Etat actuel :  $E_3$

- $x = c$
- transitions : aucune

expr = (a|b)|c



$D = \{0, 2, 4, 6, 8\}$

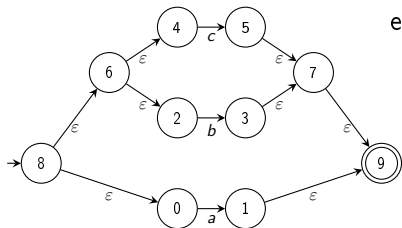
$E_1 = \{1, 5, 9\}$

$E_2 = \{3, 5, 9\}$

$E_3 = \{7, 9\}$

AFD terminé, nombre d'états : 4

expr = a|(b|c)

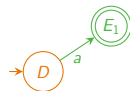
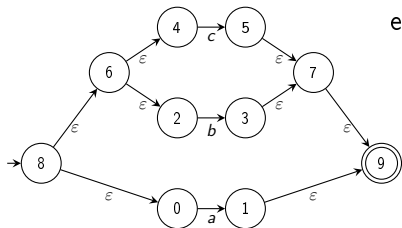


$$D = \{0, 2, 4, 6, 8\}$$

Calcul de l'état de départ :

$$D = \text{EpsilonFermeture}(\{8\}) = \{0, 2, 4, 6, 8\}$$

expr = a|(b|c)



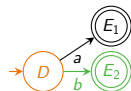
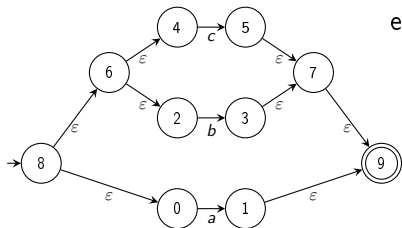
$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

Etat actuel :  $D$

- $x = a$
- transitions : 0a1
- $EpsilonFermeture(\{1\}) = \{1, 9\} = E_1$
- etat final : oui

expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

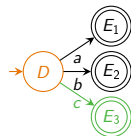
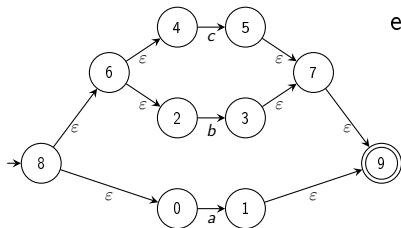
$E_2 = \{3, 7, 9\}$

Etat actuel :  $D$

- $x = b$
- transitions : 2b3
- $EpsilonFermeture(\{3\}) = \{3, 7, 9\} = E_2$
- etat final : oui



expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

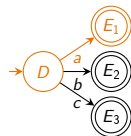
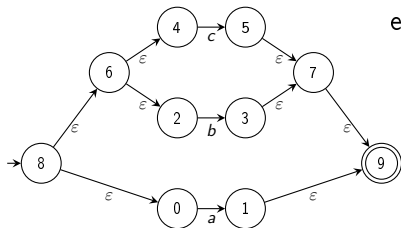
$E_2 = \{3, 7, 9\}$

$E_3 = \{5, 7, 9\}$

Etat actuel :  $D$

- $x = c$
- transitions : 4c5
- $EpsilonFermeture(\{5\}) = \{5, 7, 9\} = E_3$
- etat final : oui

expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

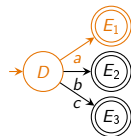
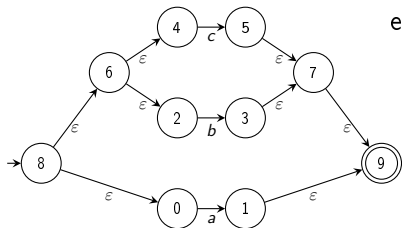
$E_2 = \{3, 7, 9\}$

$E_3 = \{5, 7, 9\}$

Etat actuel :  $E_1$

- $x = a$
- transitions : aucune

expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

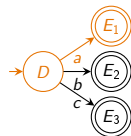
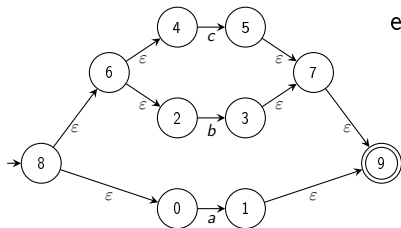
$E_2 = \{3, 7, 9\}$

$E_3 = \{5, 7, 9\}$

Etat actuel :  $E_1$

- $x = b$
- transitions : aucune

expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

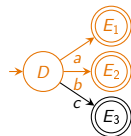
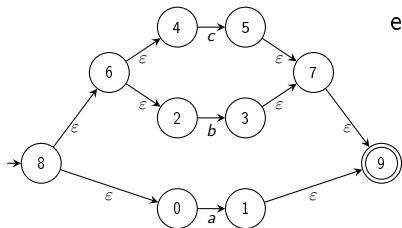
$E_2 = \{3, 7, 9\}$

$E_3 = \{5, 7, 9\}$

Etat actuel :  $E_1$

- $x = c$
- transitions : aucune

expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

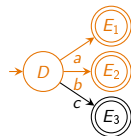
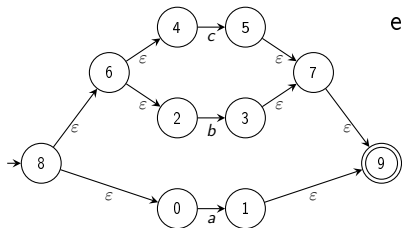
$E_2 = \{3, 7, 9\}$

$E_3 = \{5, 7, 9\}$

Etat actuel :  $E_2$

- $x = a$
- transitions : aucune

expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

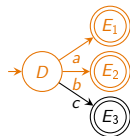
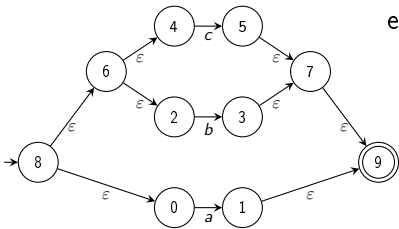
$E_2 = \{3, 7, 9\}$

$E_3 = \{5, 7, 9\}$

Etat actuel :  $E_2$

- $x = b$
- transitions : aucune

expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

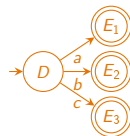
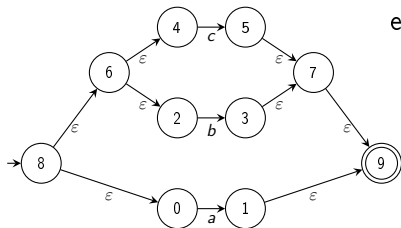
$E_2 = \{3, 7, 9\}$

$E_3 = \{5, 7, 9\}$

Etat actuel :  $E_2$

- $x = c$
- transitions : aucune

expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

$E_2 = \{3, 7, 9\}$

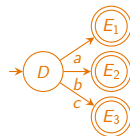
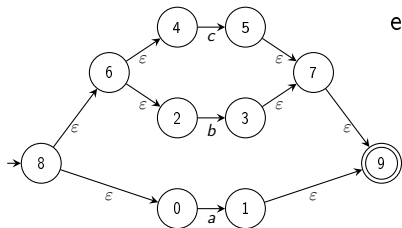
$E_3 = \{5, 7, 9\}$

Etat actuel :  $E_3$

- $x = a$
- transitions : aucune



expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

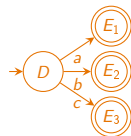
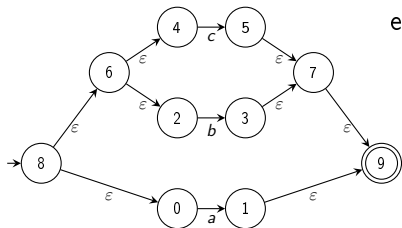
$E_2 = \{3, 7, 9\}$

$E_3 = \{5, 7, 9\}$

Etat actuel :  $E_3$

- $x = b$
- transitions : aucune

expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

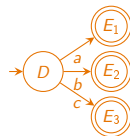
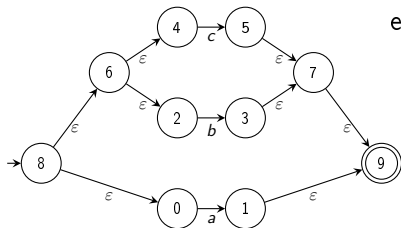
$E_2 = \{3, 7, 9\}$

$E_3 = \{5, 7, 9\}$

Etat actuel :  $E_3$

- $x = c$
- transitions : aucune

expr = a|(b|c)



$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

$E_2 = \{3, 7, 9\}$

$E_3 = \{5, 7, 9\}$

AFD terminé, nombre d'états : 4

Les AFD des expressions régulières  $(a|b)|c$  et  $a|(b|c)$  sont strictement identiques. Cela montre que quels que soient  $a$ ,  $b$  et  $c$ , la règle  $|$  est associative. Il est donc possible de supprimer les parenthèses sans ambiguïté.

$$(a|b)|c = a|(b|c) = a|b|c$$