HAI601I - Exercices de révisions

Benoît Huftier

2022

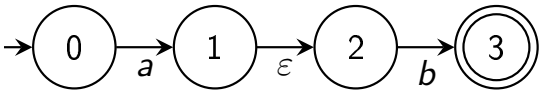
Construction d'un AFD à partir d'un AFN

Enoncé

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

1. ab
2. b*
3. a|b
4. ab*|c
5. ((a|b)|cc)*
6. b*a*|(cb)*
7. abc
8. (a|b)|c
9. a|(b|c)

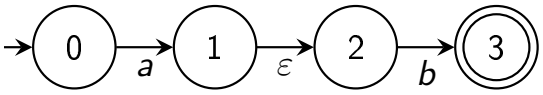
Avec les AFD des expressions régulières (a|b)|c et a|(b|c), que peut-on en déduire sur la règle | ?

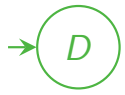


On rappelle que pour créer un AFD à partir d'un AFN, il faut créer des ε-fermetures d'ensemble d'états, en commençant par l'état de départ (ici l'état 0).

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

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





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

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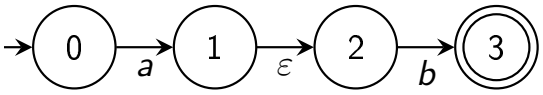

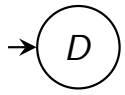

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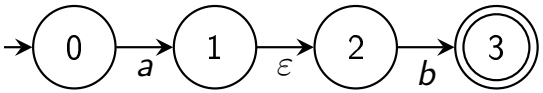
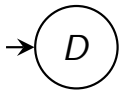
On part maintenant de D, pour créer notre AFD.





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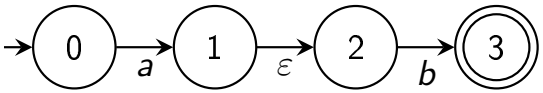
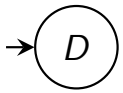
Etat actuel : $D = \{0\}$.





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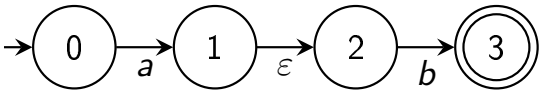

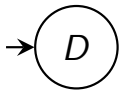

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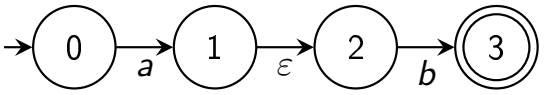
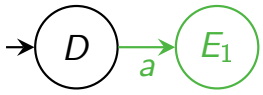
$$EpsilonFermeture(\{1\}) = E_1 = \{1, 2\}$$





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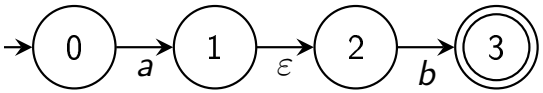

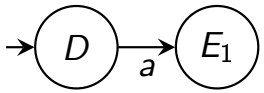

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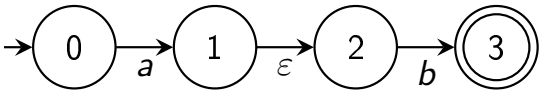

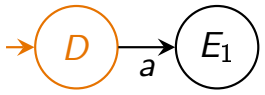

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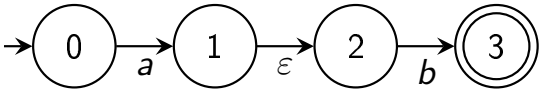

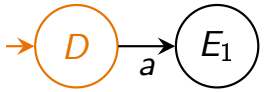

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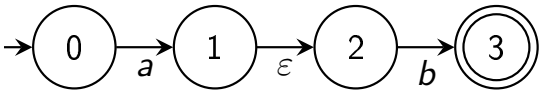

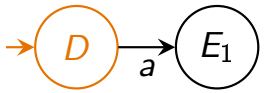

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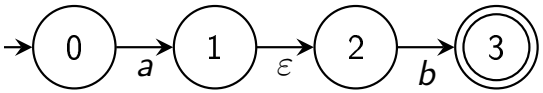

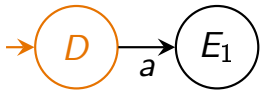

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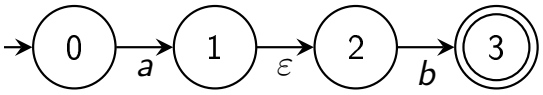

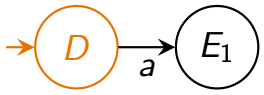

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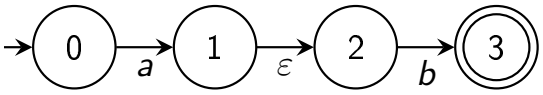
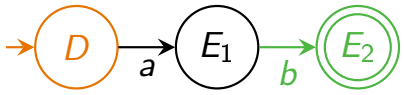
Pour x = b, il y a la transition 2b3, on calcule donc l'ε-fermeture de 3.

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





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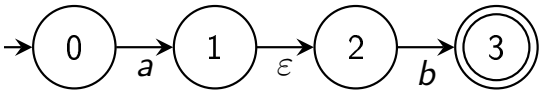

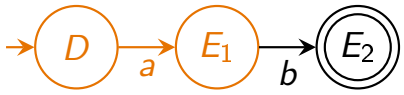

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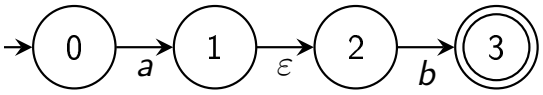

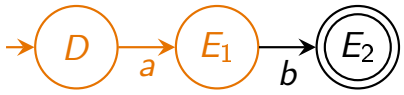

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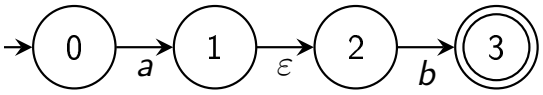
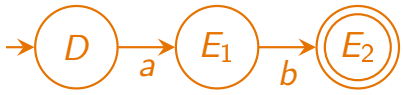
Etat actuel : $E_2 = \{3\}$.





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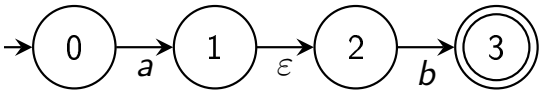
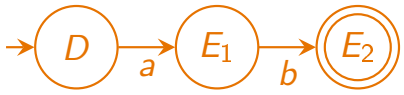
Etat actuel : $E_2 = \{3\}$.
Il n'y a aucune transition depuis l'état 3 donc on marque directement l'état E_2.





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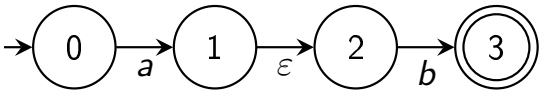
Tous les états sont maintenant marqués, l'AFD est terminé.



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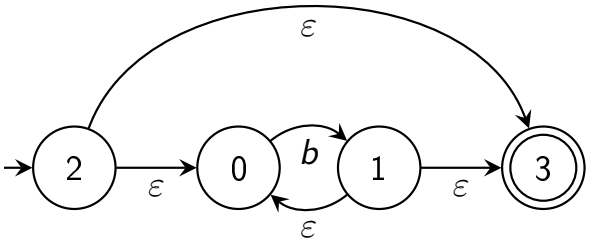
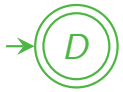
Notez que la correction a été expliquée pour cet exemple mais ne le sera pas pour les prochains.





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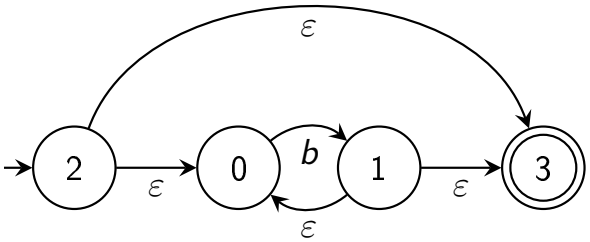
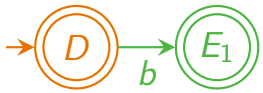
Calcul de l'état de départ :

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





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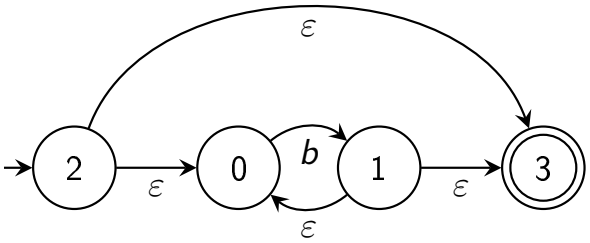
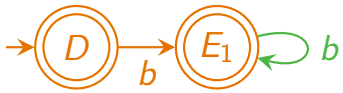
$E_1 = \{0, 1, 3\}$

Etat actuel : D

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





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Etat actuel : E_1

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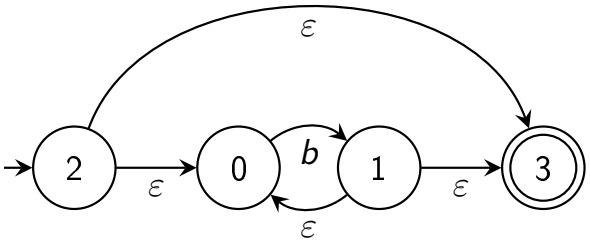
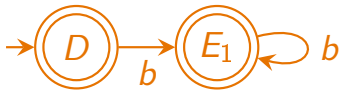
- transitions : 0b1
- $EpsilonFermeture(\{1\}) = \{0, 1, 3\} = E_1$
- etat final : oui

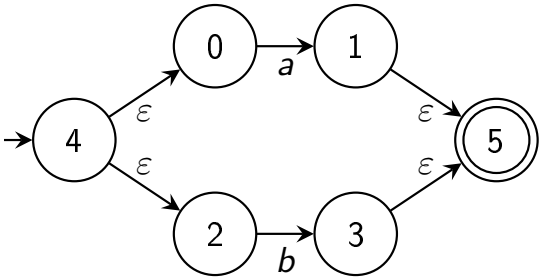


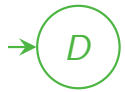


$D = \{0, 2, 3\}$

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

AFD terminé, nombre d'états : 2

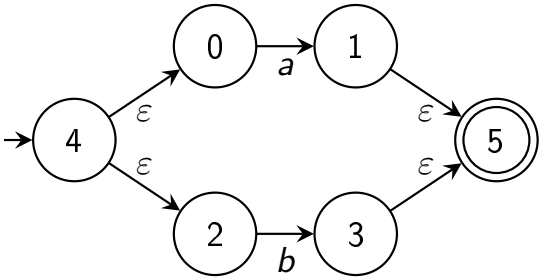


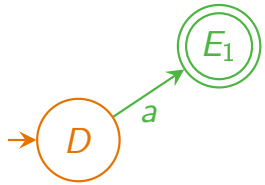


$D = \{0, 2, 4\}$

Calcul de l'état de départ :

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

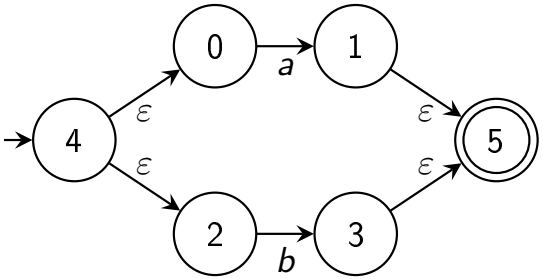


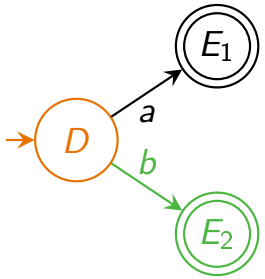


$D = \{0, 2, 4\}$
$E_1 = \{1, 5\}$

Etat actuel : D

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

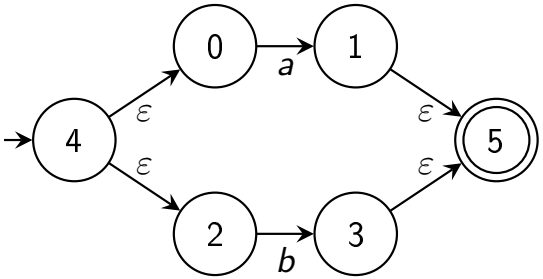


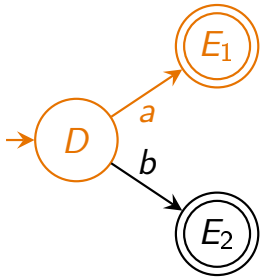


$D = \{0, 2, 4\}$
$E_1 = \{1, 5\}$
$E_2 = \{3, 5\}$

Etat actuel : D

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

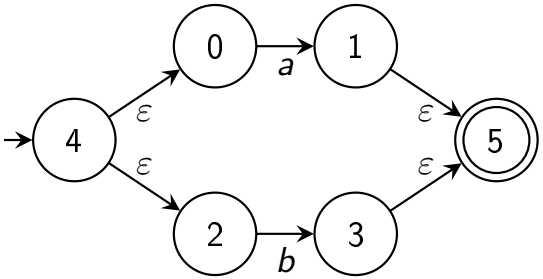


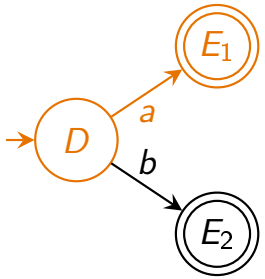


$D = \{0, 2, 4\}$
$E_1 = \{1, 5\}$
$E_2 = \{3, 5\}$

Etat actuel : E_1

- x = a
- transitions : aucune

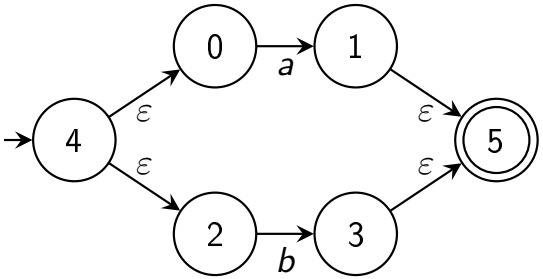


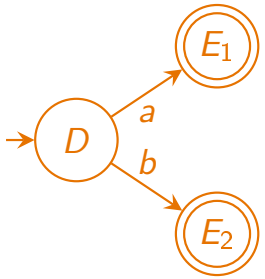


$D = \{0, 2, 4\}$
$E_1 = \{1, 5\}$
$E_2 = \{3, 5\}$

Etat actuel : E_1

- x = b
- transitions : aucune

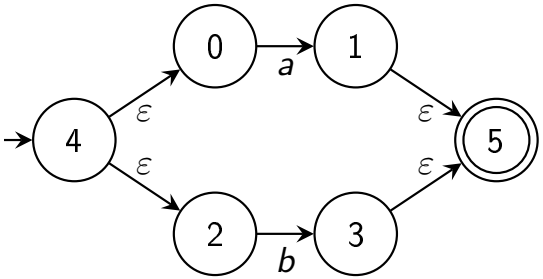


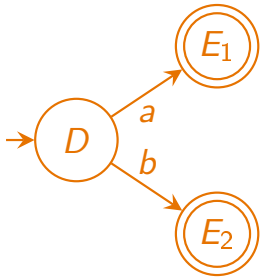


$D = \{0, 2, 4\}$
$E_1 = \{1, 5\}$
$E_2 = \{3, 5\}$

Etat actuel : E_2

- x = a
- transitions : aucune

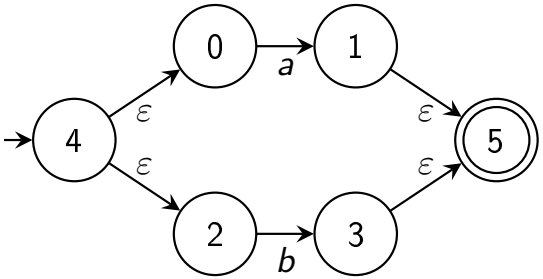


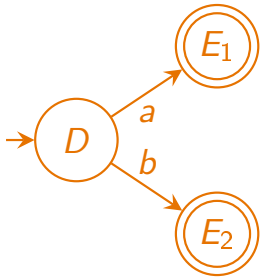


$D = \{0, 2, 4\}$
$E_1 = \{1, 5\}$
$E_2 = \{3, 5\}$

Etat actuel : E_2

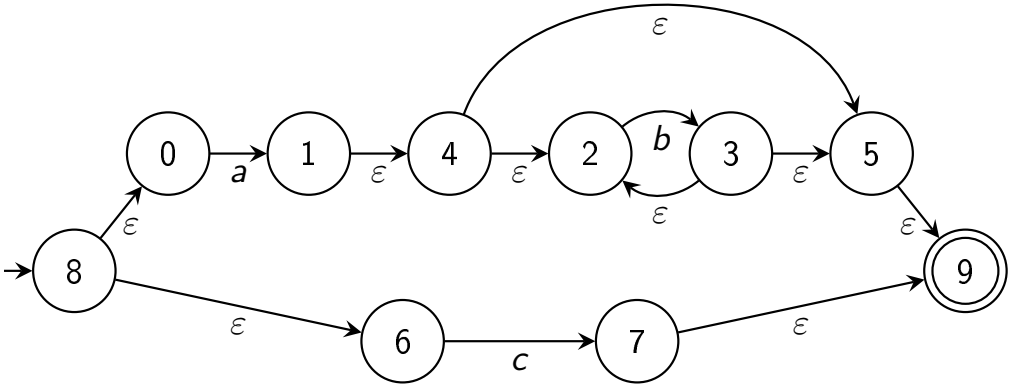
- x = b
- transitions : aucune

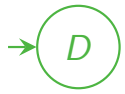




$D = \{0, 2, 4\}$
$E_1 = \{1, 5\}$
$E_2 = \{3, 5\}$

AFD terminé, nombre d'états : 3

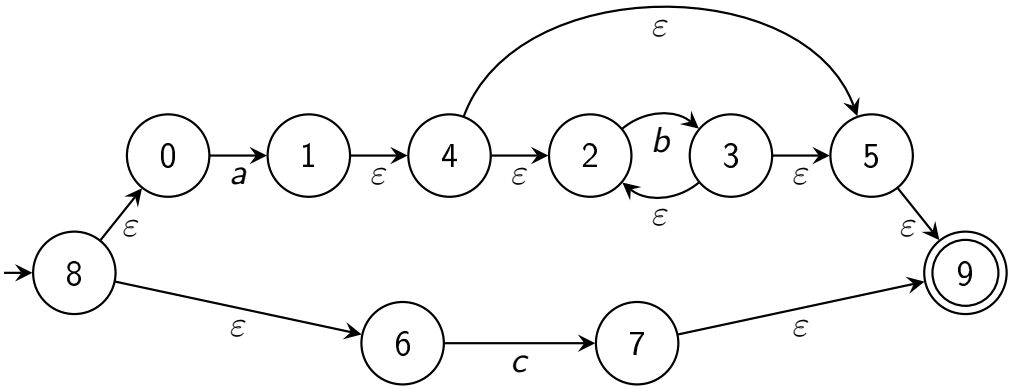


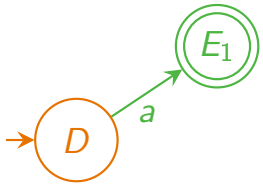


$D = \{0, 6, 8\}$

Calcul de l'état de départ :

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



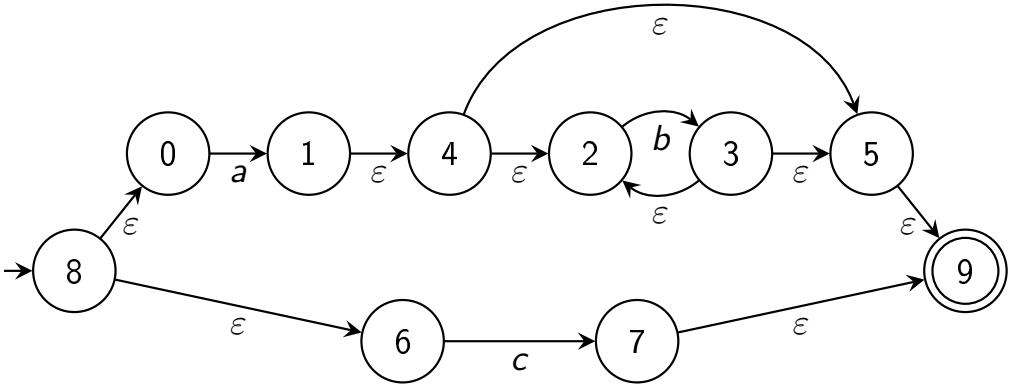


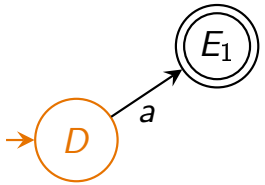
$D = \{0, 6, 8\}$

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

Etat actuel : D

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

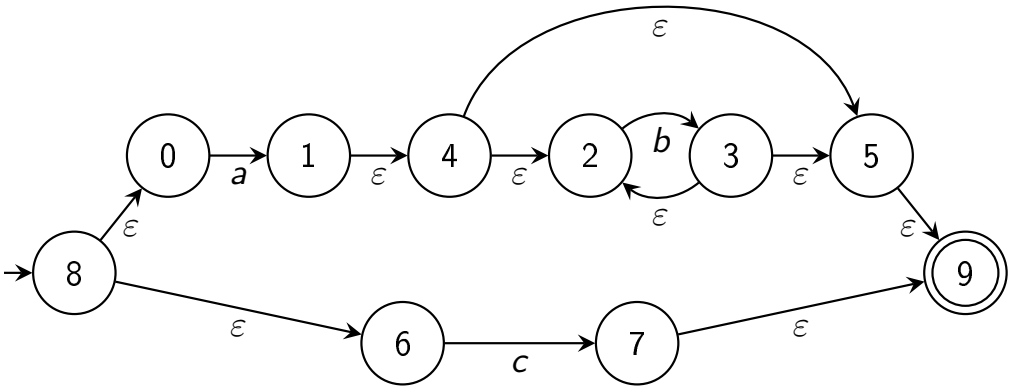


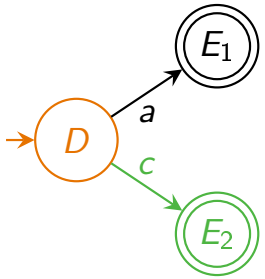


$D = \{0, 6, 8\}$
$E_1 = \{1, 2, 4, 5, 9\}$

Etat actuel : D

- x = b
- transitions : aucune

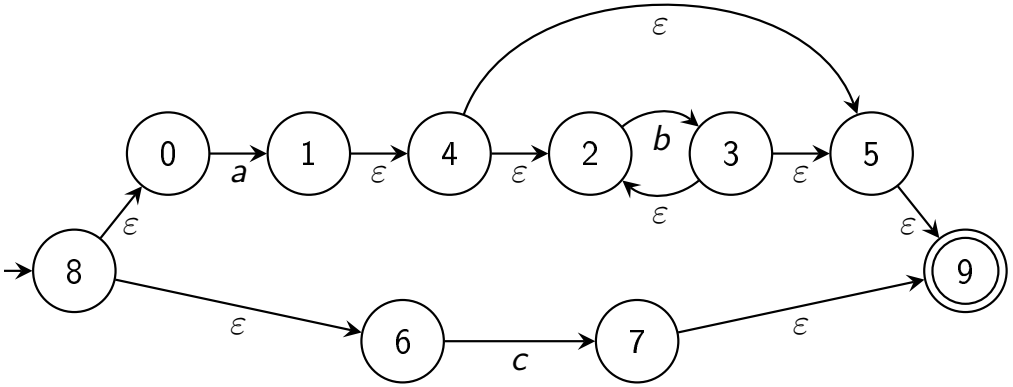


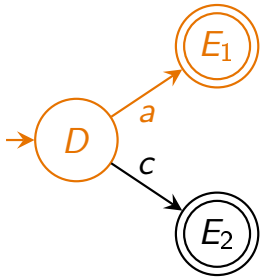


$D = \{0, 6, 8\}$
$E_1 = \{1, 2, 4, 5, 9\}$
$E_2 = \{7, 9\}$

Etat actuel : D

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

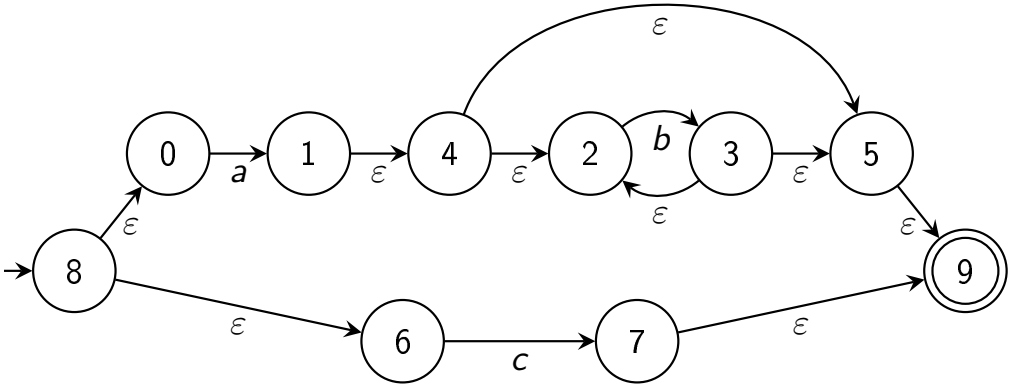


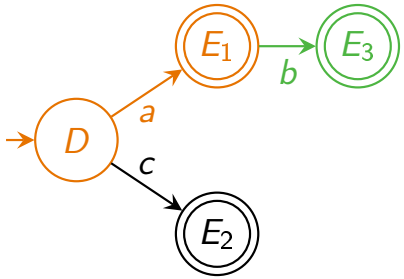


$D = \{0, 6, 8\}$
$E_1 = \{1, 2, 4, 5, 9\}$
$E_2 = \{7, 9\}$

Etat actuel : E_1

- x = a
- transitions : aucune

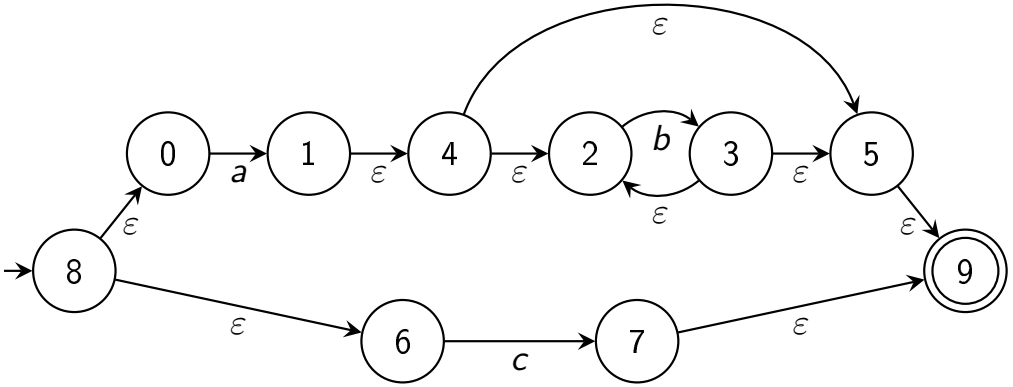


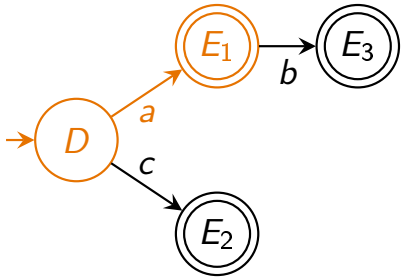


$D = \{0, 6, 8\}$
$E_1 = \{1, 2, 4, 5, 9\}$
$E_2 = \{7, 9\}$
$E_3 = \{2, 3, 5, 9\}$

Etat actuel : E_1

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

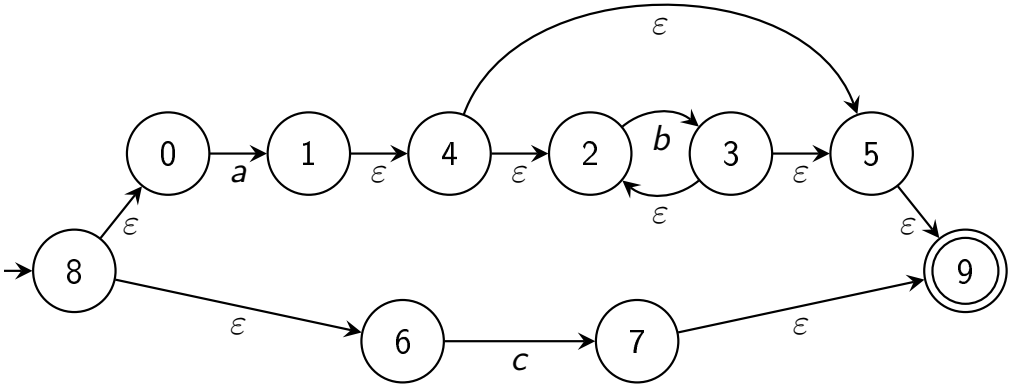


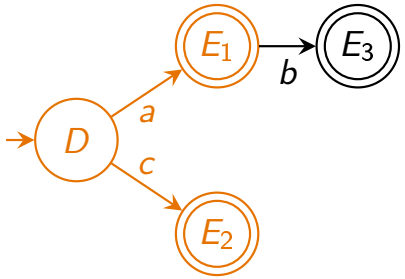


$D = \{0, 6, 8\}$
$E_1 = \{1, 2, 4, 5, 9\}$
$E_2 = \{7, 9\}$
$E_3 = \{2, 3, 5, 9\}$

Etat actuel : E_1

- x = c
- transitions : aucune

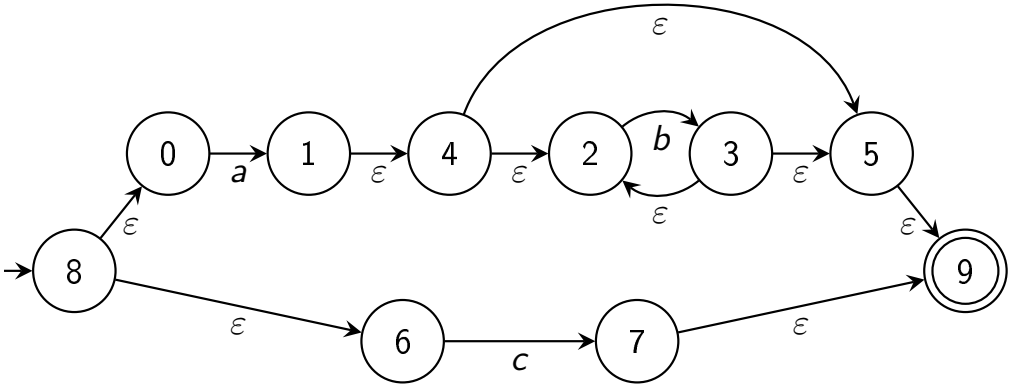


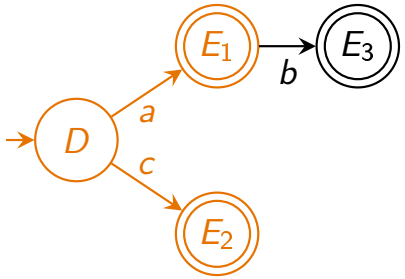


$D = \{0, 6, 8\}$
$E_1 = \{1, 2, 4, 5, 9\}$
$E_2 = \{7, 9\}$
$E_3 = \{2, 3, 5, 9\}$

Etat actuel : E_2

- x = a
- transitions : aucune

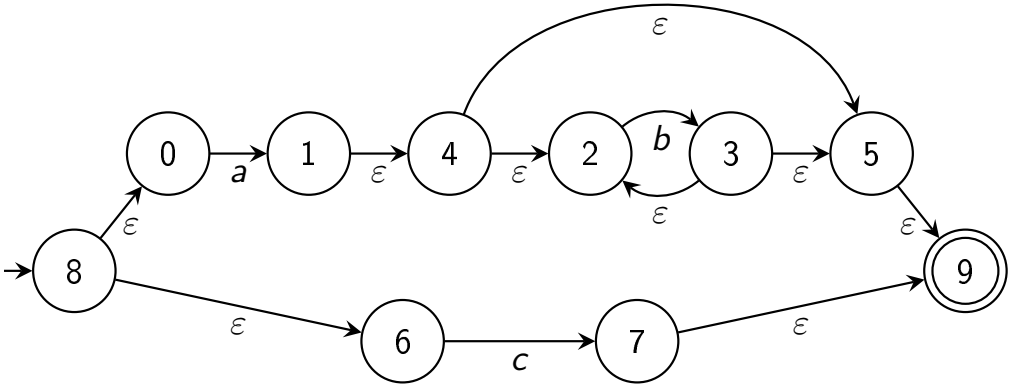


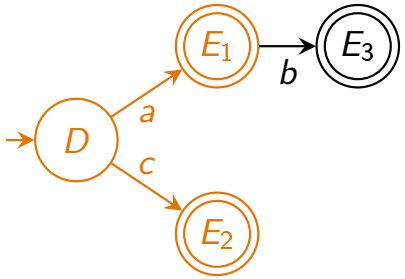


$D = \{0, 6, 8\}$
$E_1 = \{1, 2, 4, 5, 9\}$
$E_2 = \{7, 9\}$
$E_3 = \{2, 3, 5, 9\}$

Etat actuel : E_2

- x = b
- transitions : aucune

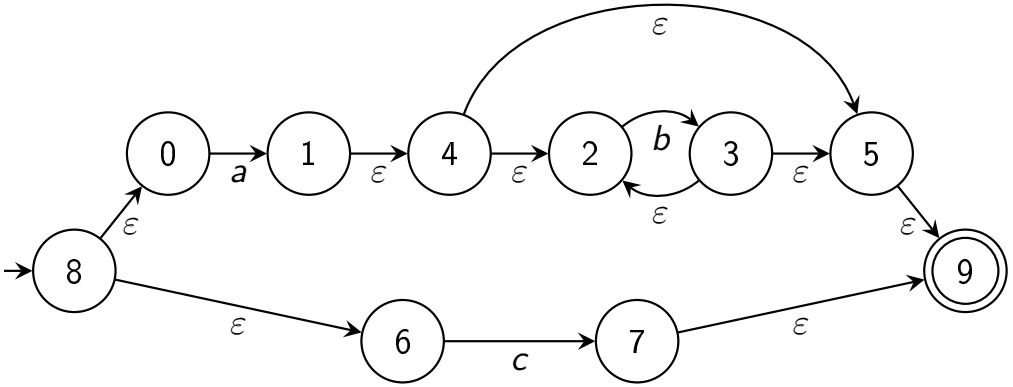


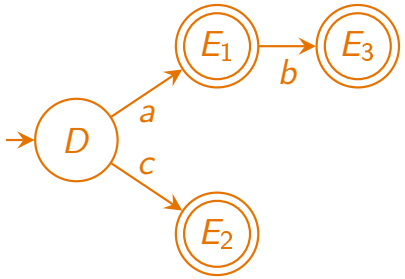


$D = \{0, 6, 8\}$
$E_1 = \{1, 2, 4, 5, 9\}$
$E_2 = \{7, 9\}$
$E_3 = \{2, 3, 5, 9\}$

Etat actuel : E_2

- x = c
- transitions : aucune

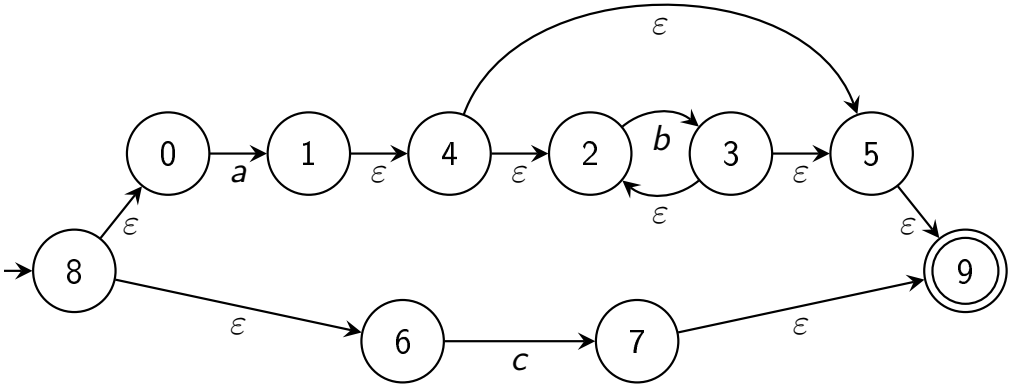


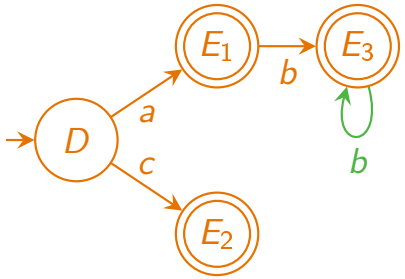


$D = \{0, 6, 8\}$
$E_1 = \{1, 2, 4, 5, 9\}$
$E_2 = \{7, 9\}$
$E_3 = \{2, 3, 5, 9\}$

Etat actuel : E_3

- x = a
- transitions : aucune

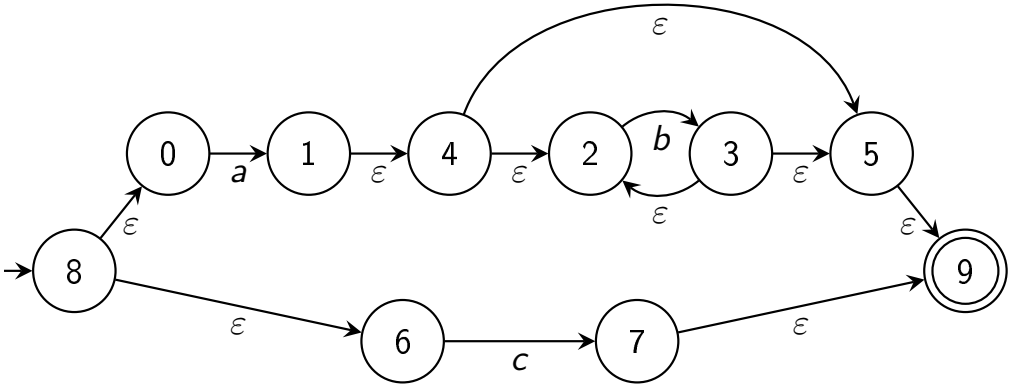


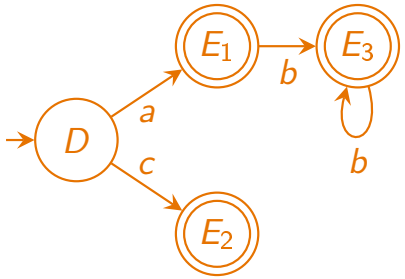


$D = \{0, 6, 8\}$
$E_1 = \{1, 2, 4, 5, 9\}$
$E_2 = \{7, 9\}$
$E_3 = \{2, 3, 5, 9\}$

Etat actuel : E_3

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

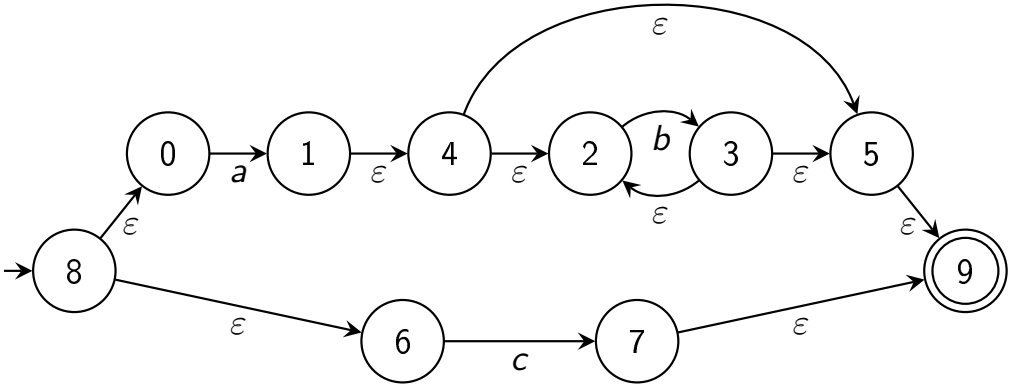


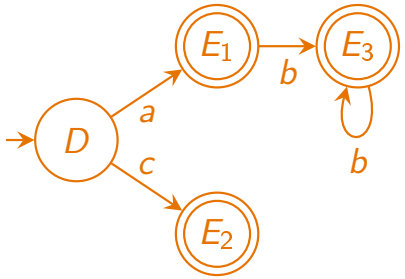


$$D = \{0, 6, 8\}$$
$$E_1 = \{1, 2, 4, 5, 9\}$$
$$E_2 = \{7, 9\}$$
$$E_3 = \{2, 3, 5, 9\}$$

Etat actuel : E_3

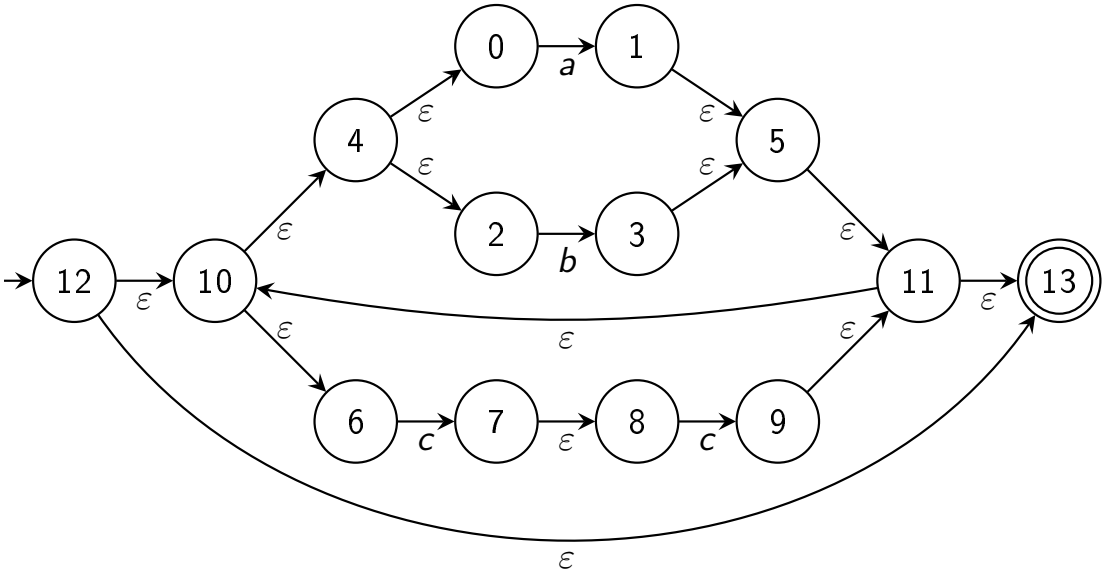
- x = c
- transitions : aucune





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

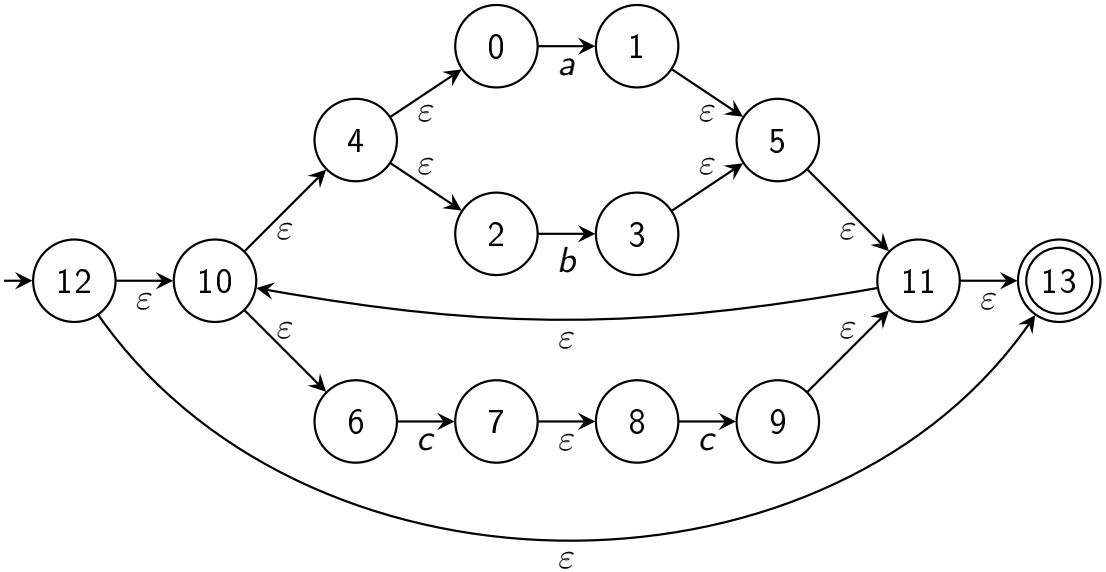
AFD terminé, nombre d'états : 4

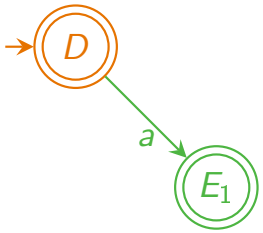


$D = \{0, 2, 4, 6, 10, 12, 13\}$

Calcul de l'état de départ :

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



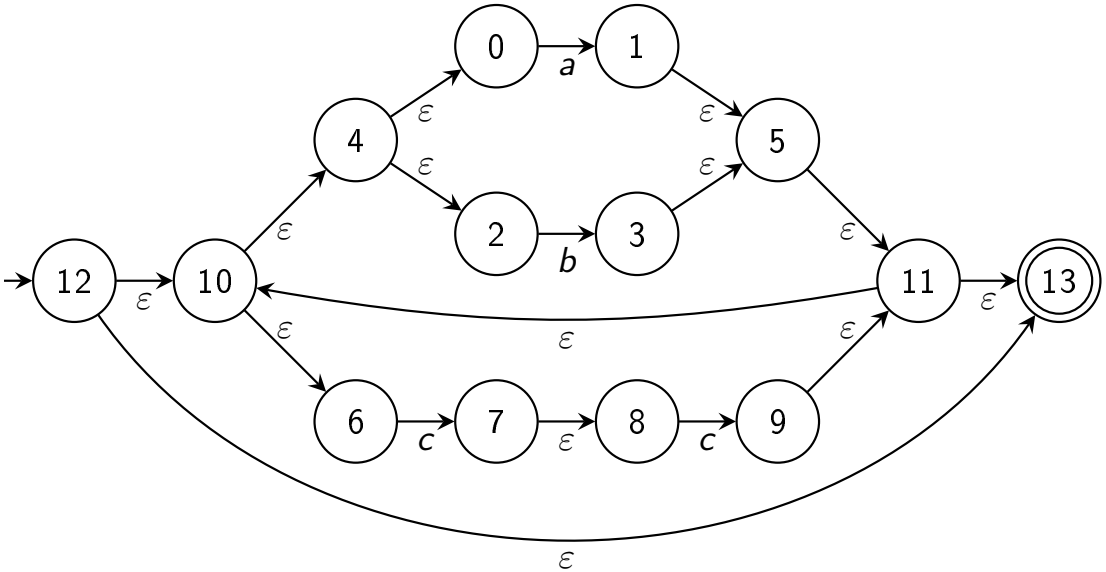


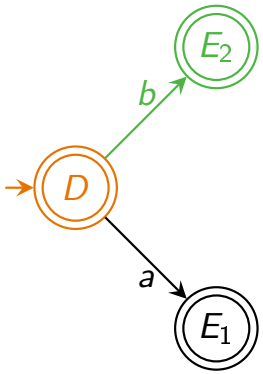
Etat actuel : D

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

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

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

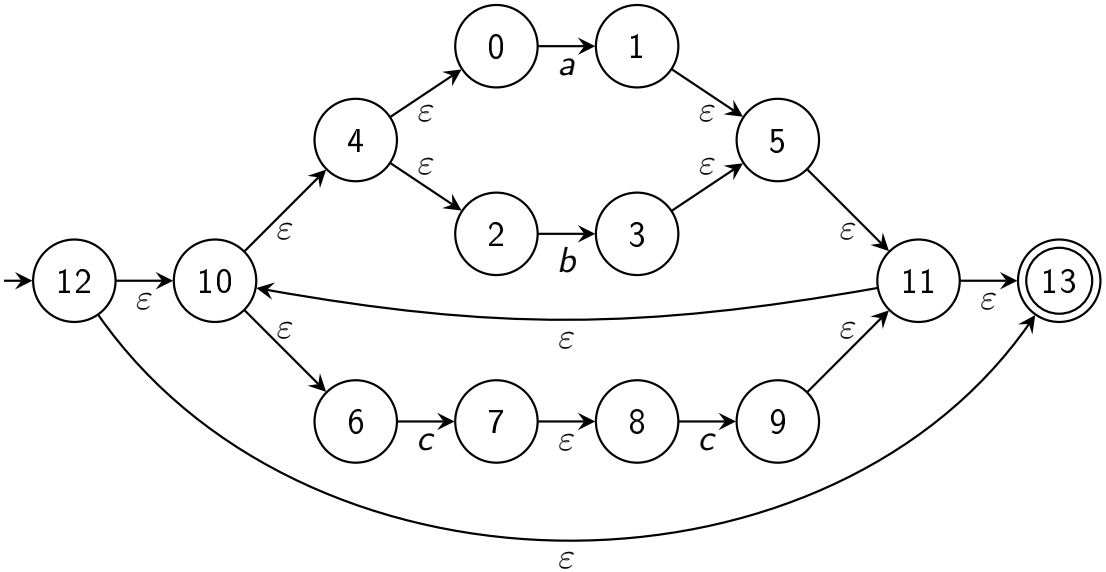


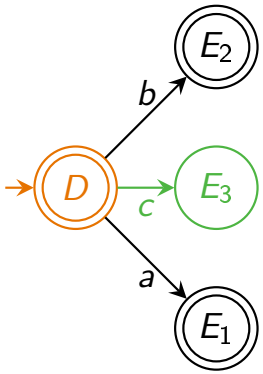


Etat actuel : D

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

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

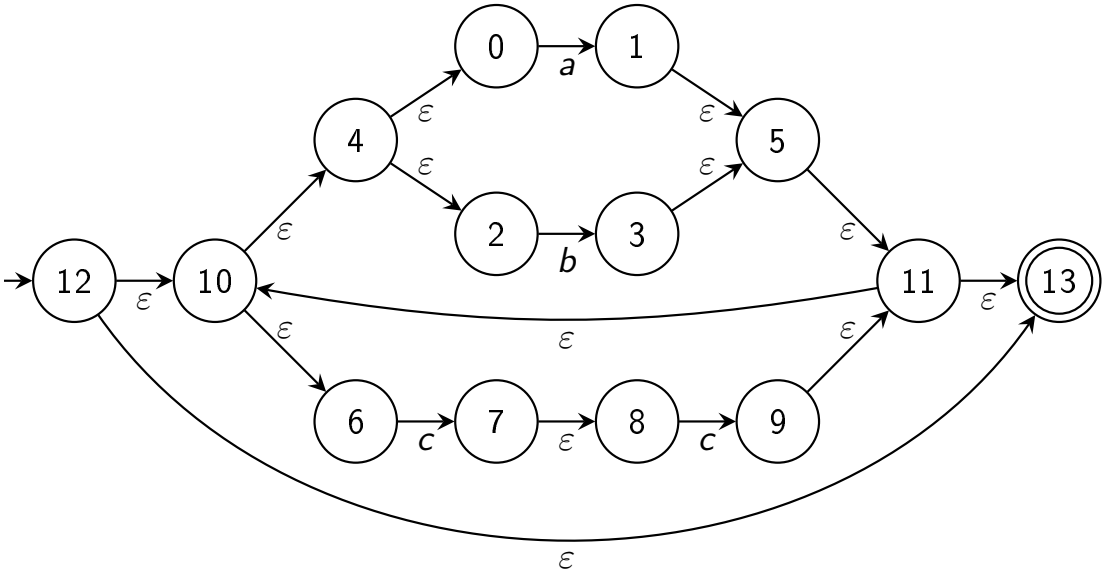


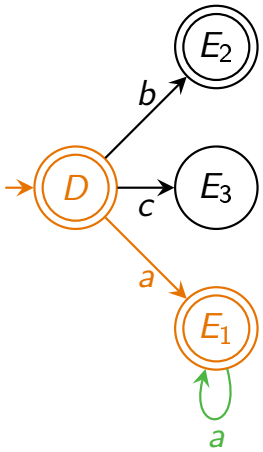


Etat actuel : D

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

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

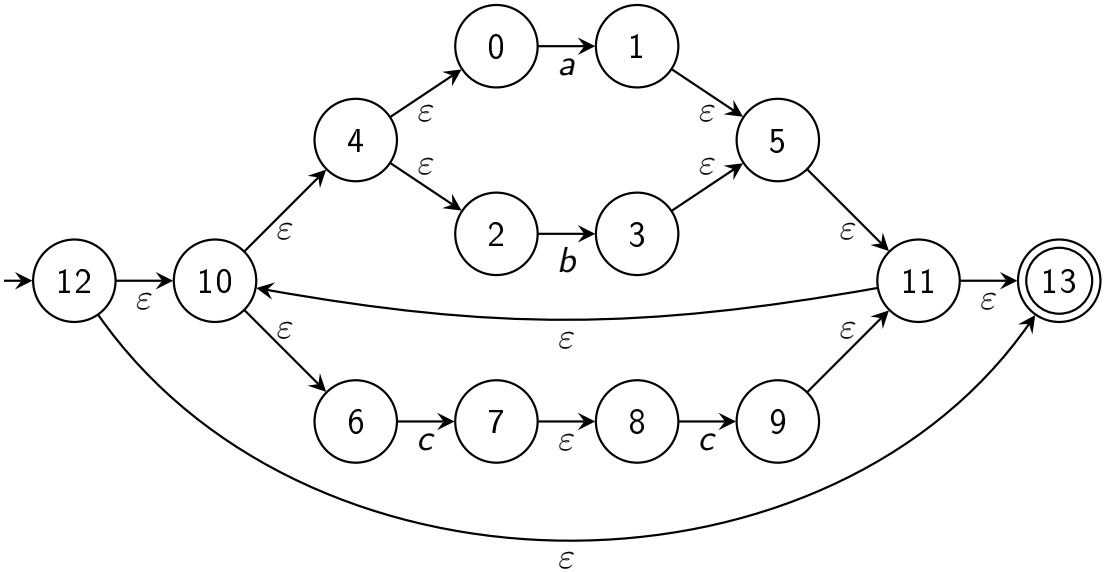


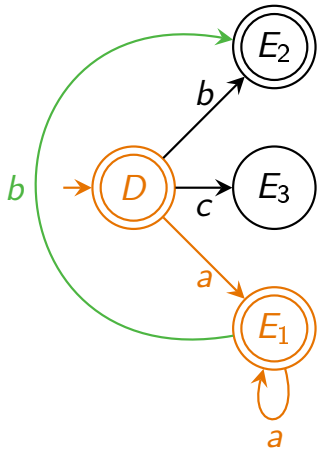


Etat actuel : E_1

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

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

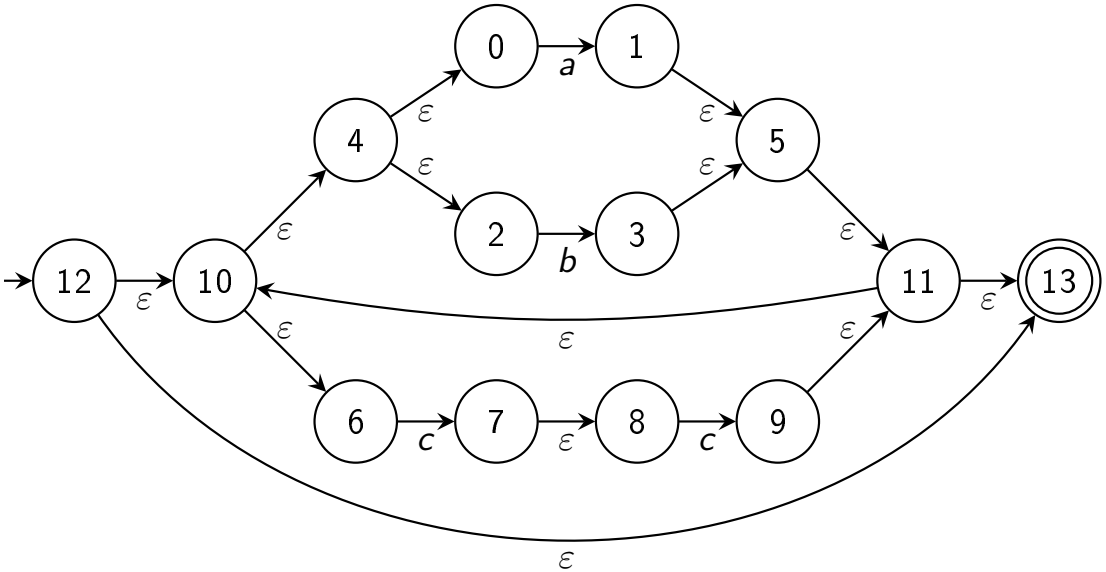


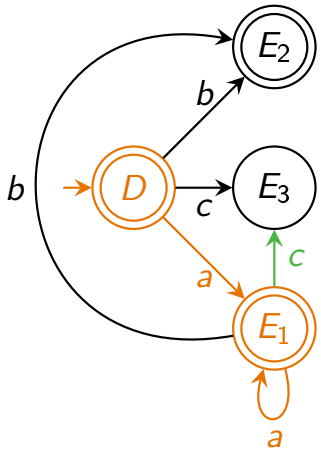


Etat actuel : E_1

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

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

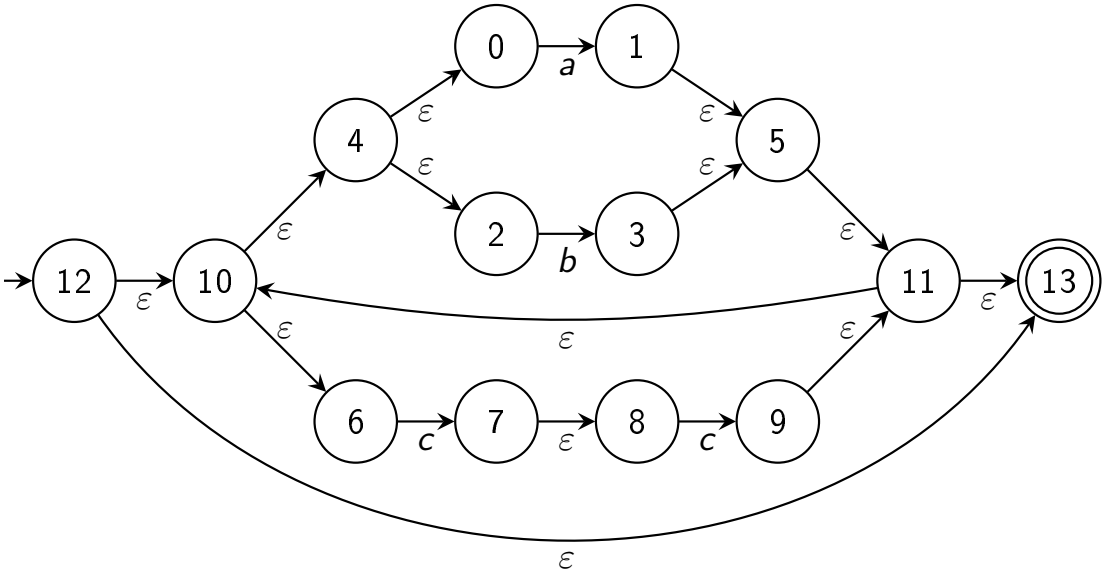


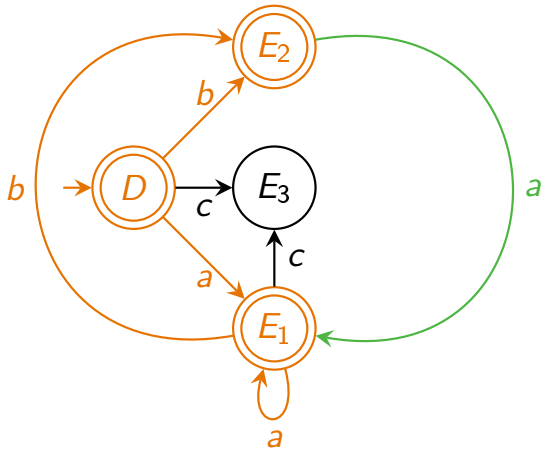


Etat actuel : E_1

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

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

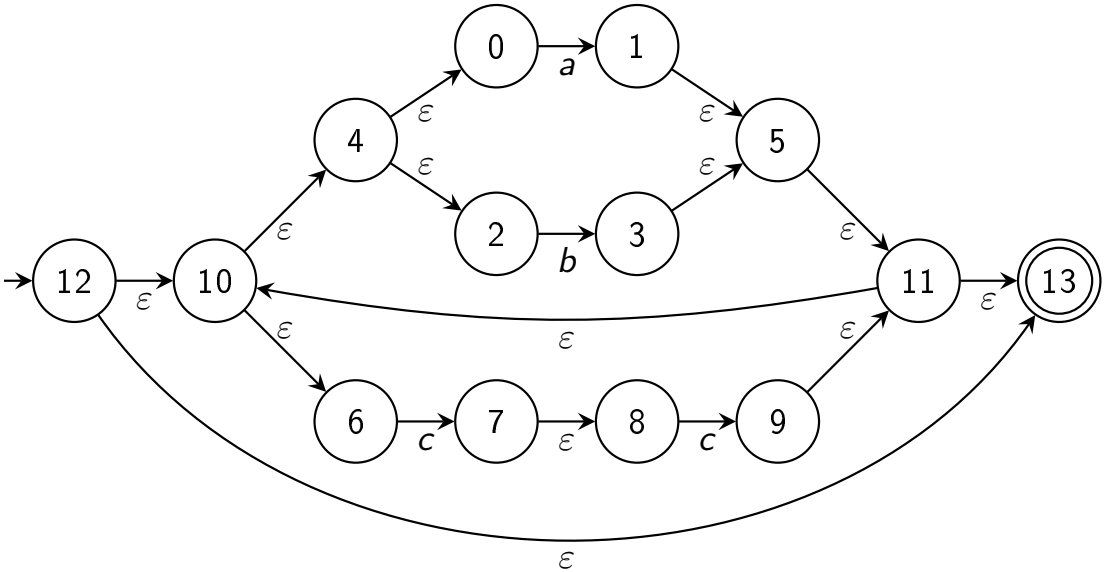


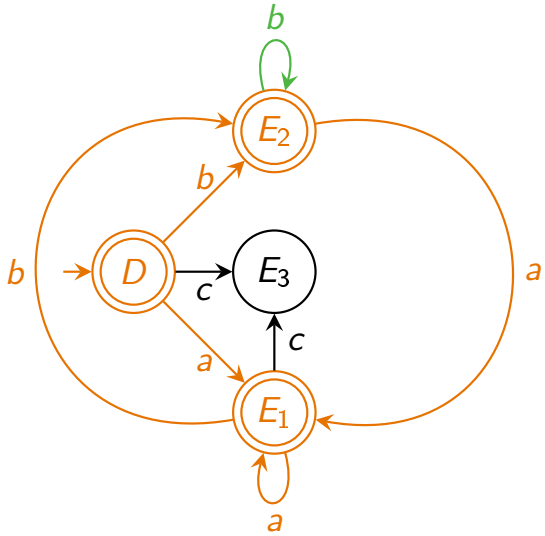


Etat actuel : E_2

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

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

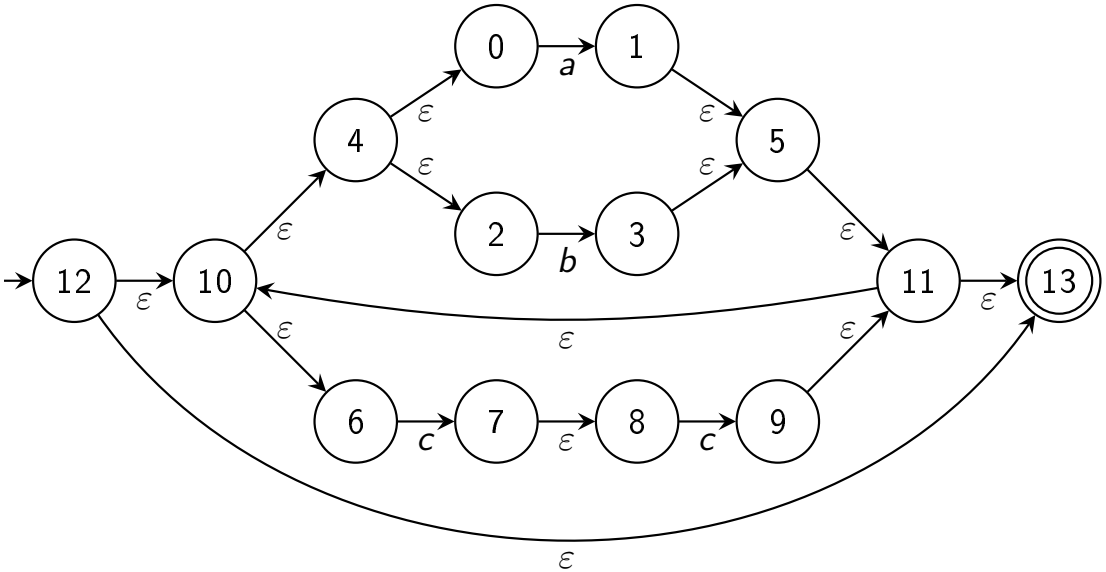


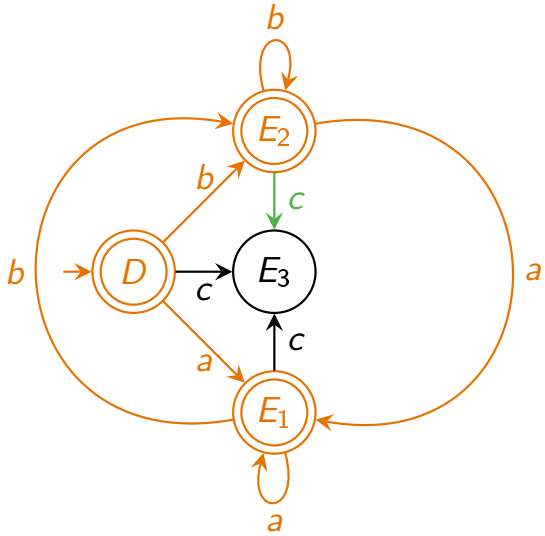


Etat actuel : E_2

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

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

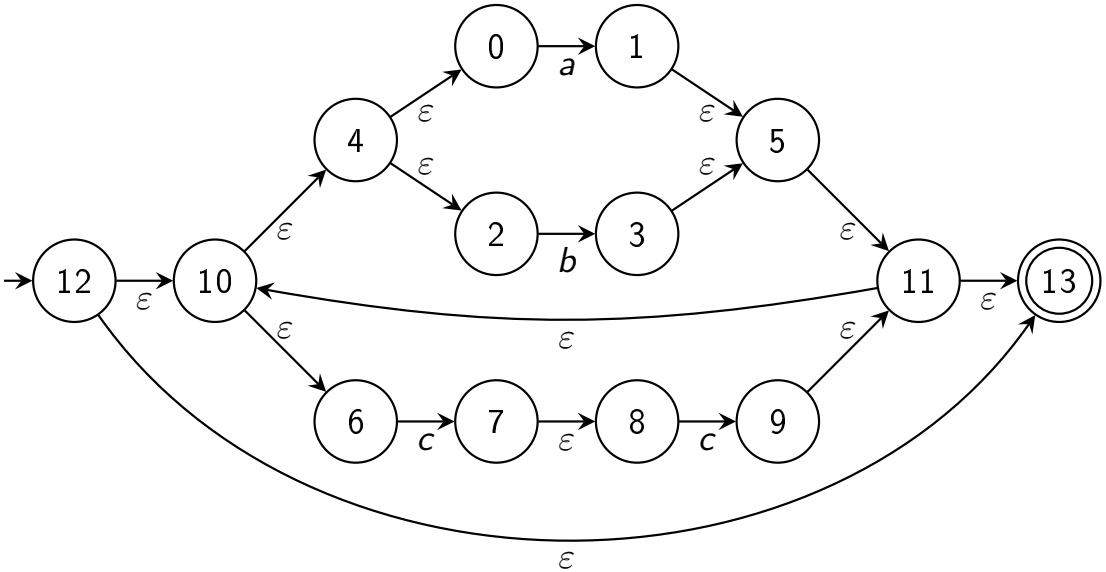


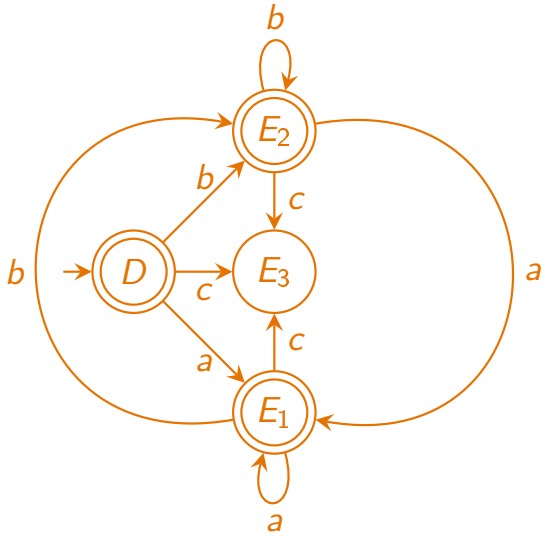


Etat actuel : E_2

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

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

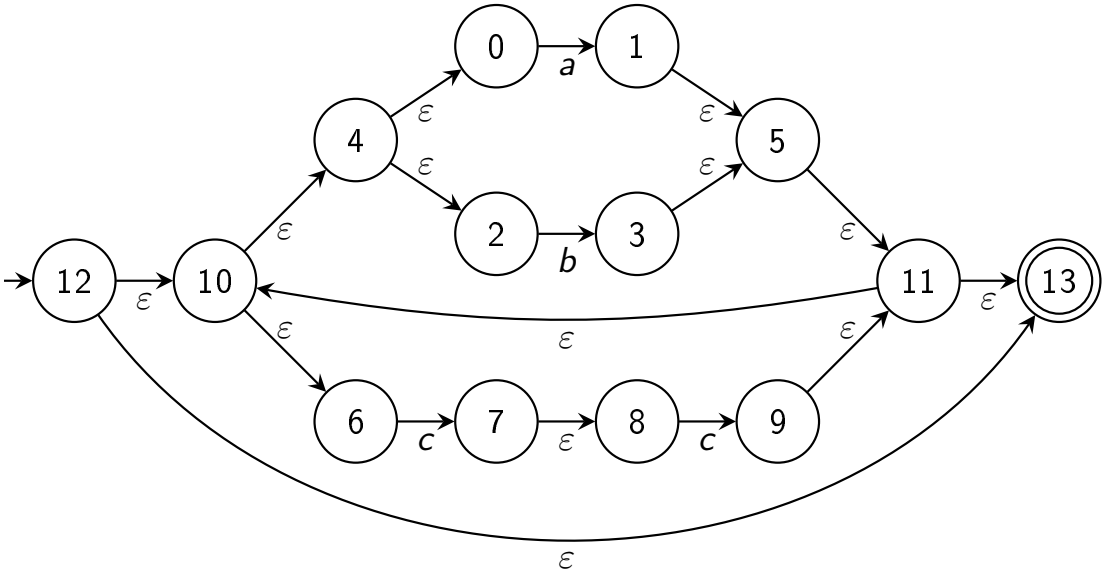


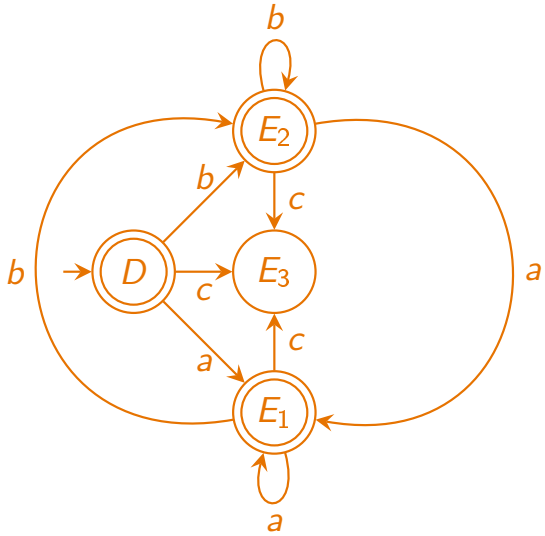


$$D = \{0, 2, 4, 6, 10, 12, 13\}$$
$$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$$
$$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$$
$$E_3 = \{7, 8\}$$

Etat actuel : E_3

- x = a
- transitions : aucune

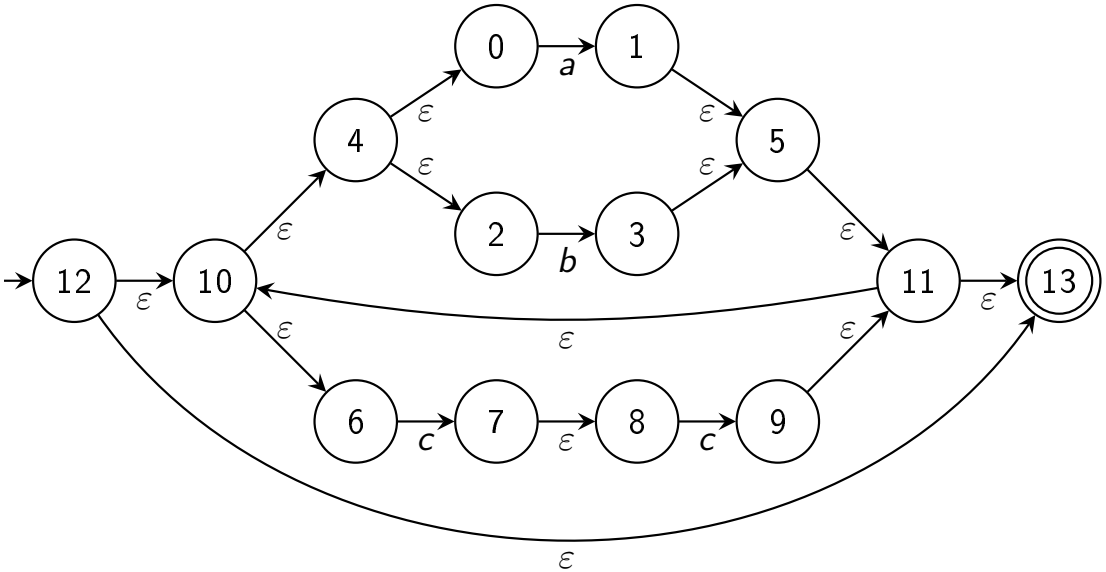


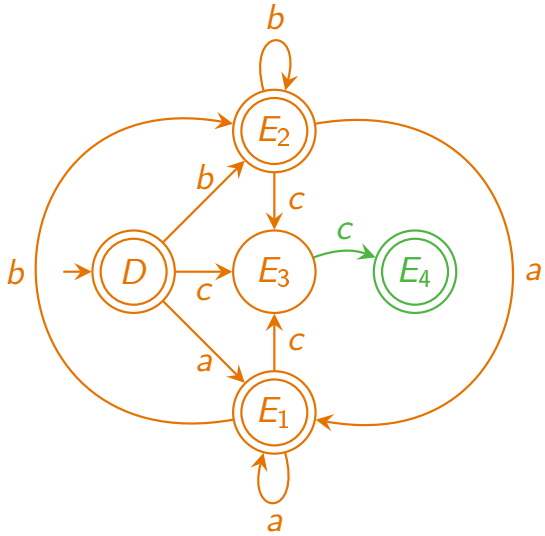


Etat actuel : E_3

- x = b
- transitions : aucune

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

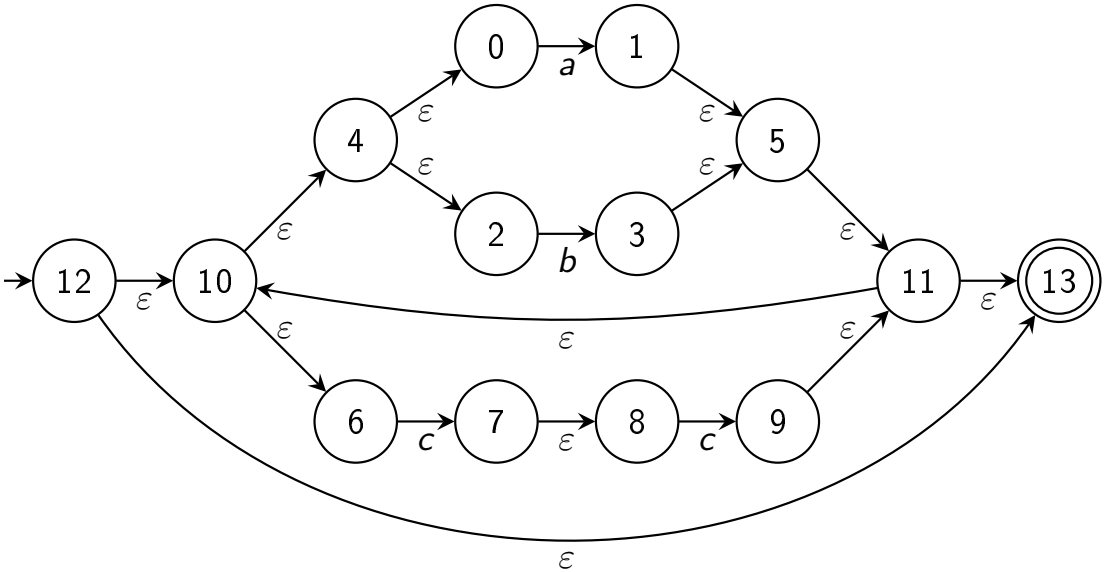


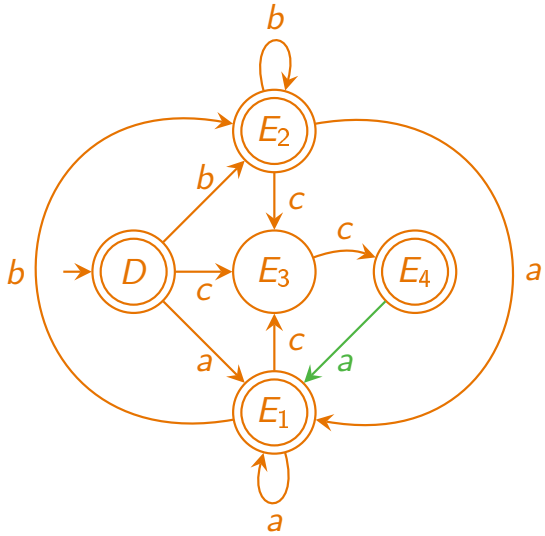


Etat actuel : E_3

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

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

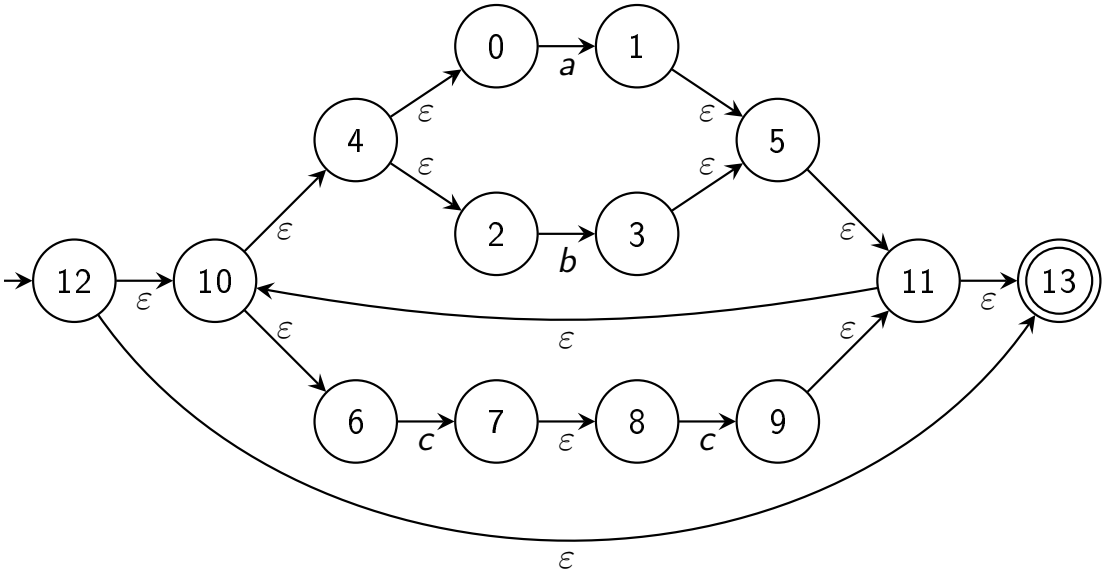


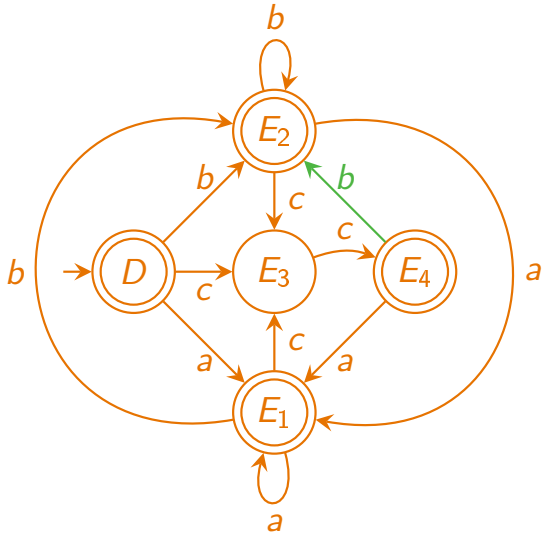


Etat actuel : E_4

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

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

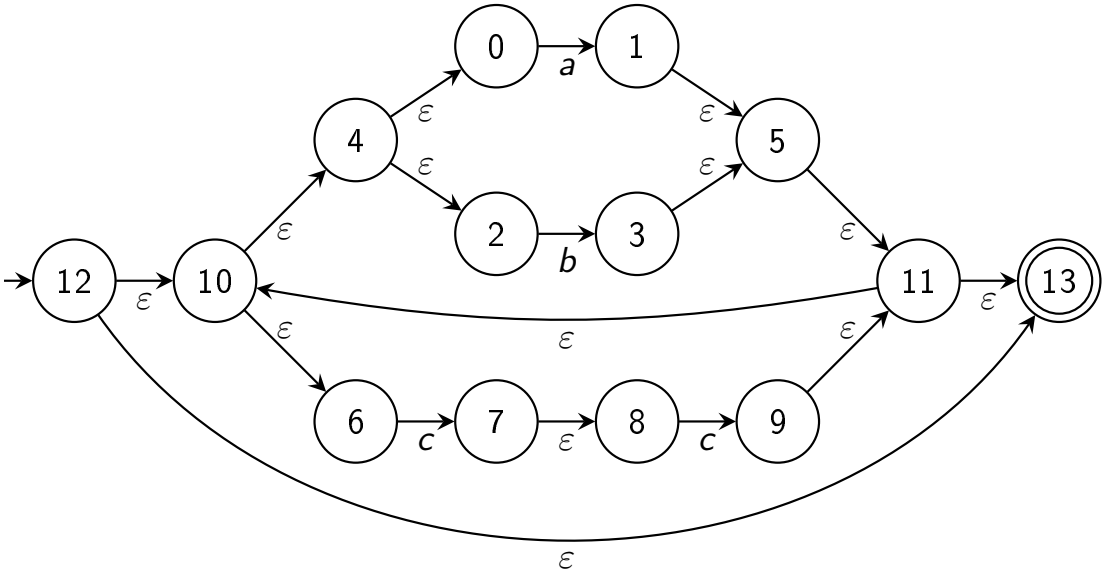


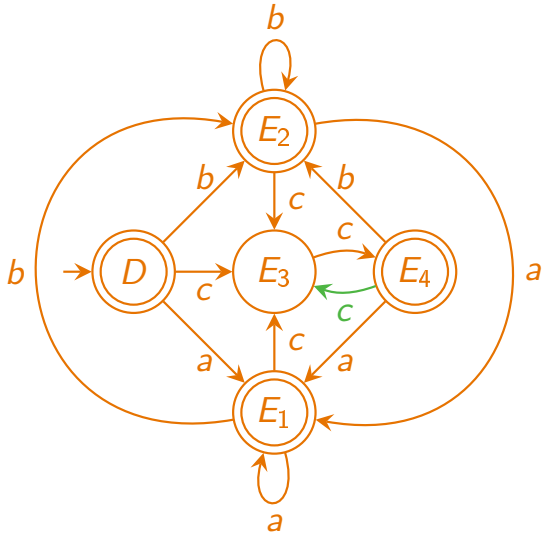


Etat actuel : E_4

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

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

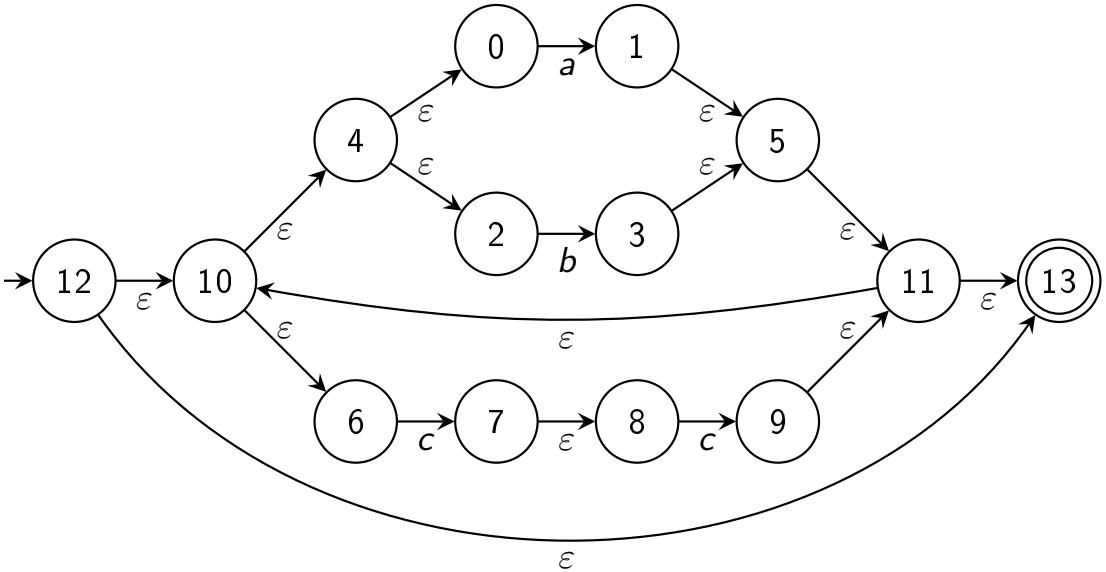


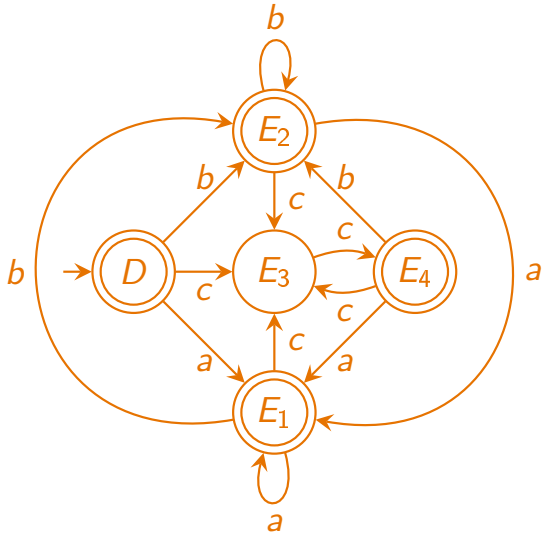


Etat actuel : E_4

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

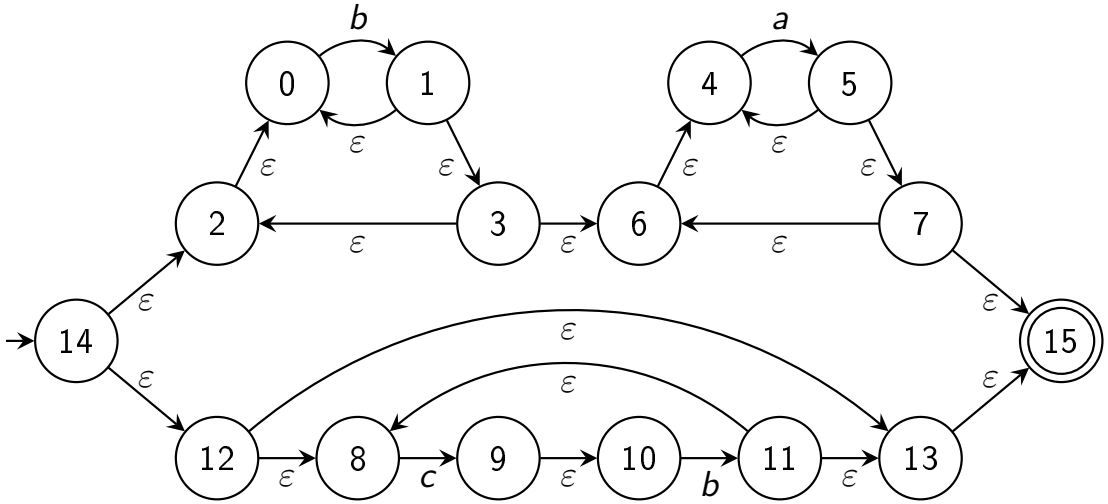
$$D = \{0, 2, 4, 6, 10, 12, 13\}$$
$$E_1 = \{0, 1, 2, 4, 5, 6, 10, 11, 13\}$$
$$E_2 = \{0, 2, 3, 4, 5, 6, 10, 11, 13\}$$
$$E_3 = \{7, 8\}$$
$$E_4 = \{0, 2, 4, 6, 9, 10, 11, 13\}$$

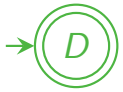




AFD terminé, nombre d'états : 5

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

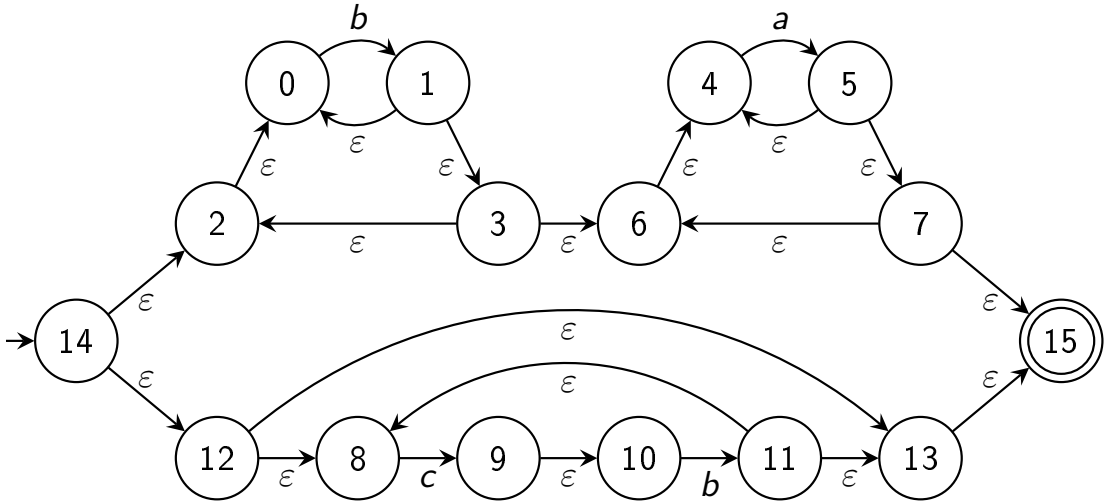


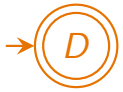


$D = \{0, 2, 8, 12, 13, 14, 15\}$

Calcul de l'état de départ :

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

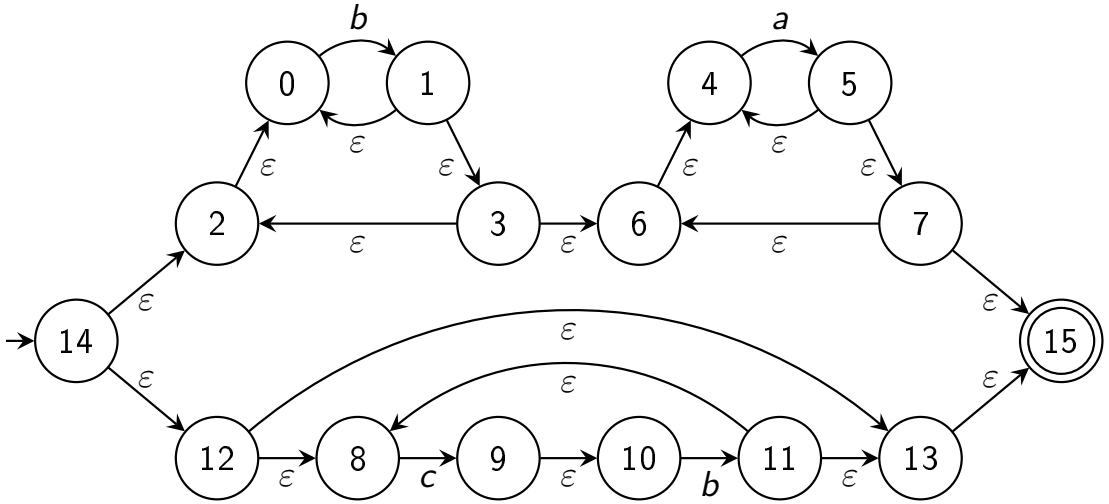


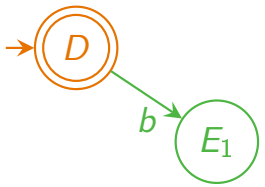


$D = \{0, 2, 8, 12, 13, 14, 15\}$

Etat actuel : D

- x = a
- transitions : aucune



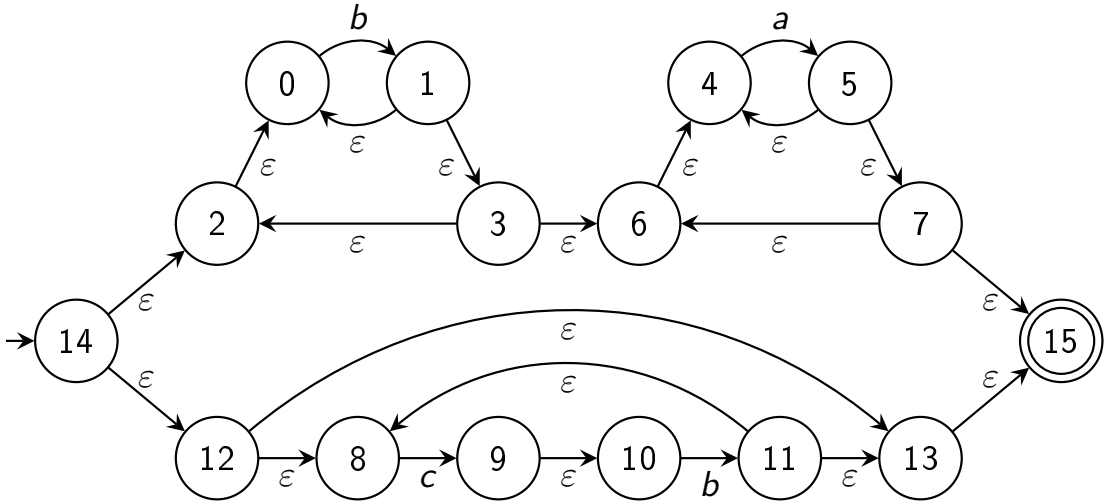


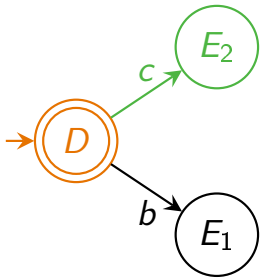
$D = \{0, 2, 8, 12, 13, 14, 15\}$

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

Etat actuel : D

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

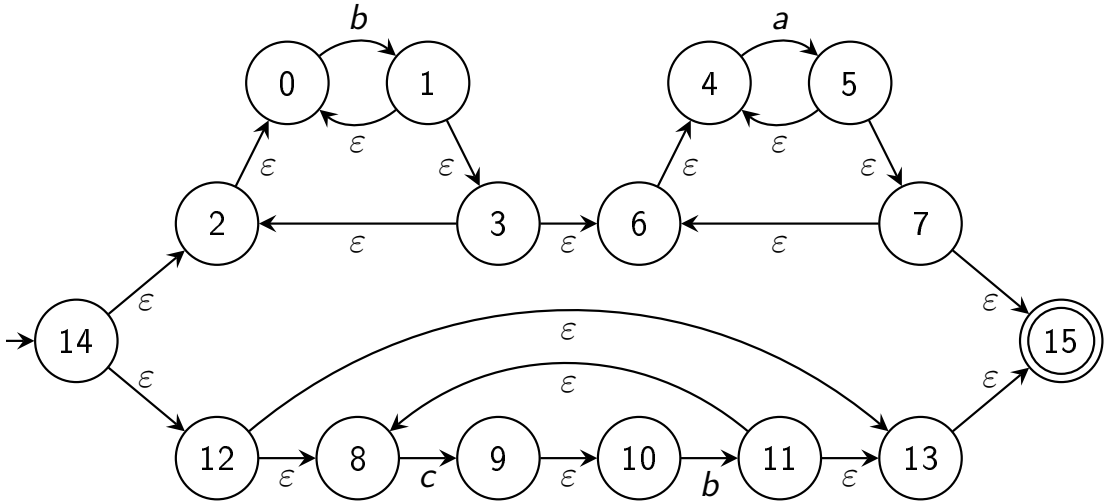


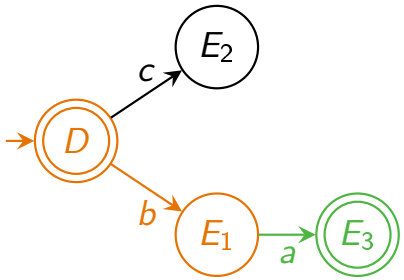


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$

Etat actuel : D

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

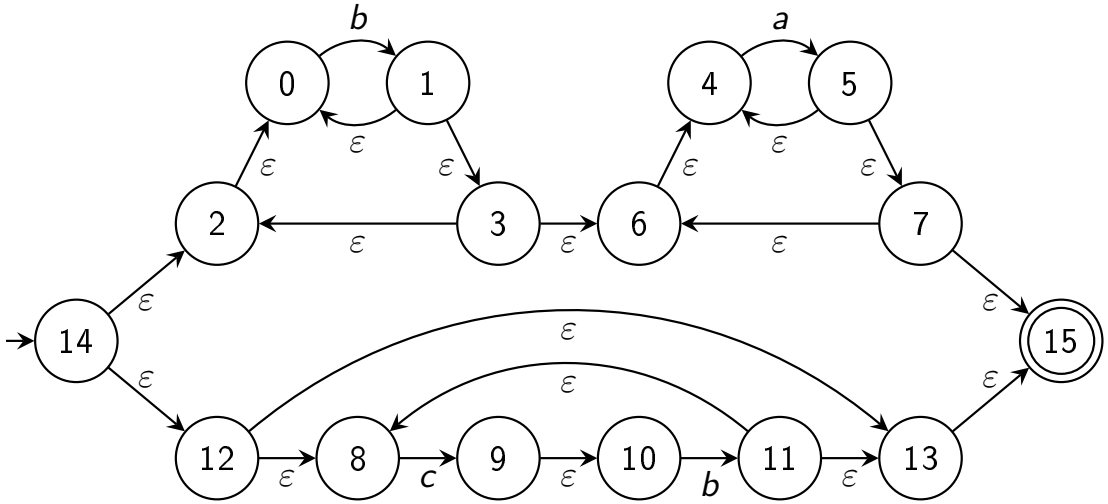


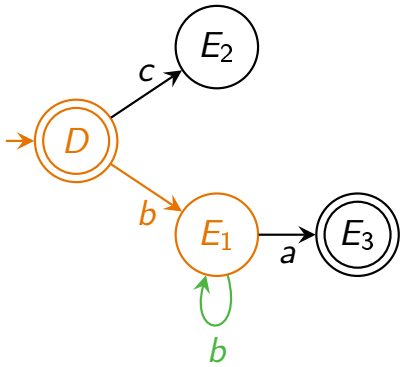


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$
$E_3 = \{4, 5, 6, 7, 15\}$

Etat actuel : E_1

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

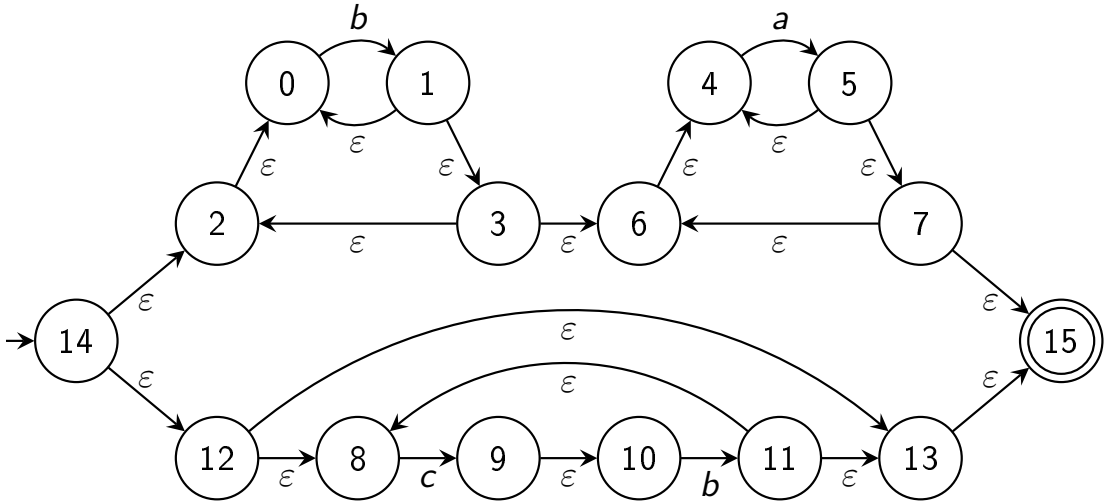


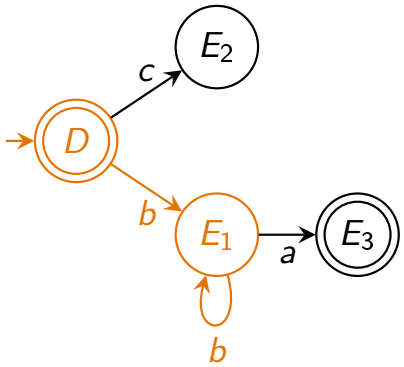


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$
$E_3 = \{4, 5, 6, 7, 15\}$

Etat actuel : E_1

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

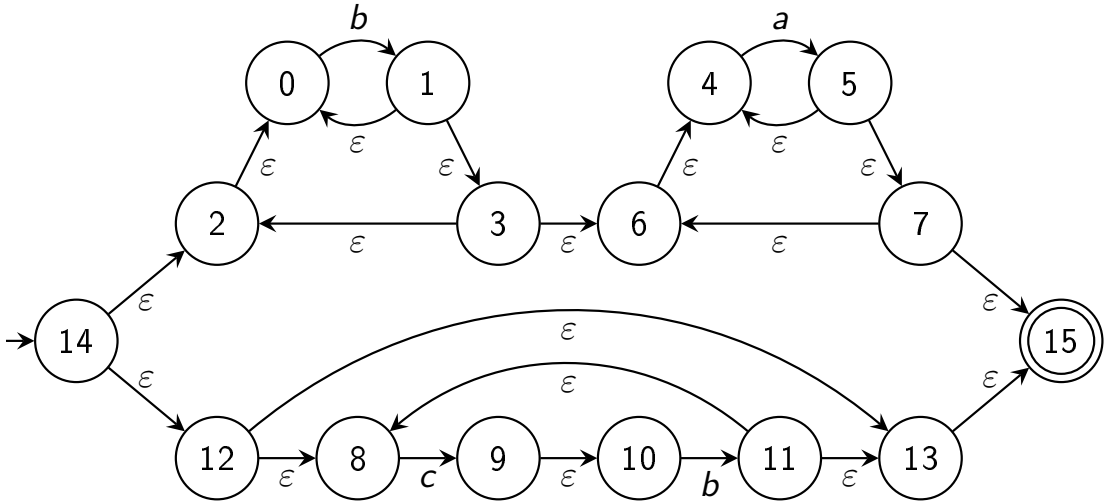


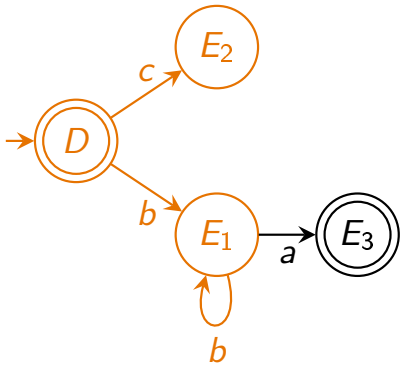


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$
$E_3 = \{4, 5, 6, 7, 15\}$

Etat actuel : E_1

- x = c
- transitions : aucune

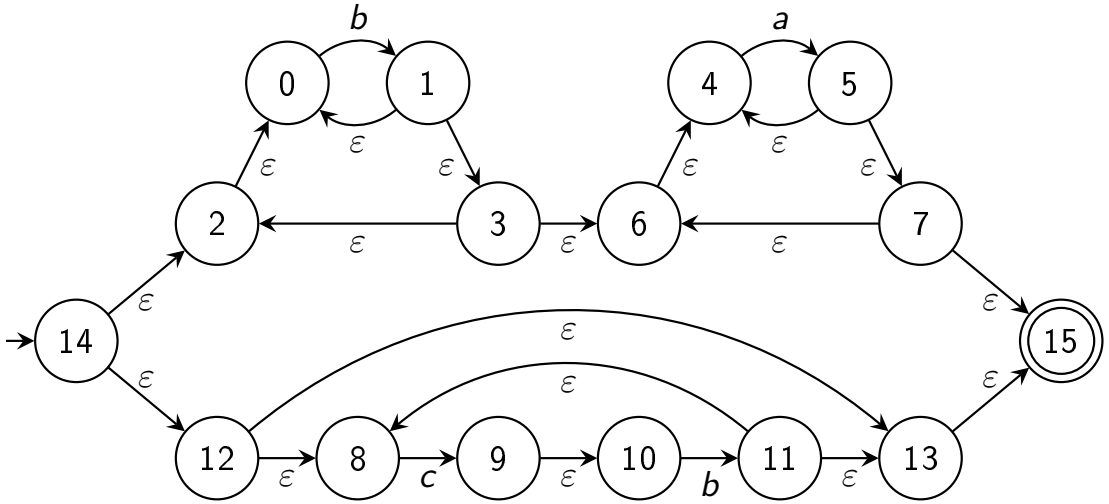


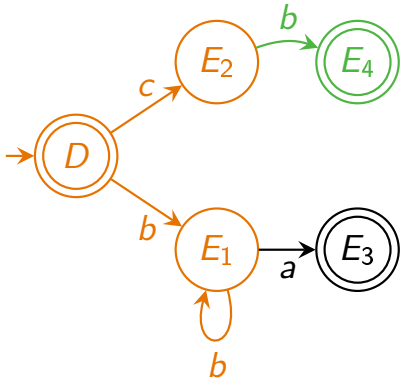


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$
$E_3 = \{4, 5, 6, 7, 15\}$

Etat actuel : E_2

- x = a
- transitions : aucune

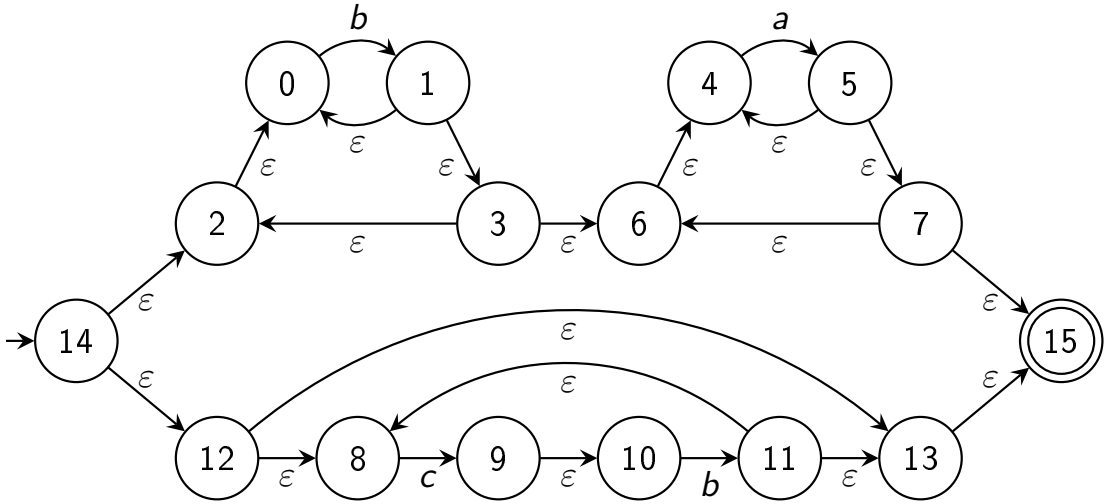


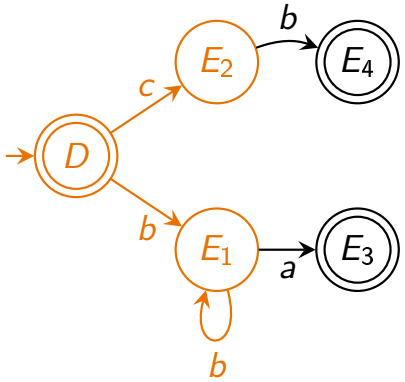


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$
$E_3 = \{4, 5, 6, 7, 15\}$
$E_4 = \{8, 10, 11, 13, 15\}$

Etat actuel : E_2

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

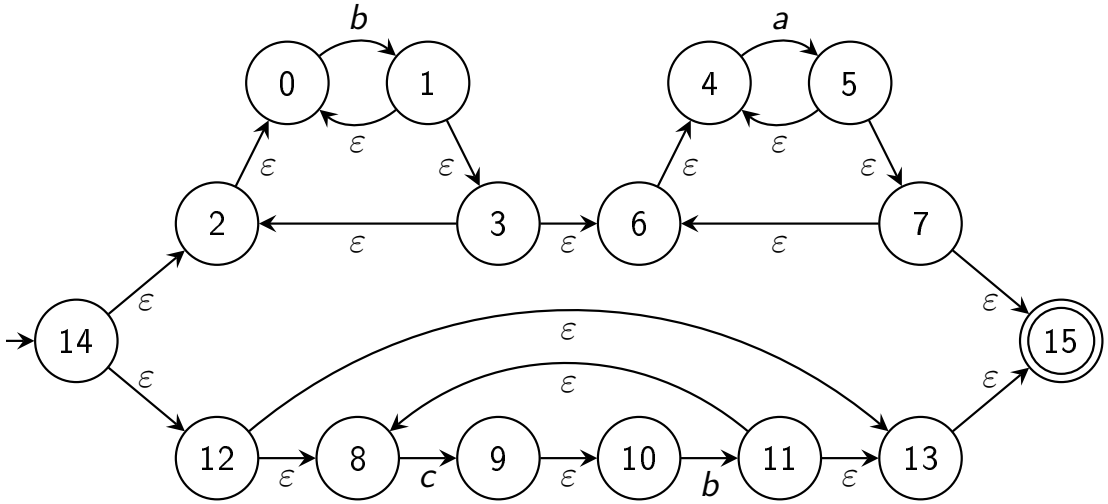


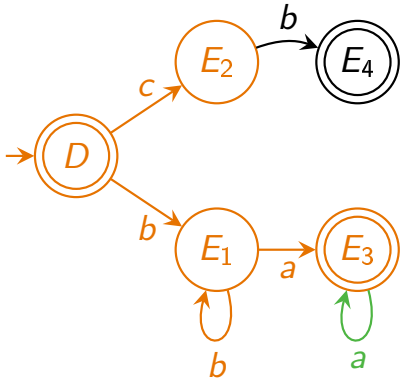


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$
$E_3 = \{4, 5, 6, 7, 15\}$
$E_4 = \{8, 10, 11, 13, 15\}$

Etat actuel : E_2

- x = c
- transitions : aucune

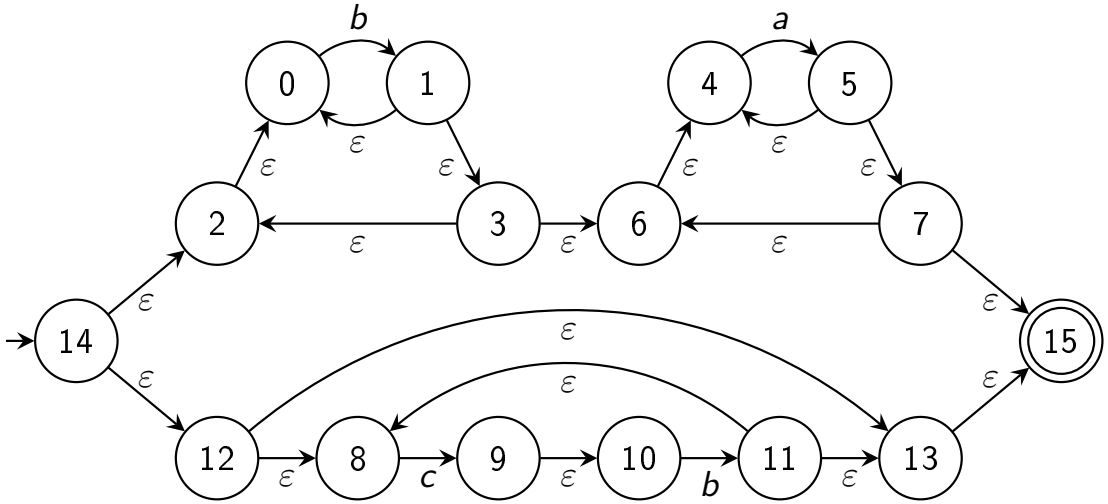


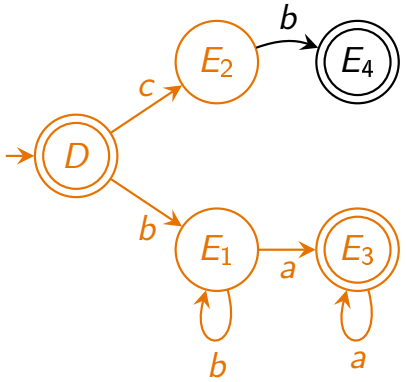


$$D = \{0, 2, 8, 12, 13, 14, 15\}$$
$$E_1 = \{0, 1, 2, 3, 4, 6\}$$
$$E_2 = \{9, 10\}$$
$$E_3 = \{4, 5, 6, 7, 15\}$$
$$E_4 = \{8, 10, 11, 13, 15\}$$

Etat actuel : E_3

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

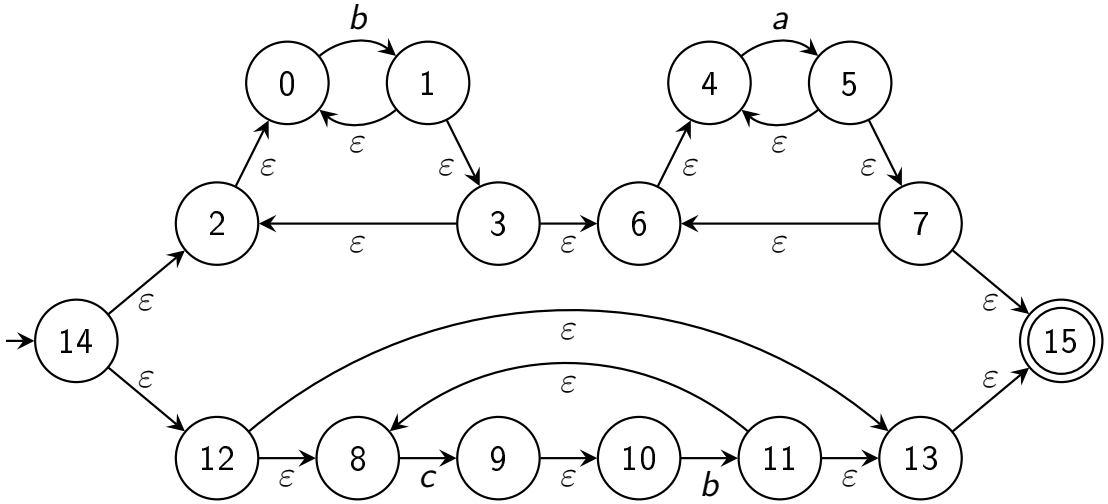


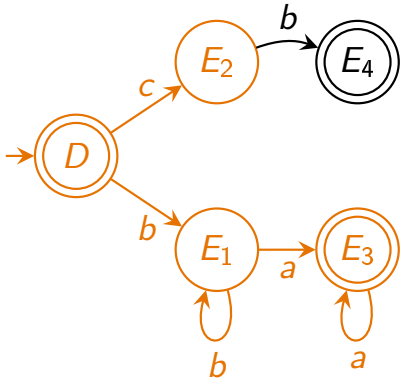


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$
$E_3 = \{4, 5, 6, 7, 15\}$
$E_4 = \{8, 10, 11, 13, 15\}$

Etat actuel : E_3

- x = b
- transitions : aucune

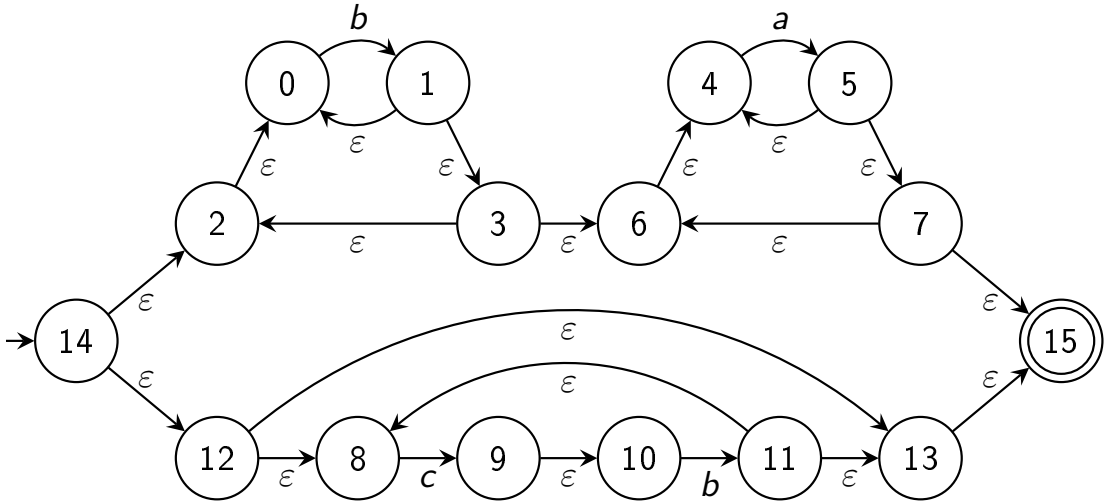


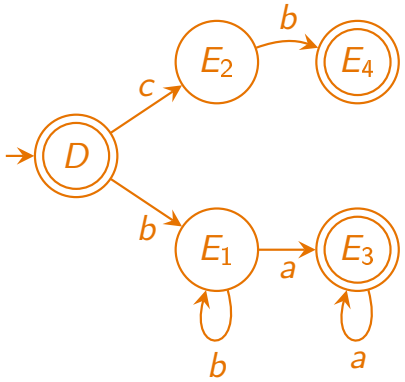


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$
$E_3 = \{4, 5, 6, 7, 15\}$
$E_4 = \{8, 10, 11, 13, 15\}$

Etat actuel : E_3

- x = c
- transitions : aucune

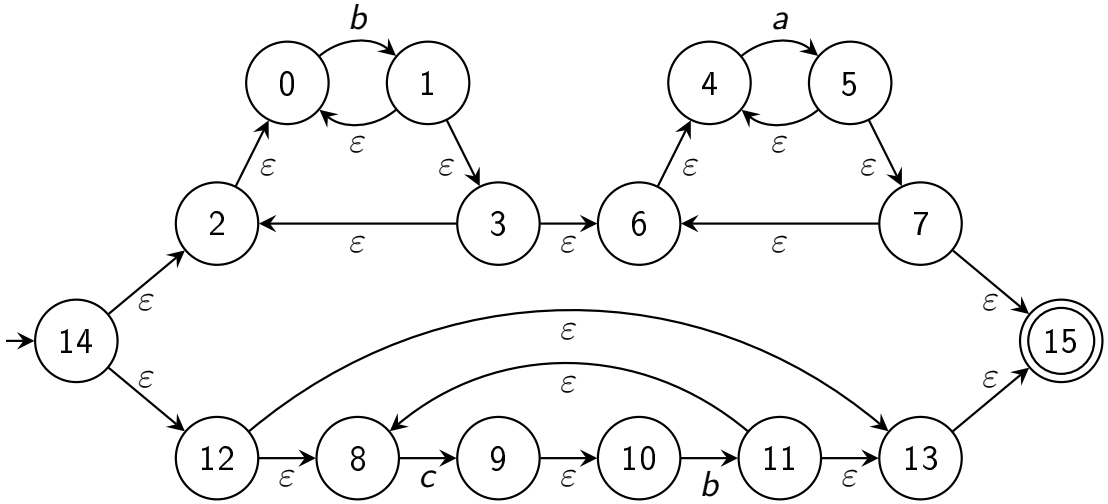


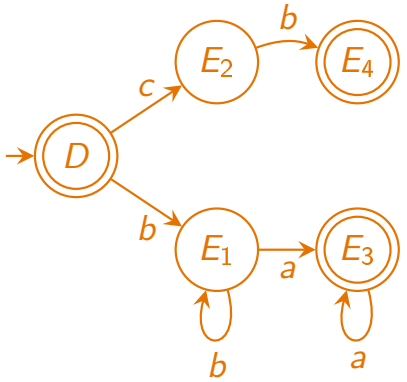


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$
$E_3 = \{4, 5, 6, 7, 15\}$
$E_4 = \{8, 10, 11, 13, 15\}$

Etat actuel : E_4

- x = a
- transitions : aucune

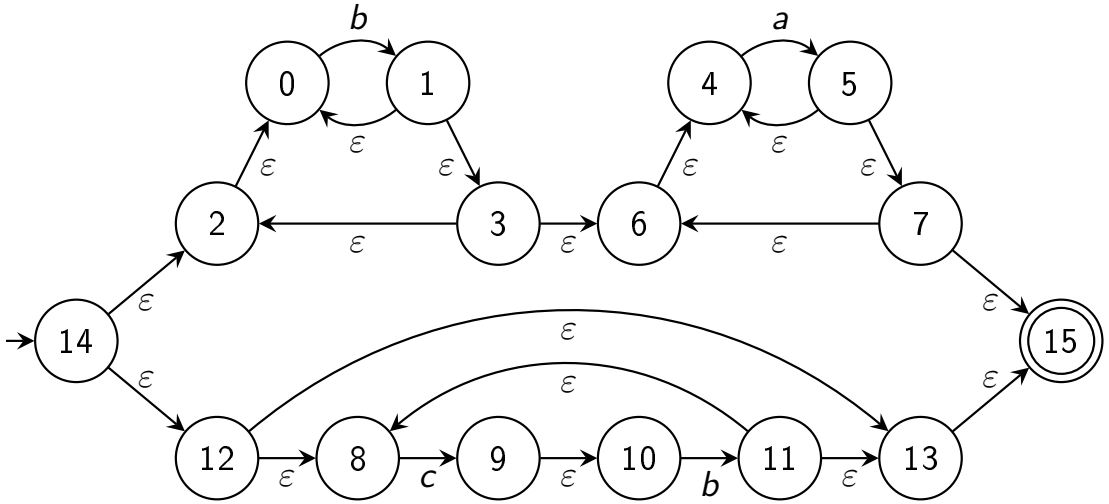


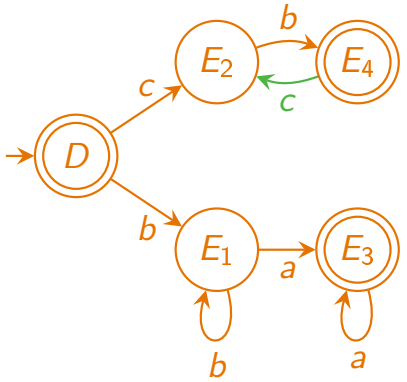


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$
$E_3 = \{4, 5, 6, 7, 15\}$
$E_4 = \{8, 10, 11, 13, 15\}$

Etat actuel : E_4

- x = b
- transitions : aucune

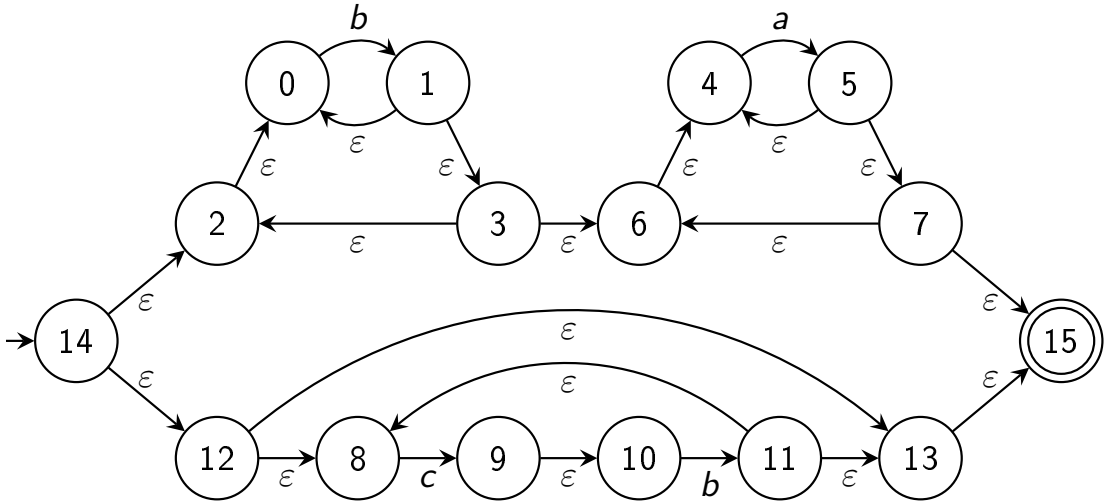


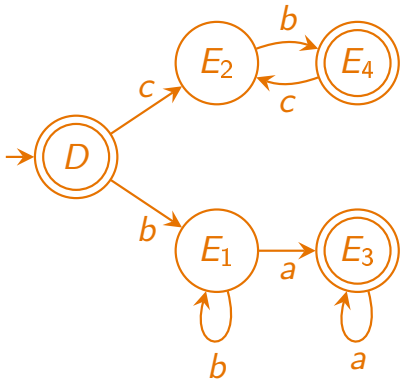


$D = \{0, 2, 8, 12, 13, 14, 15\}$
$E_1 = \{0, 1, 2, 3, 4, 6\}$
$E_2 = \{9, 10\}$
$E_3 = \{4, 5, 6, 7, 15\}$
$E_4 = \{8, 10, 11, 13, 15\}$

Etat actuel : E_4

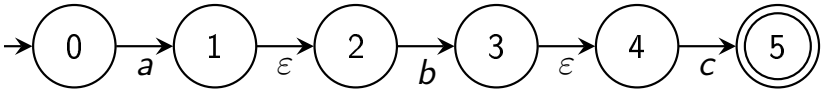
- x = c
- transitions : 8c9
- $EpsilonFermeture(\{9\}) = \{9, 10\} = E_2$
- etat final : non

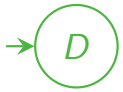




$$D = \{0, 2, 8, 12, 13, 14, 15\}$$
$$E_1 = \{0, 1, 2, 3, 4, 6\}$$
$$E_2 = \{9, 10\}$$
$$E_3 = \{4, 5, 6, 7, 15\}$$
$$E_4 = \{8, 10, 11, 13, 15\}$$

AFD terminé, nombre d'états : 5

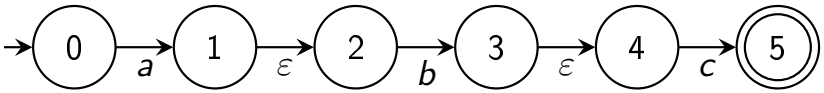


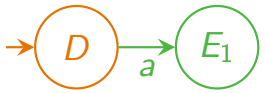


$D = \{0\}$

Calcul de l'état de départ :

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



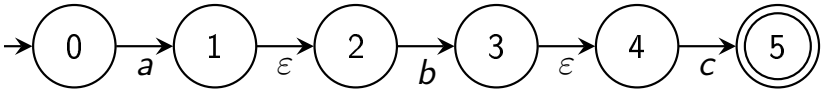


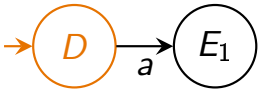
$D = \{0\}$

$E_1 = \{1, 2\}$

Etat actuel : D

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

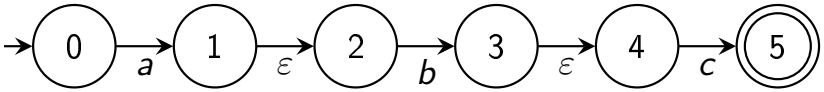


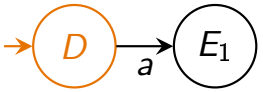


$D = \{0\}$
$E_1 = \{1, 2\}$

Etat actuel : D

- x = b
- transitions : aucune

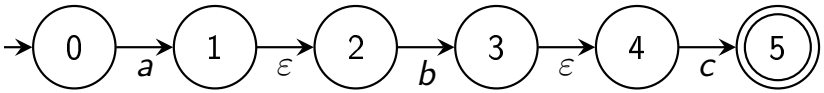


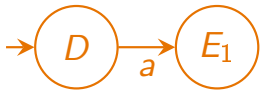


$D = \{0\}$
$E_1 = \{1, 2\}$

Etat actuel : D

- x = c
- transitions : aucune

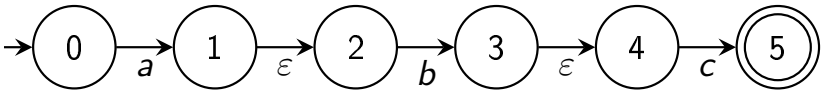


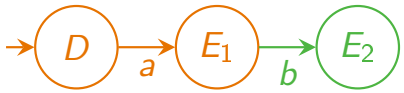


$D = \{0\}$
$E_1 = \{1, 2\}$

Etat actuel : E_1

- x = a
- transitions : aucune

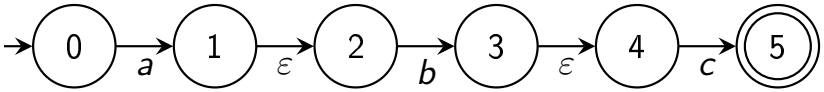


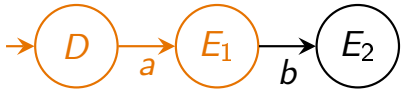


$D = \{0\}$
$E_1 = \{1, 2\}$
$E_2 = \{3, 4\}$

Etat actuel : E_1

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

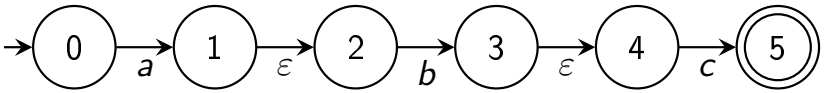


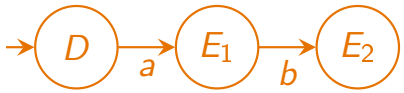


$D = \{0\}$
$E_1 = \{1, 2\}$
$E_2 = \{3, 4\}$

Etat actuel : E_1

- x = c
- transitions : aucune

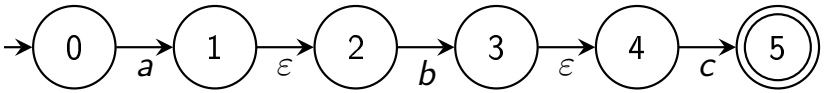


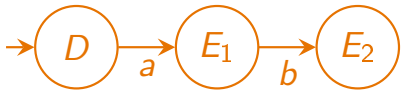


$D = \{0\}$
$E_1 = \{1, 2\}$
$E_2 = \{3, 4\}$

Etat actuel : E_2

- x = a
- transitions : aucune

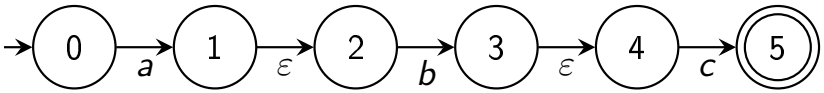


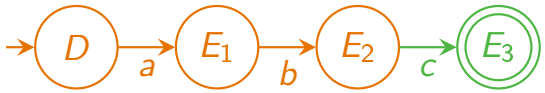


$D = \{0\}$
$E_1 = \{1, 2\}$
$E_2 = \{3, 4\}$

Etat actuel : E_2

- x = b
- transitions : aucune

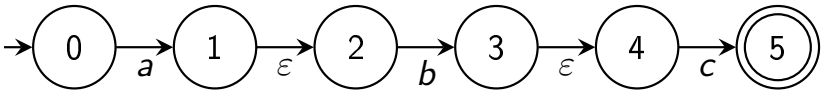


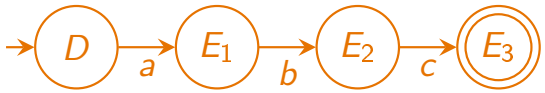


$D = \{0\}$
$E_1 = \{1, 2\}$
$E_2 = \{3, 4\}$
$E_3 = \{5\}$

Etat actuel : E_2

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

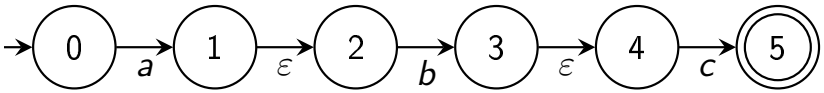


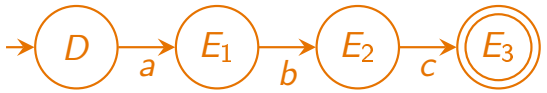


$D = \{0\}$
$E_1 = \{1, 2\}$
$E_2 = \{3, 4\}$
$E_3 = \{5\}$

Etat actuel : E_3

- x = a
- transitions : aucune

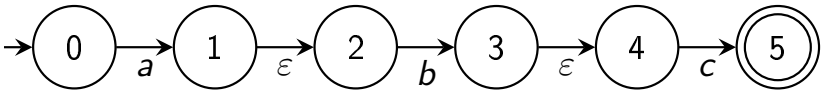


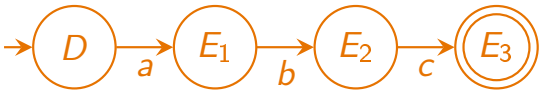


$D = \{0\}$
$E_1 = \{1, 2\}$
$E_2 = \{3, 4\}$
$E_3 = \{5\}$

Etat actuel : E_3

- x = b
- transitions : aucune

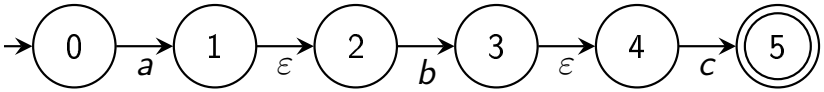


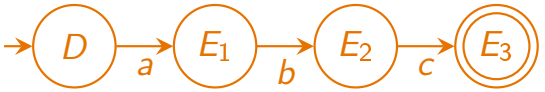


$D = \{0\}$
$E_1 = \{1, 2\}$
$E_2 = \{3, 4\}$
$E_3 = \{5\}$

Etat actuel : E_3

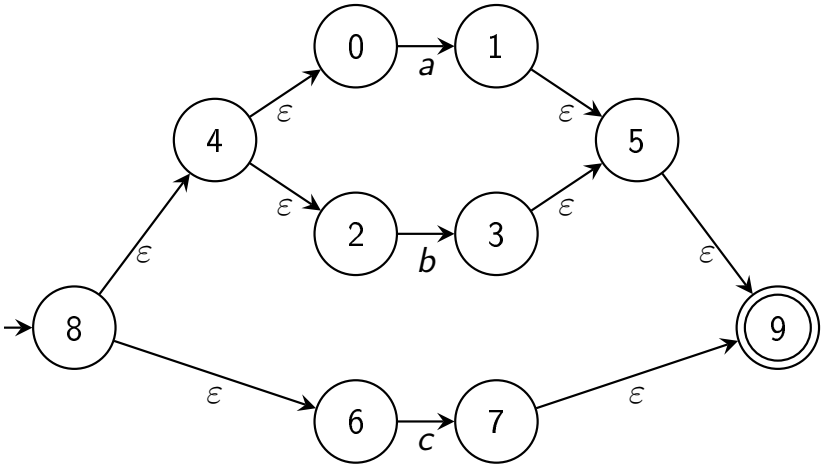
- x = c
- transitions : aucune

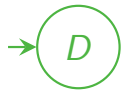




$$D = \{0\}$$
$$E_1 = \{1, 2\}$$
$$E_2 = \{3, 4\}$$
$$E_3 = \{5\}$$

AFD terminé, nombre d'états : 4

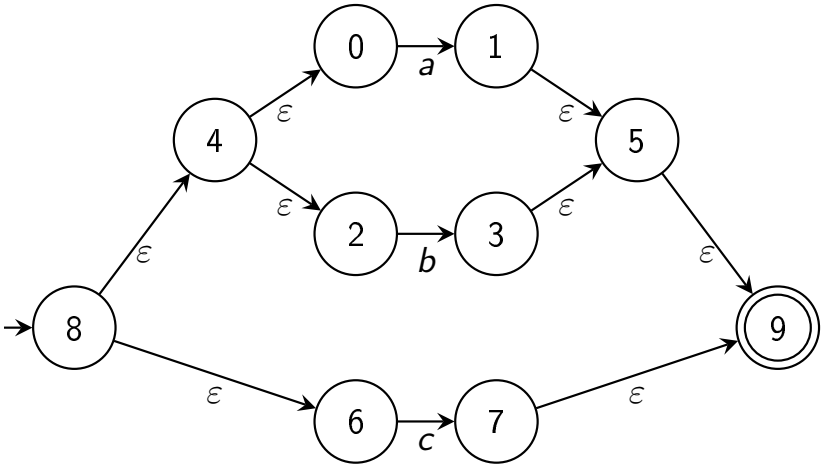


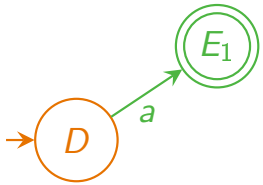


$D = \{0, 2, 4, 6, 8\}$

Calcul de l'état de départ :

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

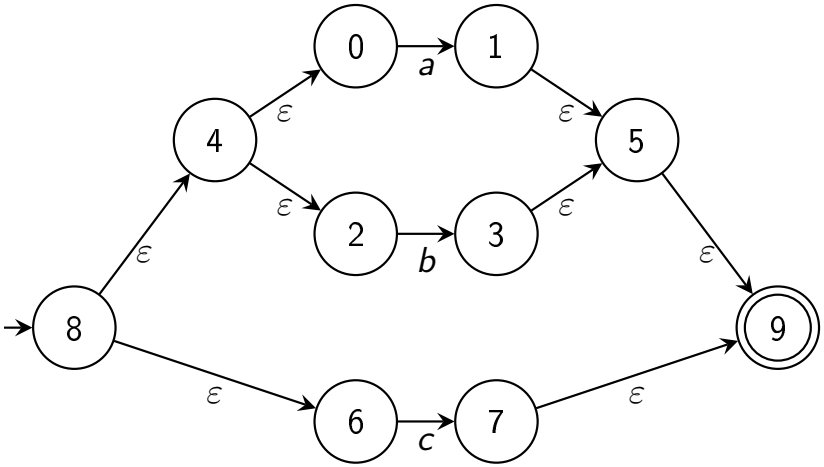


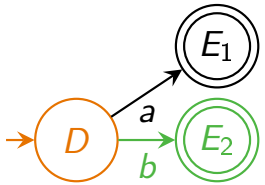


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$

Etat actuel : D

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

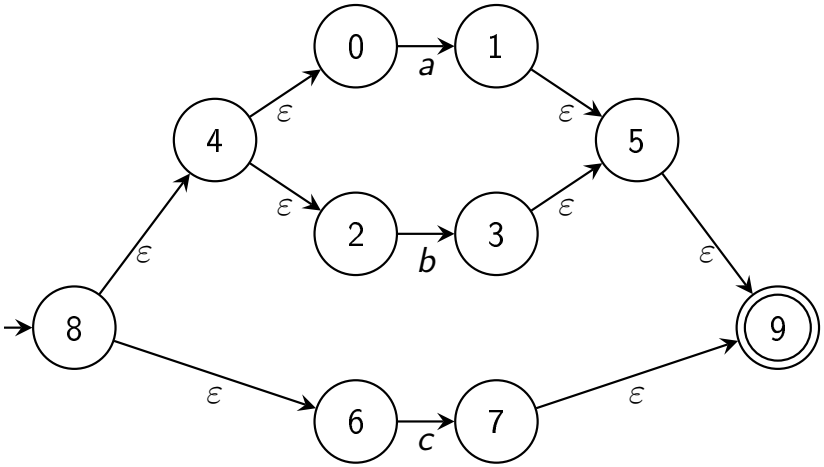


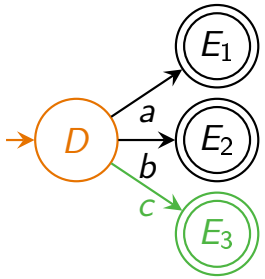


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$
$E_2 = \{3, 5, 9\}$

Etat actuel : D

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

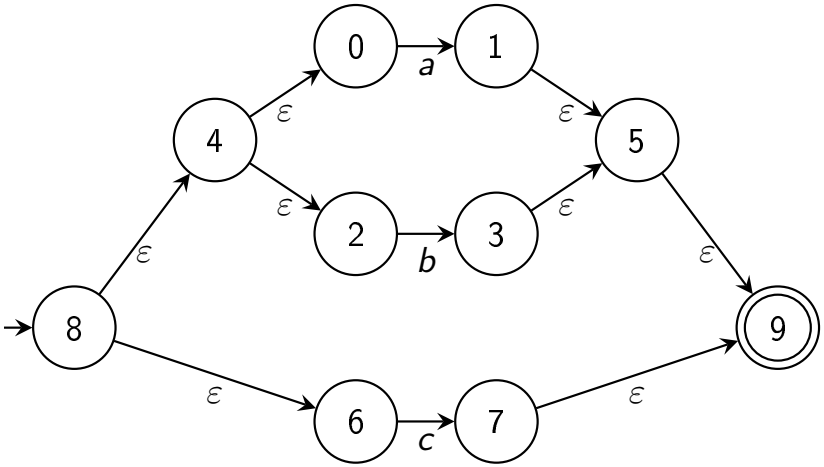


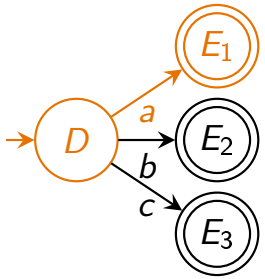


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$
$E_2 = \{3, 5, 9\}$
$E_3 = \{7, 9\}$

Etat actuel : D

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

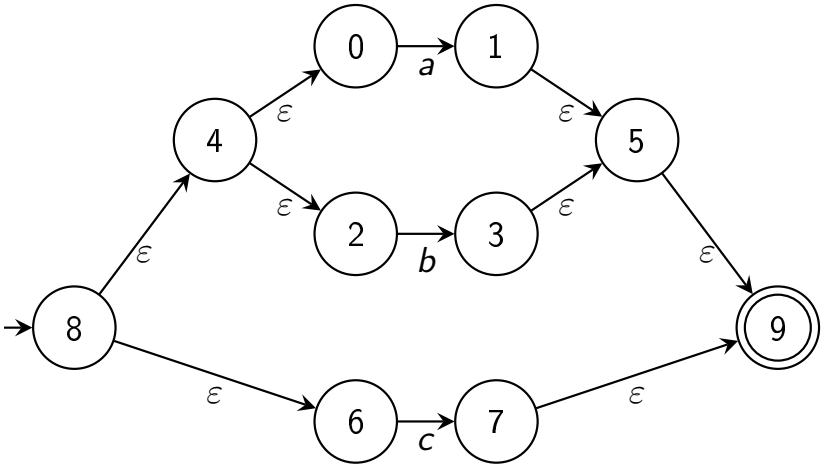


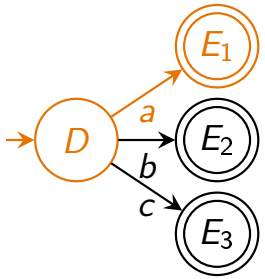


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$
$E_2 = \{3, 5, 9\}$
$E_3 = \{7, 9\}$

Etat actuel : E_1

- x = a
- transitions : aucune

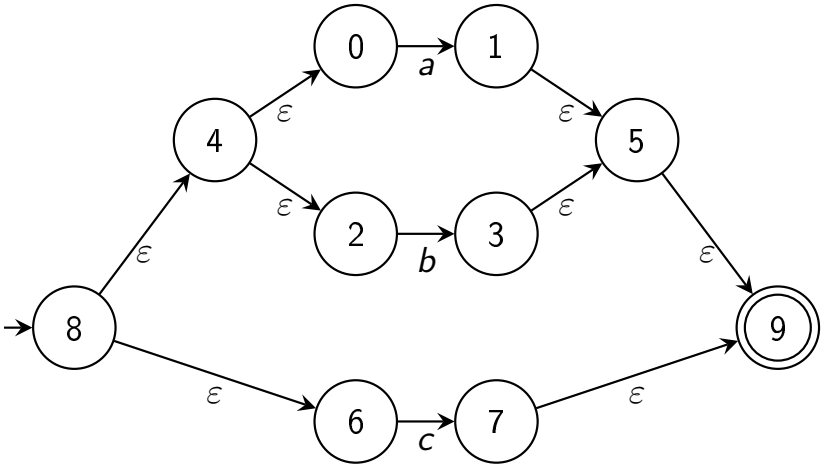


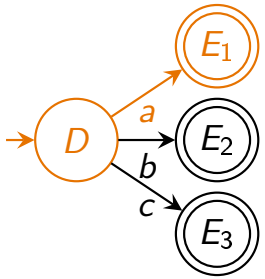


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$
$E_2 = \{3, 5, 9\}$
$E_3 = \{7, 9\}$

Etat actuel : E_1

- x = b
- transitions : aucune

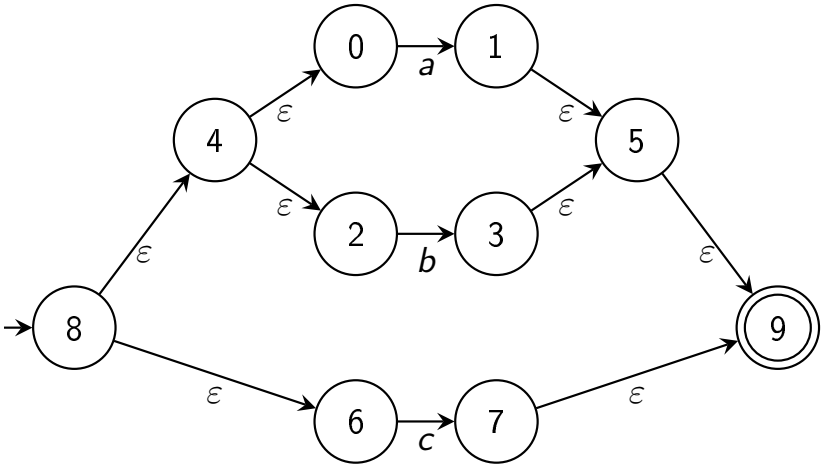


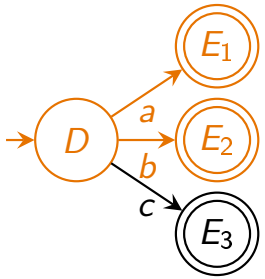


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$
$E_2 = \{3, 5, 9\}$
$E_3 = \{7, 9\}$

Etat actuel : E_1

- x = c
- transitions : aucune

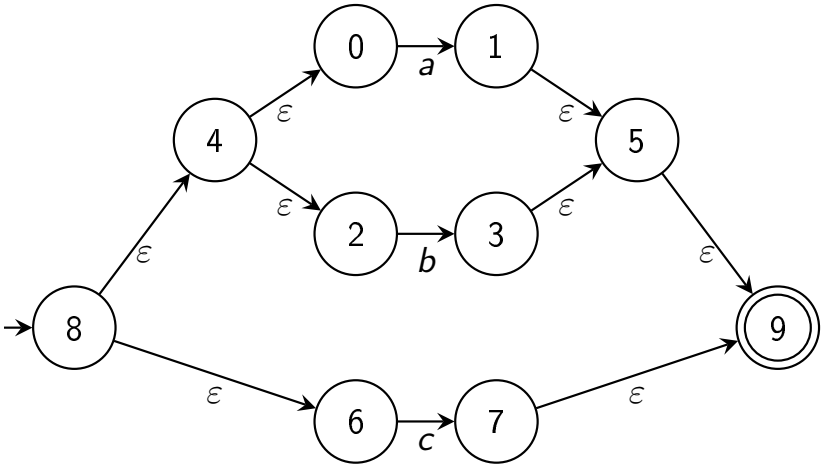


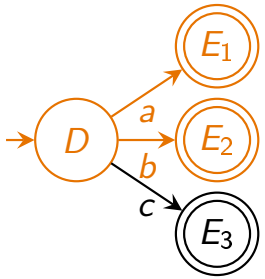


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$
$E_2 = \{3, 5, 9\}$
$E_3 = \{7, 9\}$

Etat actuel : E_2

- x = a
- transitions : aucune

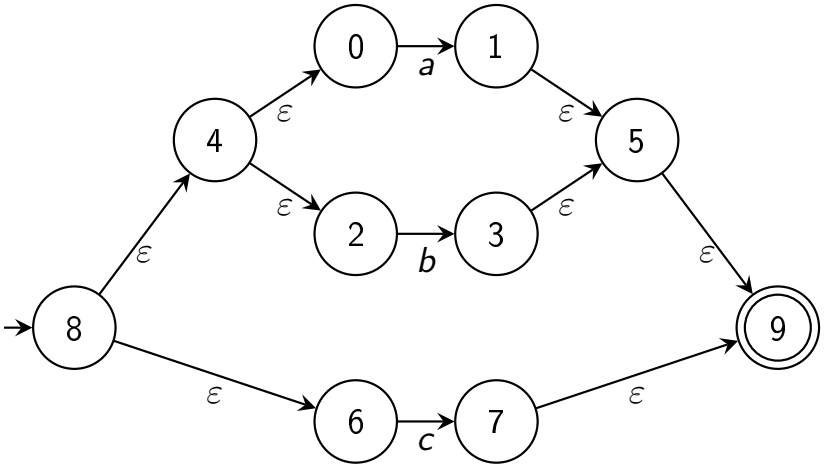


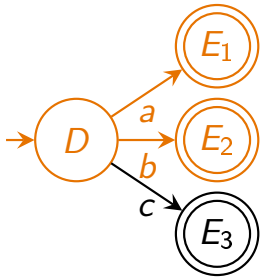


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$
$E_2 = \{3, 5, 9\}$
$E_3 = \{7, 9\}$

Etat actuel : E_2

- x = b
- transitions : aucune

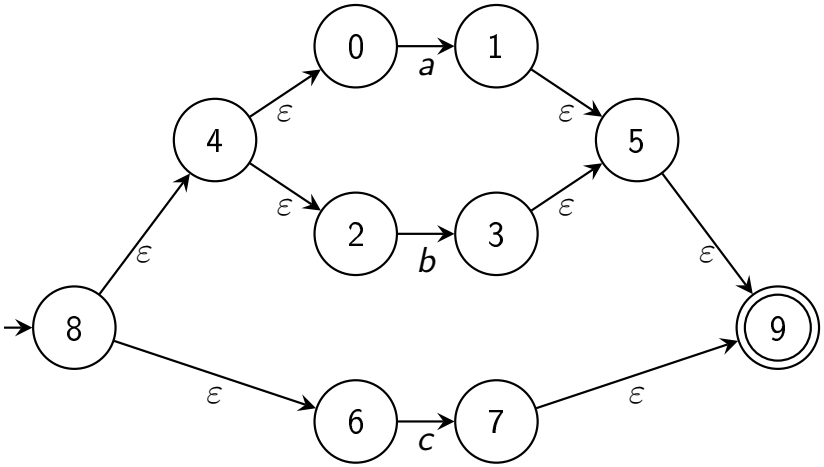


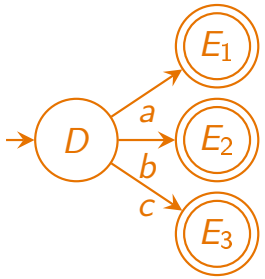


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$
$E_2 = \{3, 5, 9\}$
$E_3 = \{7, 9\}$

Etat actuel : E_2

- x = c
- transitions : aucune

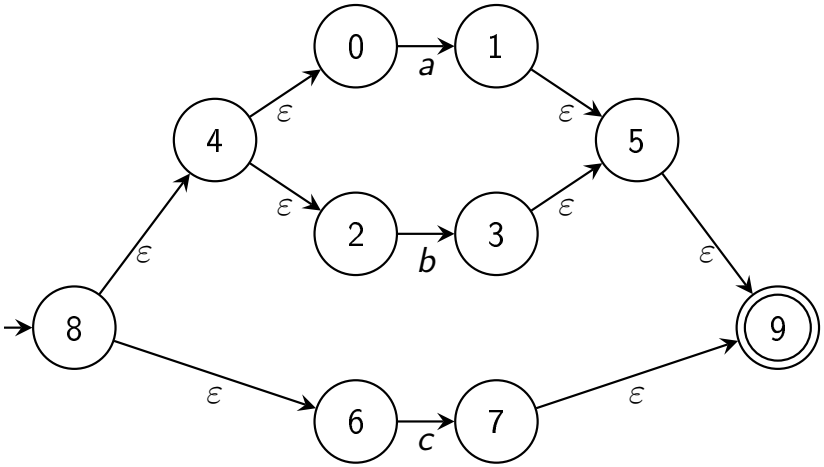


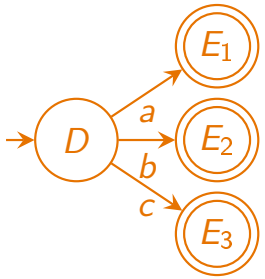


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$
$E_2 = \{3, 5, 9\}$
$E_3 = \{7, 9\}$

Etat actuel : E_3

- x = a
- transitions : aucune

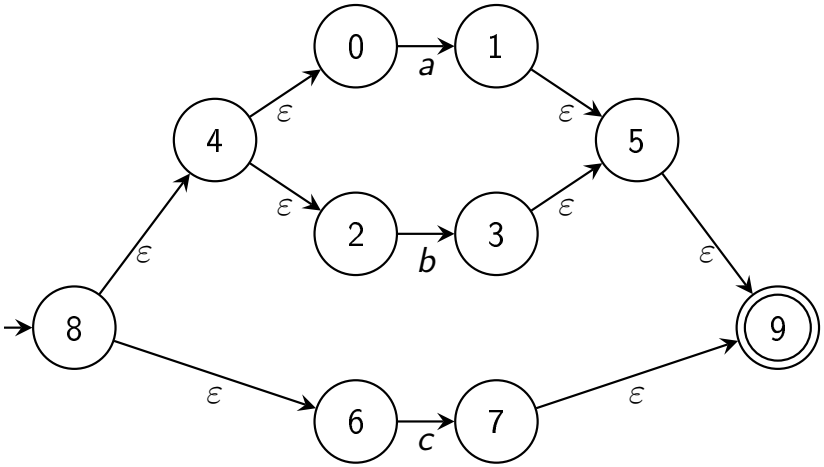


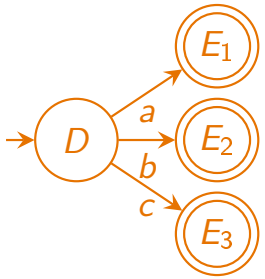


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$
$E_2 = \{3, 5, 9\}$
$E_3 = \{7, 9\}$

Etat actuel : E_3

- x = b
- transitions : aucune

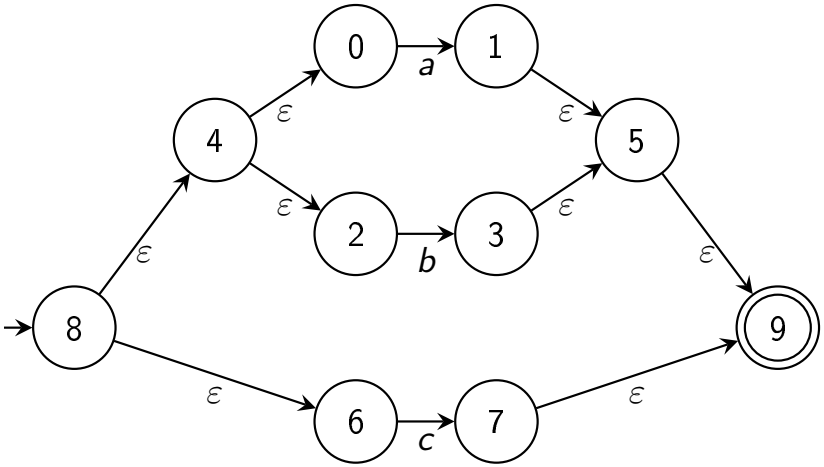


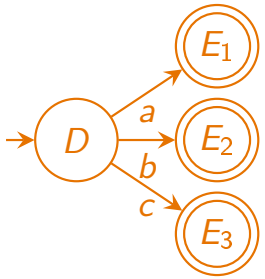


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 5, 9\}$
$E_2 = \{3, 5, 9\}$
$E_3 = \{7, 9\}$

Etat actuel : E_3

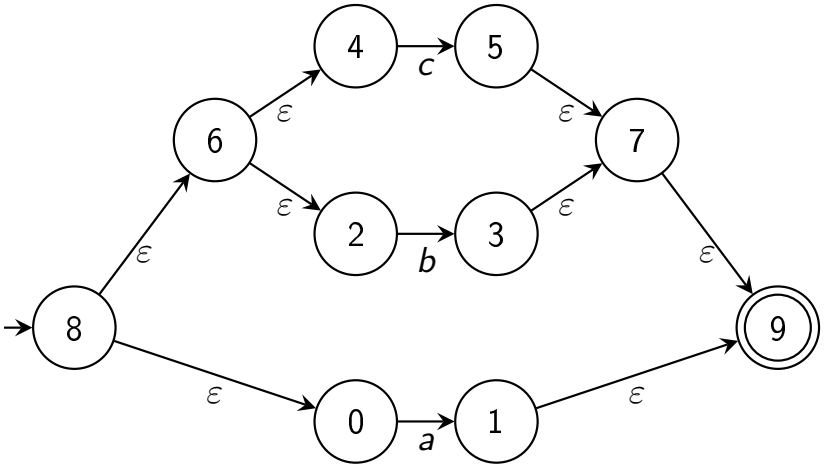
- x = c
- transitions : aucune

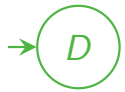




$$D = \{0, 2, 4, 6, 8\}$$
$$E_1 = \{1, 5, 9\}$$
$$E_2 = \{3, 5, 9\}$$
$$E_3 = \{7, 9\}$$

AFD terminé, nombre d'états : 4

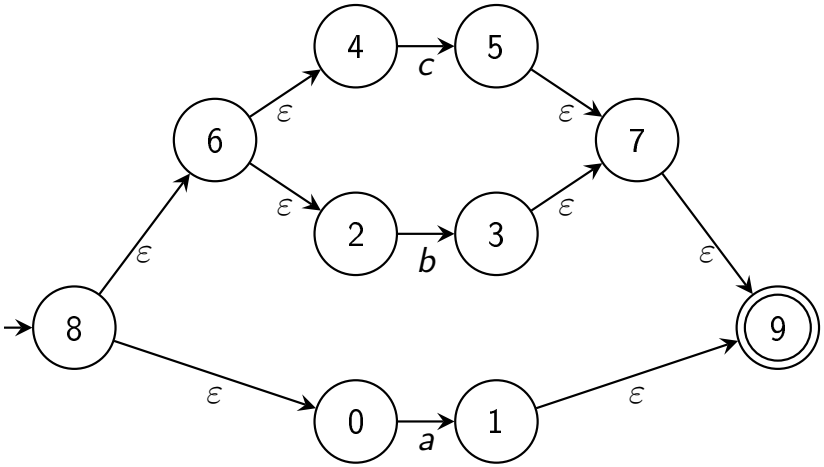


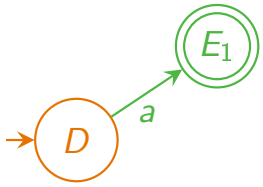


$D = \{0, 2, 4, 6, 8\}$

Calcul de l'état de départ :

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



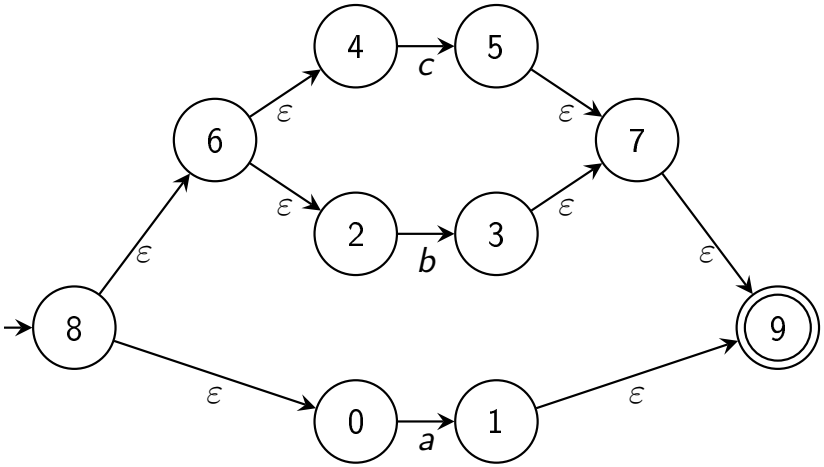


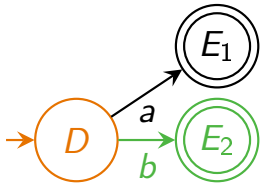
$D = \{0, 2, 4, 6, 8\}$

$E_1 = \{1, 9\}$

Etat actuel : D

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

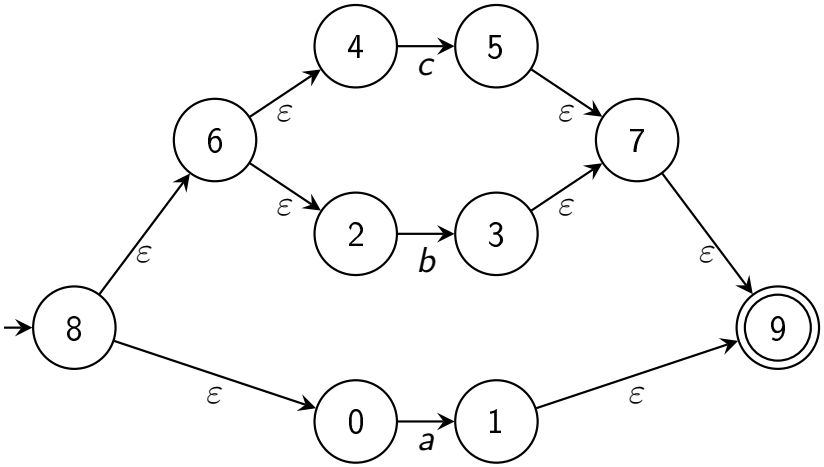


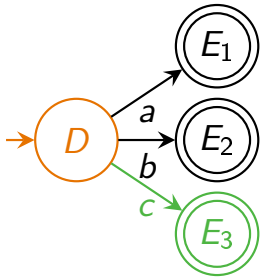


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 9\}$
$E_2 = \{3, 7, 9\}$

Etat actuel : D

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

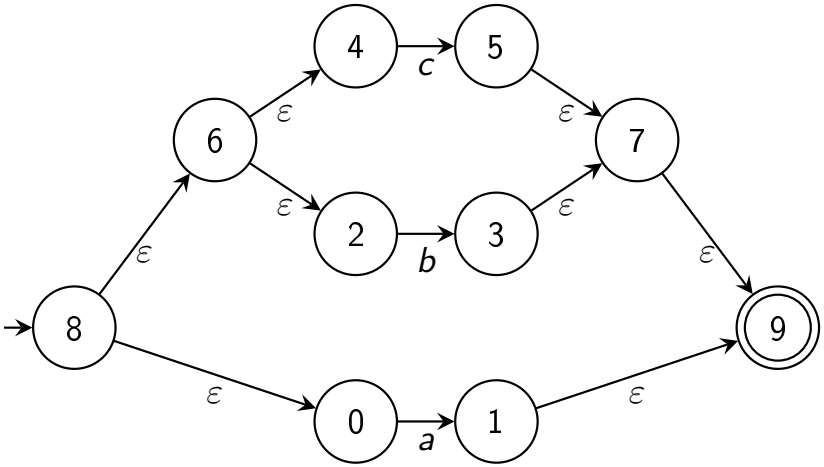


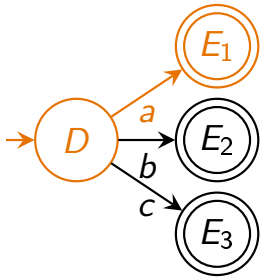


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 9\}$
$E_2 = \{3, 7, 9\}$
$E_3 = \{5, 7, 9\}$

Etat actuel : D

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

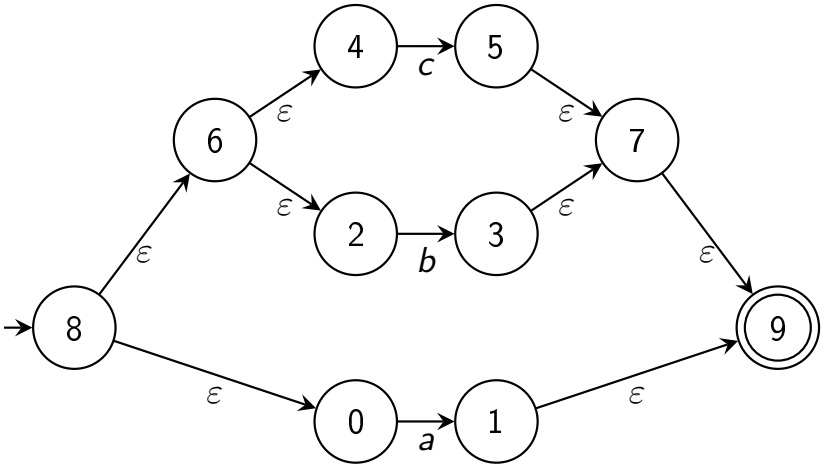


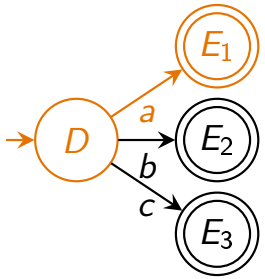


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 9\}$
$E_2 = \{3, 7, 9\}$
$E_3 = \{5, 7, 9\}$

Etat actuel : E_1

- x = a
- transitions : aucune

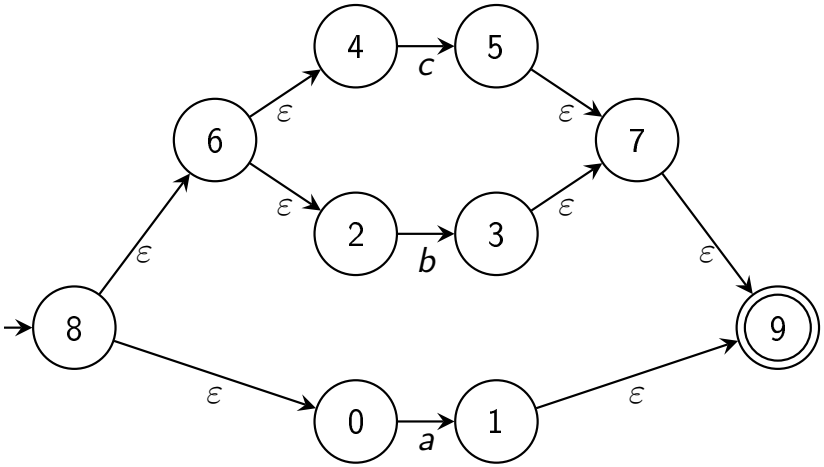


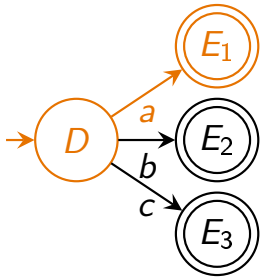


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 9\}$
$E_2 = \{3, 7, 9\}$
$E_3 = \{5, 7, 9\}$

Etat actuel : E_1

- x = b
- transitions : aucune

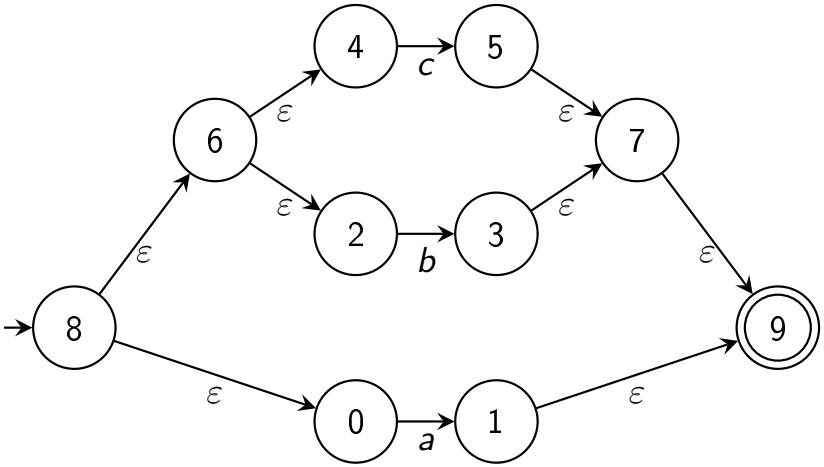


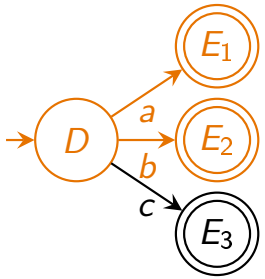


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 9\}$
$E_2 = \{3, 7, 9\}$
$E_3 = \{5, 7, 9\}$

Etat actuel : E_1

- x = c
- transitions : aucune

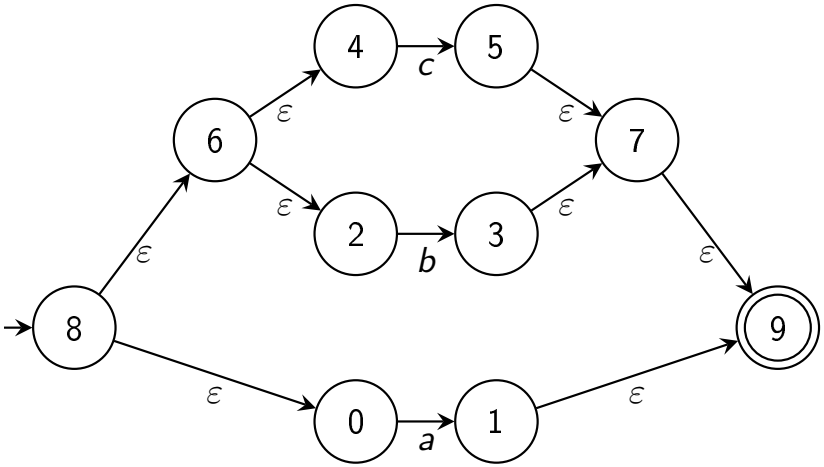


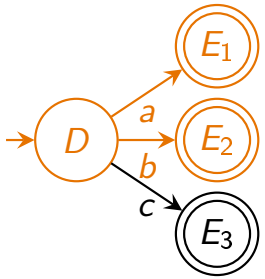


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 9\}$
$E_2 = \{3, 7, 9\}$
$E_3 = \{5, 7, 9\}$

Etat actuel : E_2

- x = a
- transitions : aucune

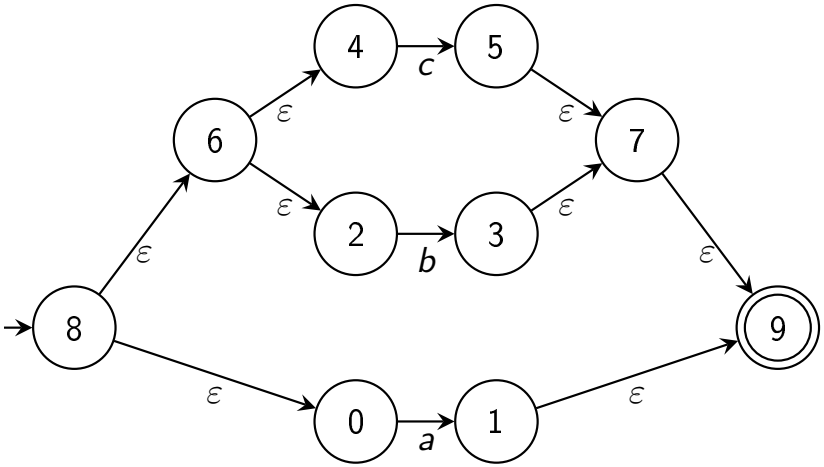


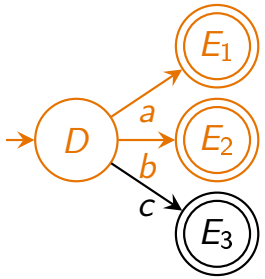


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 9\}$
$E_2 = \{3, 7, 9\}$
$E_3 = \{5, 7, 9\}$

Etat actuel : E_2

- x = b
- transitions : aucune

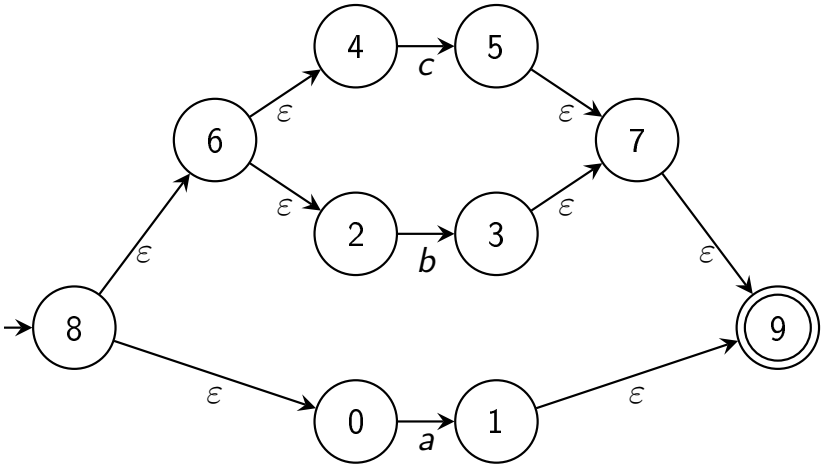


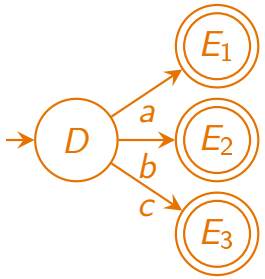


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 9\}$
$E_2 = \{3, 7, 9\}$
$E_3 = \{5, 7, 9\}$

Etat actuel : E_2

- x = c
- transitions : aucune

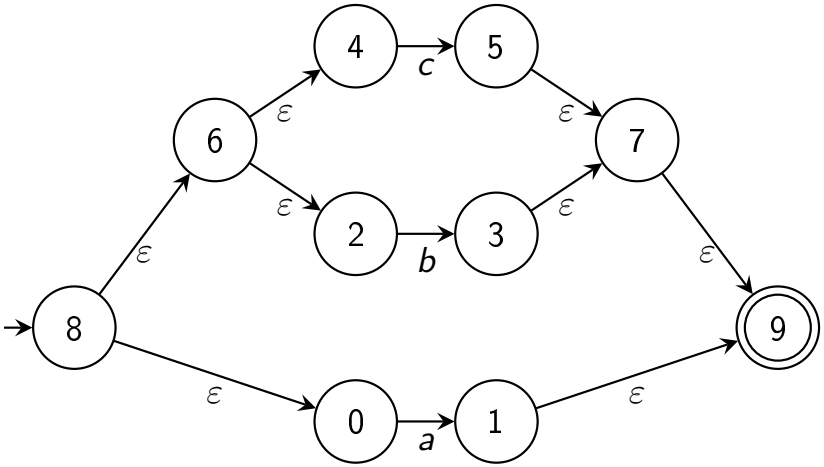


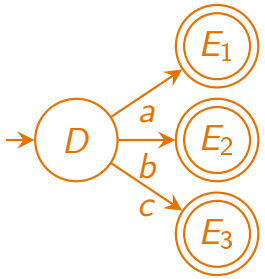


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 9\}$
$E_2 = \{3, 7, 9\}$
$E_3 = \{5, 7, 9\}$

Etat actuel : E_3

- x = a
- transitions : aucune

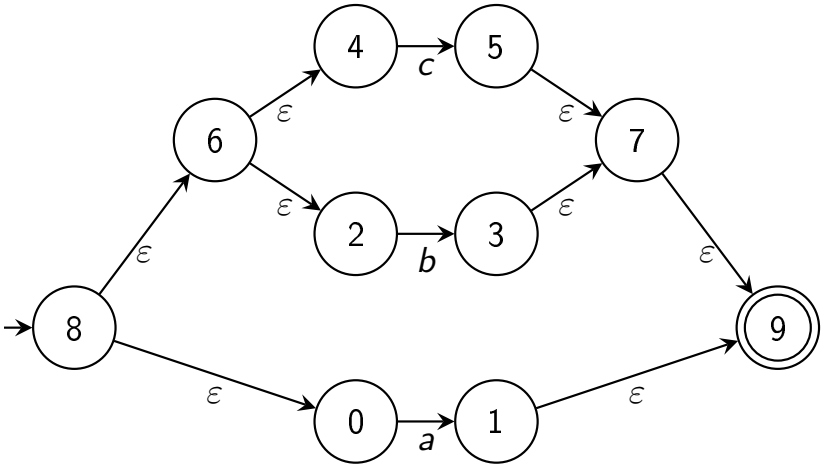


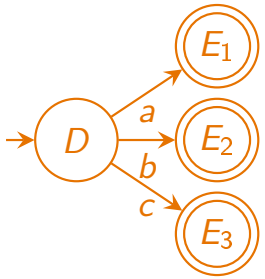


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 9\}$
$E_2 = \{3, 7, 9\}$
$E_3 = \{5, 7, 9\}$

Etat actuel : E_3

- x = b
- transitions : aucune

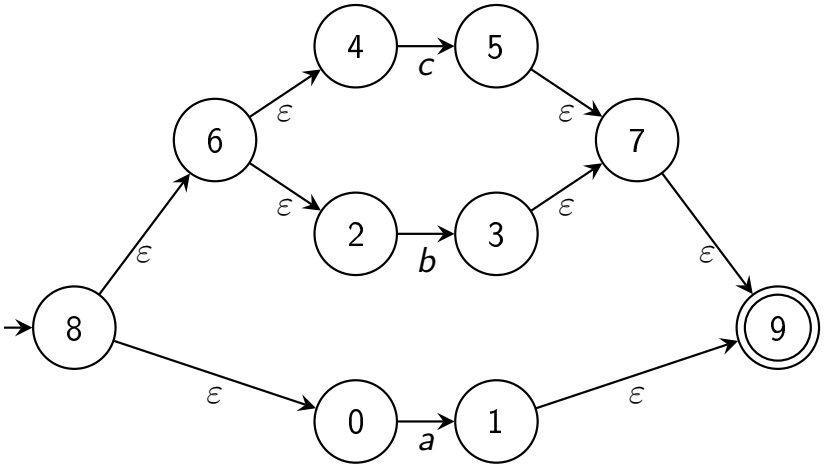


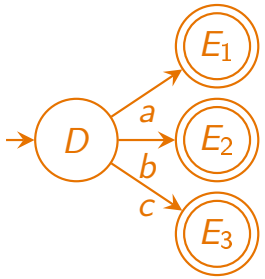


$D = \{0, 2, 4, 6, 8\}$
$E_1 = \{1, 9\}$
$E_2 = \{3, 7, 9\}$
$E_3 = \{5, 7, 9\}$

Etat actuel : E_3

- x = c
- transitions : aucune





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

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 ambiguité.

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