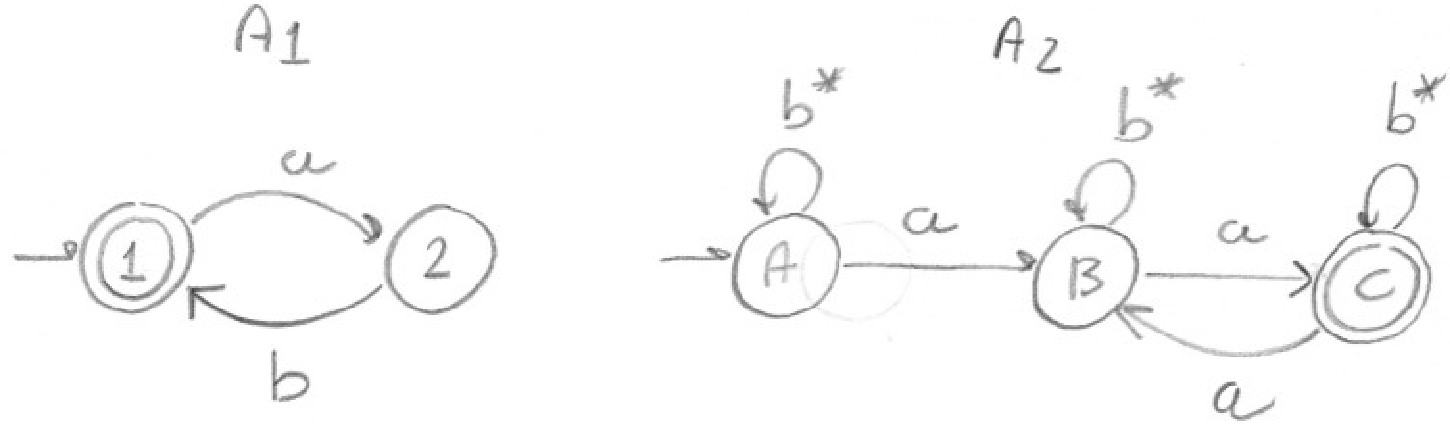
Prodotto di Automi $\Sigma = \{a, b\}$

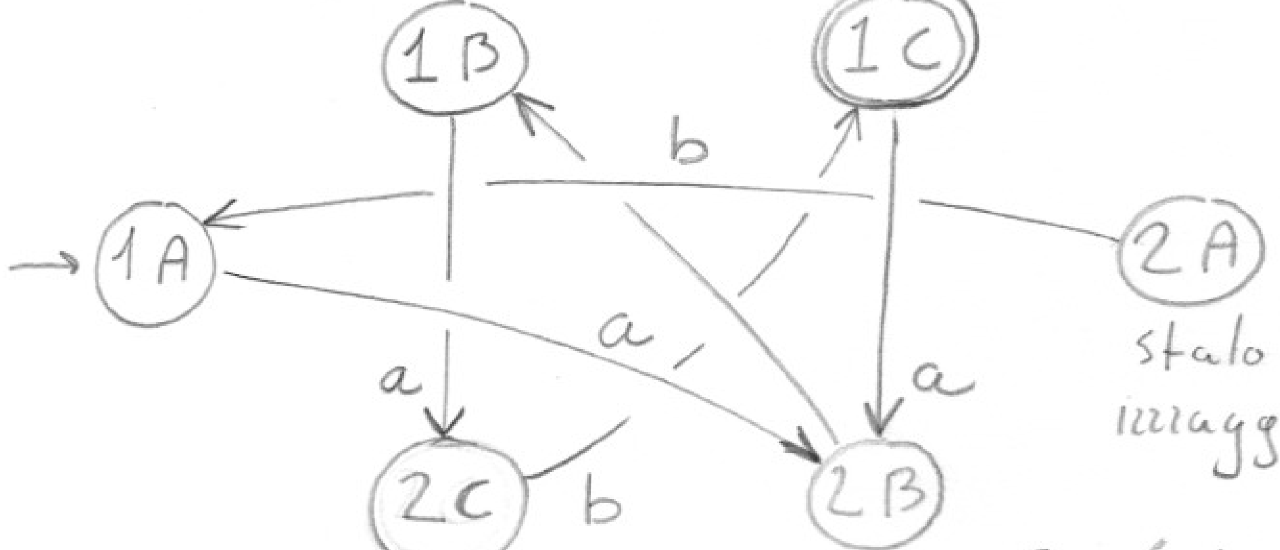
$R_1 = (ab)^*$ $\qquad$ $R_2 = (\Sigma^* a \Sigma^* a \Sigma^*)^+$



$Q_1 = \{1, 2\}$ $\qquad$ $Q_2 = \{A, B, C\}$

$$Q = Q_1 \times Q_2 = \{(1,A), (1,B), (1,C), \dots\}$$

$A = A_1 \times A_2 \quad L(A) = L(A_1) \cap L(A_2)$



stato irraggiungibile

$R = (abab)^*$

poi pulire l'automa (2A irraggiungibile)

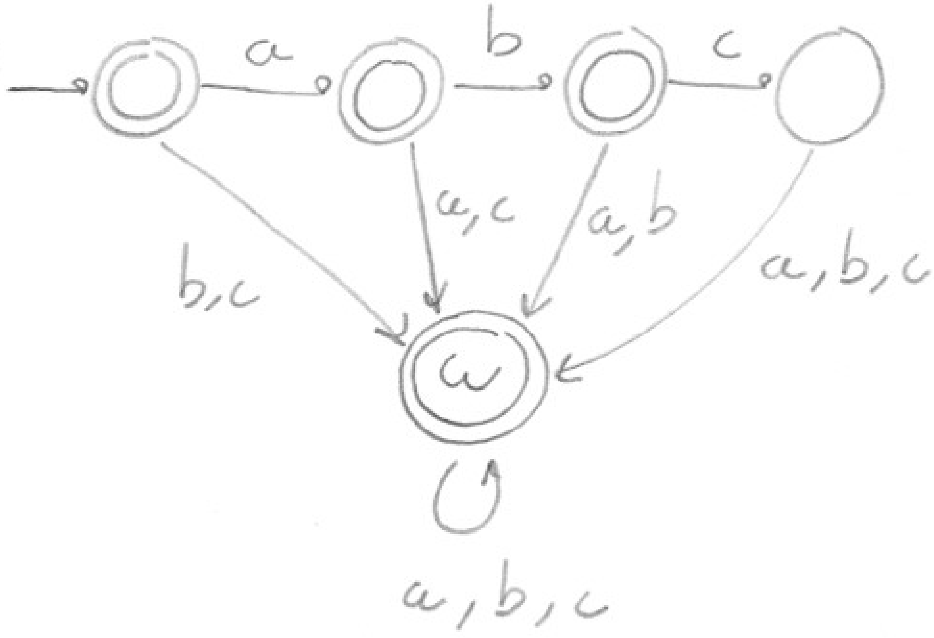
Funziona anche con automi ¬ det.

Complemento di automa <u>DET</u>!

$\Sigma = \{a, b, c\}$

A

$L(A) = \{abc\}$ (Una sola stringa)



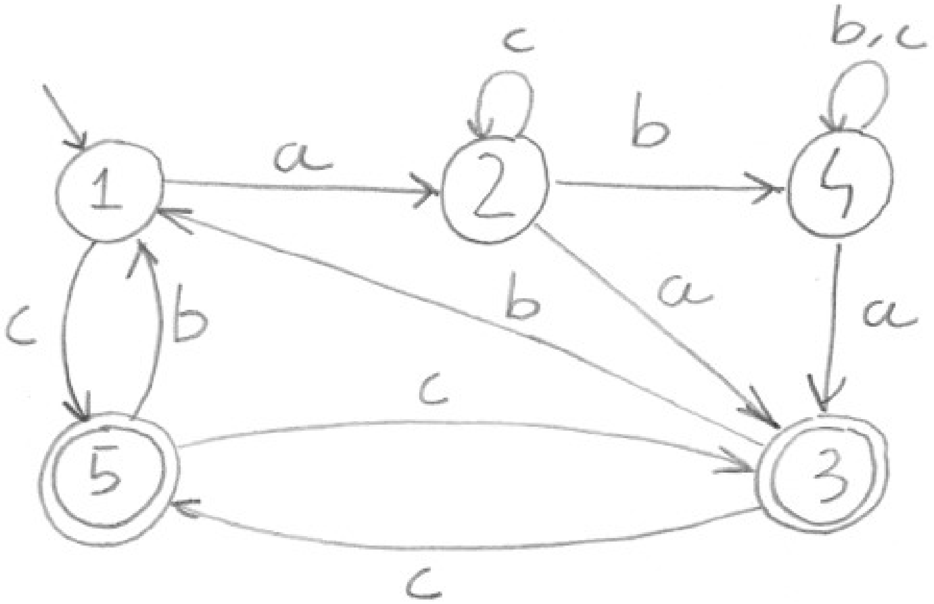
$\bar{A}$

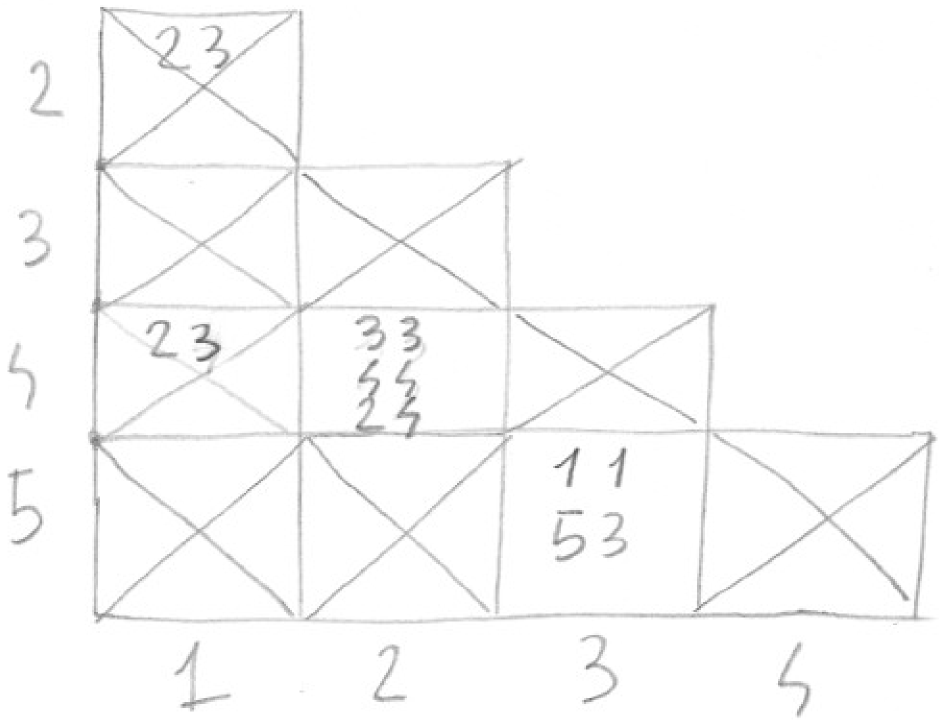
$\overline{L(A)} = L(\bar{A})$ $\qquad$ $L(\bar{A}) = \Sigma^* - \{abc\}$

Attenzione: ¬ funziona se l'automa è ¬ deterministico

Riduzione stati

(x automa deterministico) $\Sigma = \{a, b, c\}$





· 1

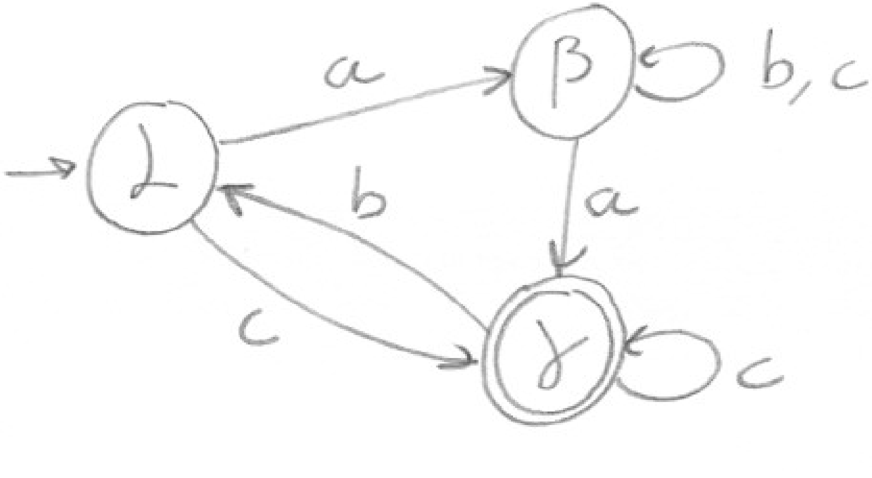
2 —24— 4

3 —53— 5

$\alpha = 1$

$\beta = 2, 4$

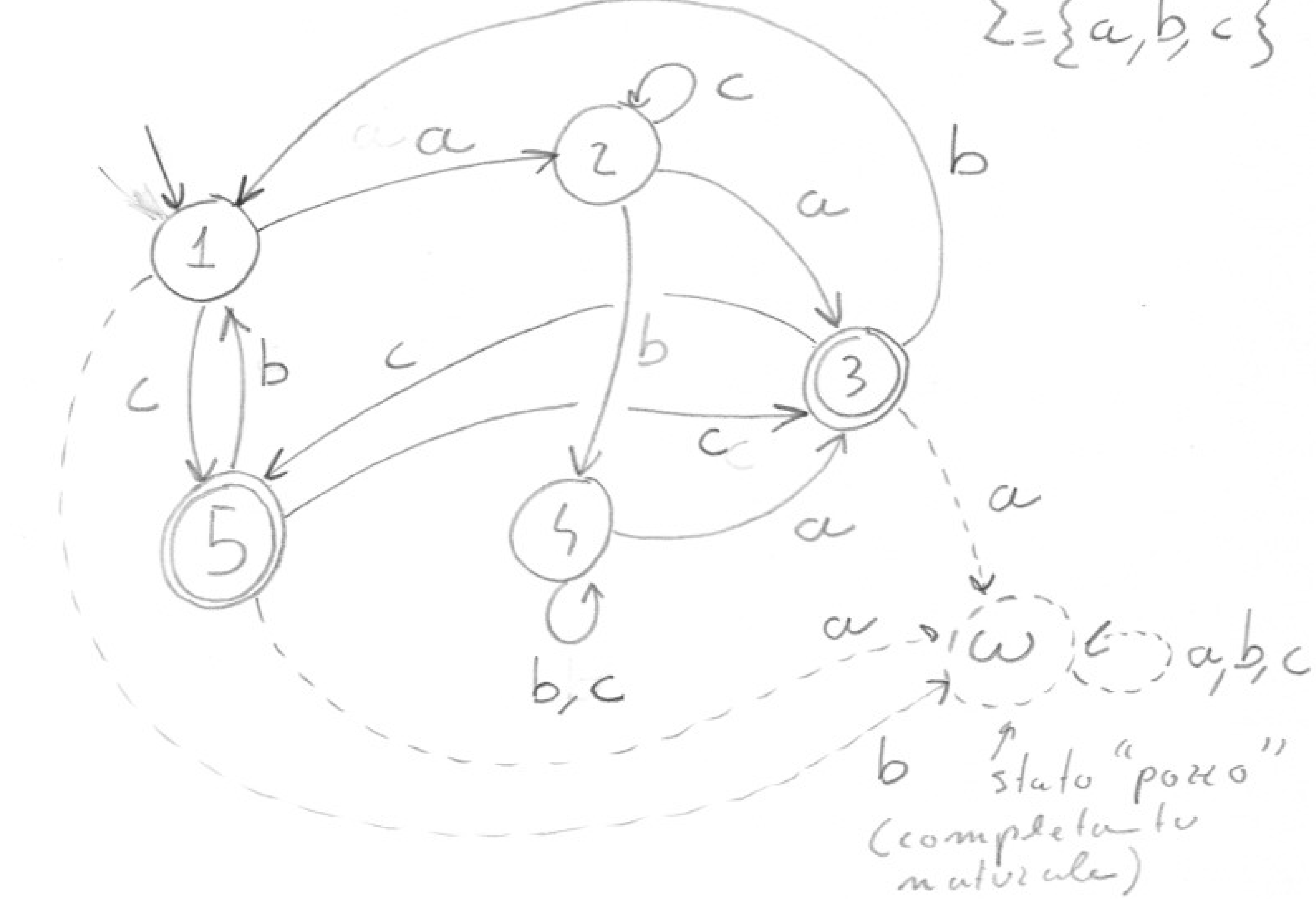
$\gamma = 3, 5$



Riduzione stati
(x automa deterministico)

1

$\Sigma = \{a, b, c\}$



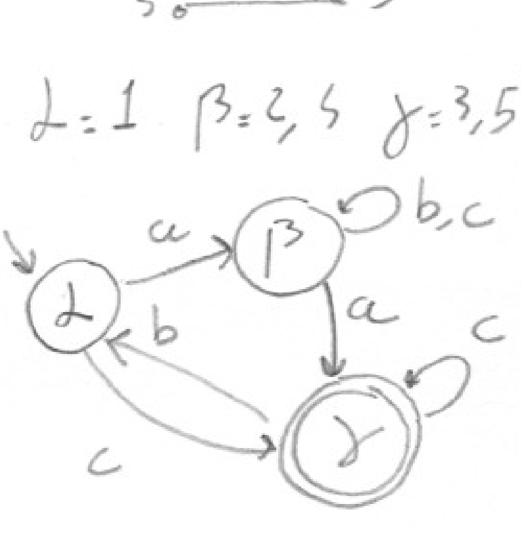
	1	2	3	4
2	2 3 ω 4 5 2			
3	2 ω ω 1 5 5	3 ω 4 1 2 5		
4	2 3 ω 4 5 4	3 3 4 4 2 4	ω 3 1 4 5 4	
5	2 ω ω 1 5 3	3 ω 4 1 2 5	ω ω 1 1 5 3	3 ω 4 1 4 3

1

$2 \xrightarrow{24} 4$

$3 \xrightarrow{53} 5$

$\alpha = 1 \quad \beta = 2,4 \quad \gamma = 3,5$



$\Sigma = \{a, b, c\}$ $\qquad$ $R = a(b \mid cc)^* c b \dashv$

(1)

$$R = \underbrace{a_1 \underbrace{\underbrace{(\underbrace{b_2 \mid \underbrace{c_3 c_4}_{6}}_{5})^*}_{3} \underbrace{c_5 b_6}_{4}}_{2}}_{1} \dashv$$

$R = 1 \cdot \dashv$

$1 = a_1 \cdot 2$

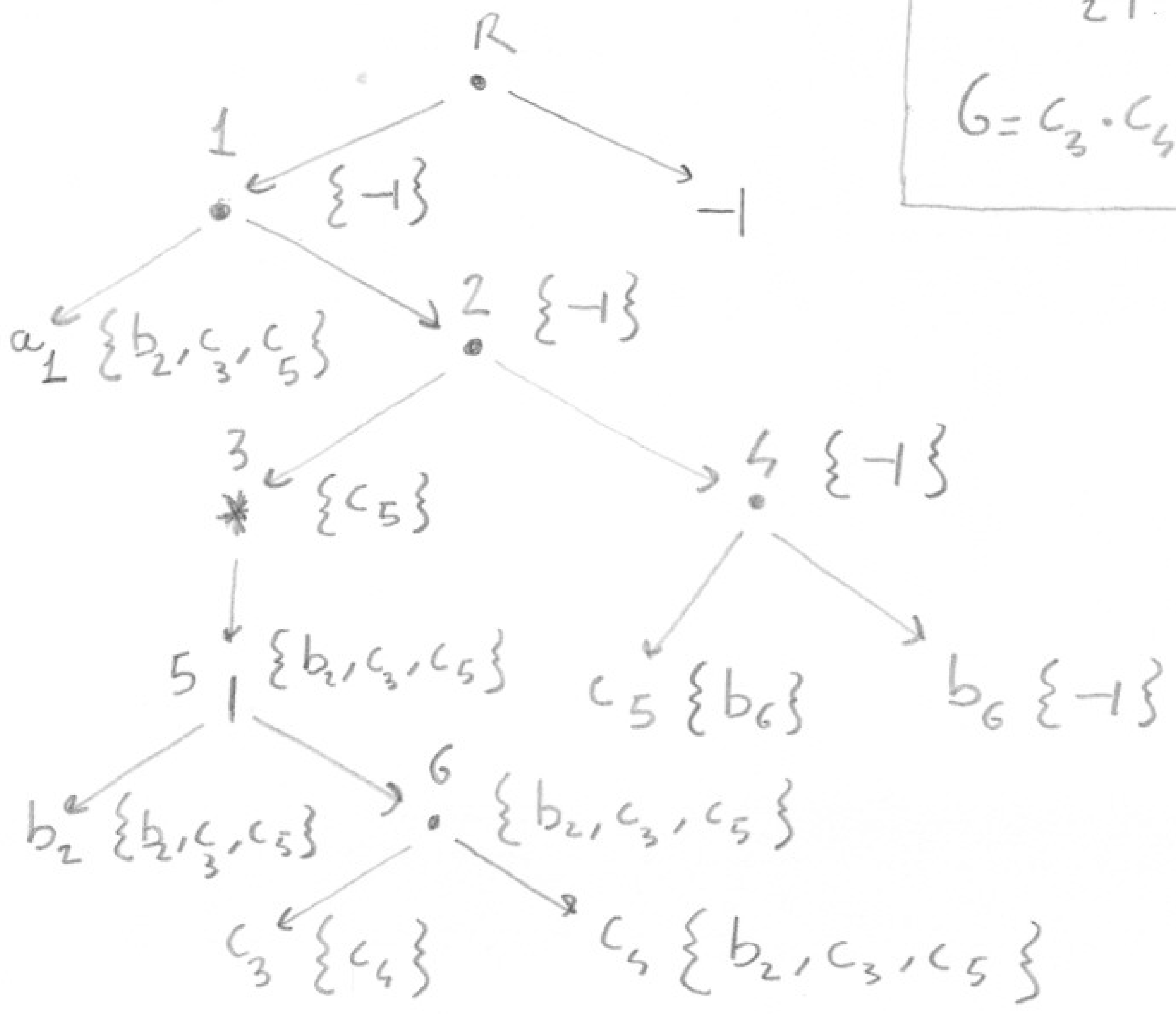
$2 = 3 \cdot 4$

$3 = 5^*$

$4 = c_5 \cdot b_6$

$5 = b_2 \mid 6$

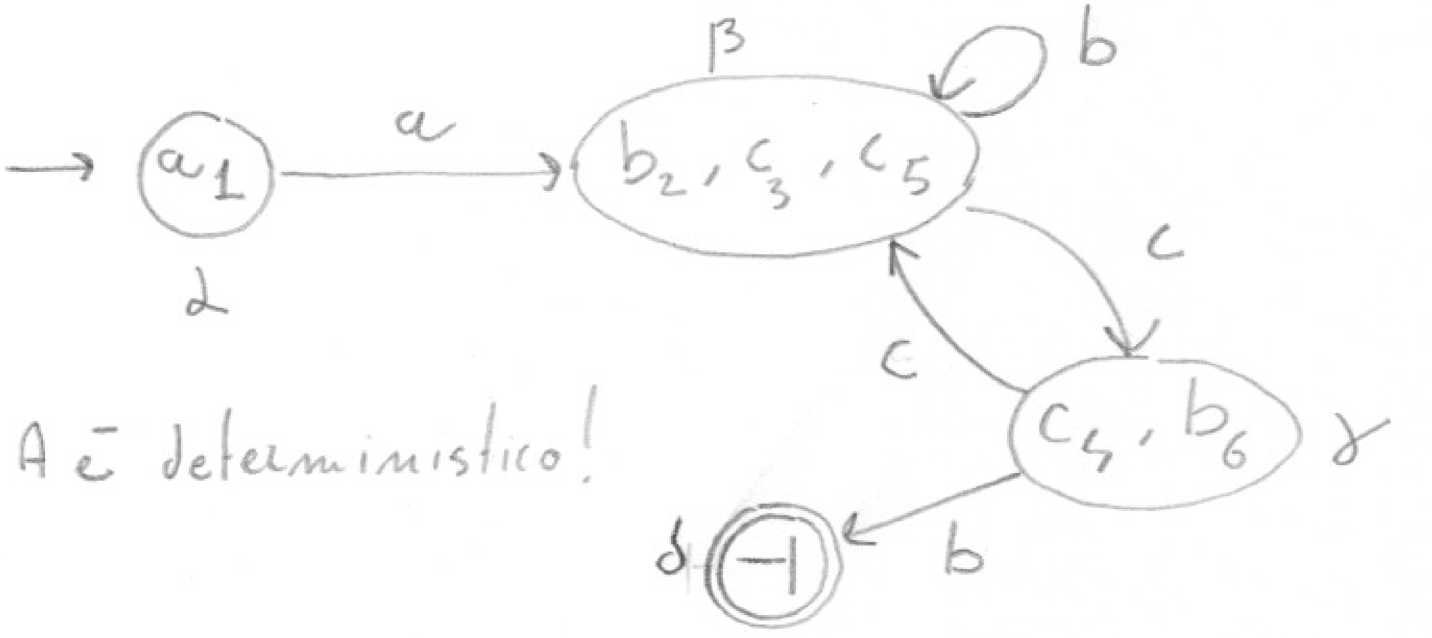
$6 = c_3 \cdot c_4$



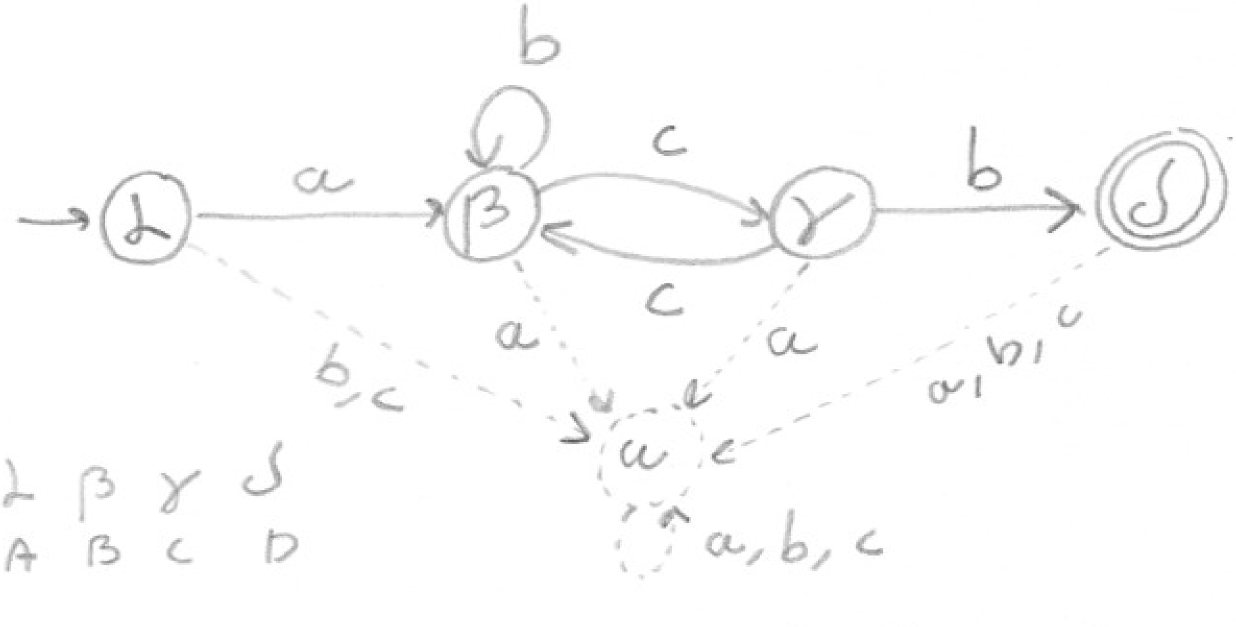
$A = (\Sigma, Q, q_0, Q_F, \delta)$

$q_0 = \{ a \mid a$ è carattere iniziale di $R\dashv \}$

vale a dire $q_0 = \{ a_1 \}$



A è deterministico!



α β γ δ
A B C D

$$G \begin{cases} A \to a B \\ B \to b B \mid c C \\ C \to c B \mid b D \\ D \to \varepsilon \end{cases}$$

G è unilineare (a destra)

A è l'assioma

$\Sigma = \{a, b\}$ $\quad R = (a(bb)^*)^*(aa|\varepsilon)\dashv$ 1

$$R = \underbrace{(\underbrace{\underbrace{a_1 \underbrace{(\underbrace{b_2 b_3}_{1})^*}_{2}}_{3})^*}_{4} (\underbrace{\underbrace{a_4 a_5}_{5} | \varepsilon}_{6})}_{7} \dashv$$

$R = 7 \cdot \dashv$

$7 = 4 \cdot 6$

$6 = 5 | \varepsilon$

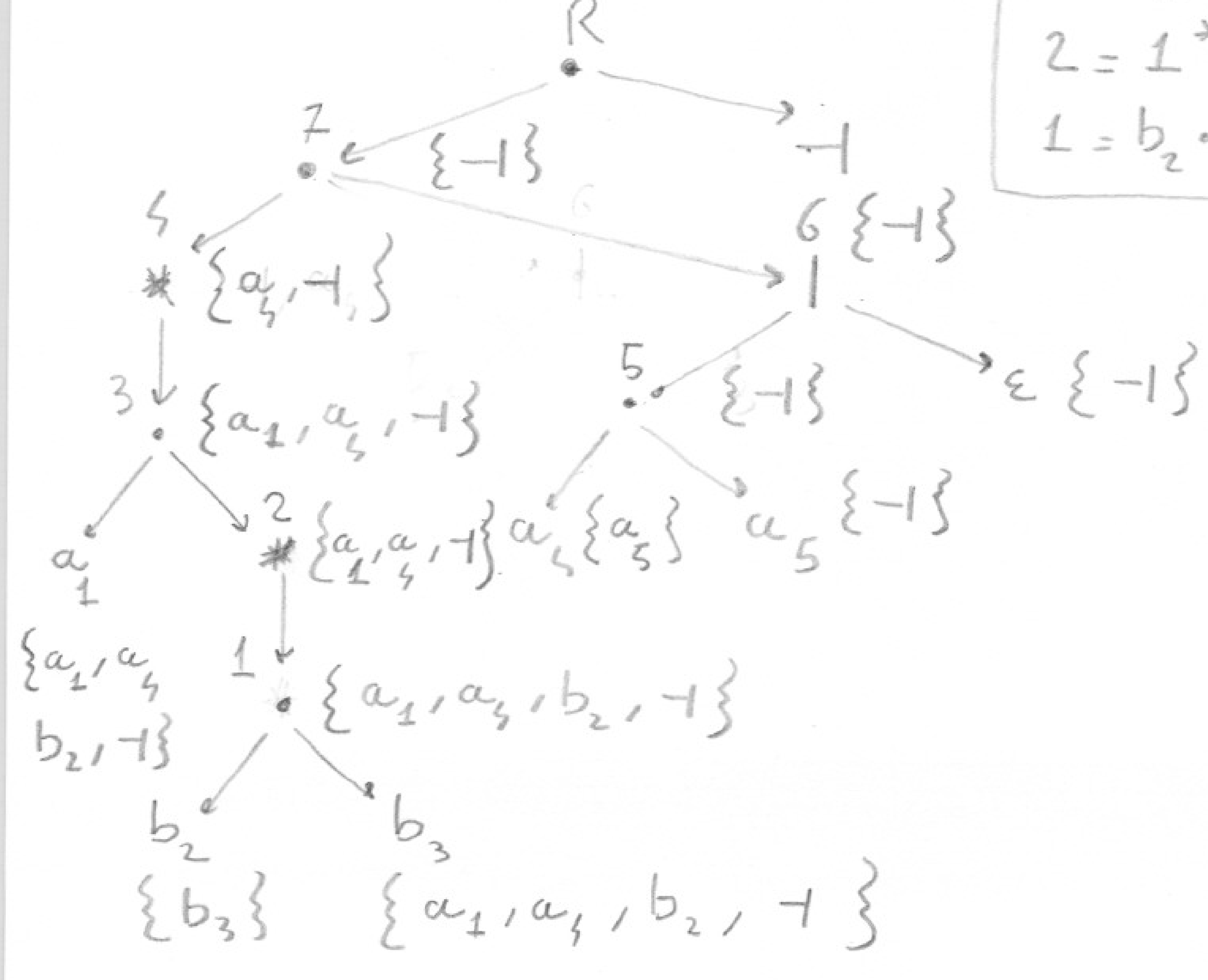
$5 = a_4 \cdot a_5$

$4 = 3^*$

$3 = a_1 \cdot 2$

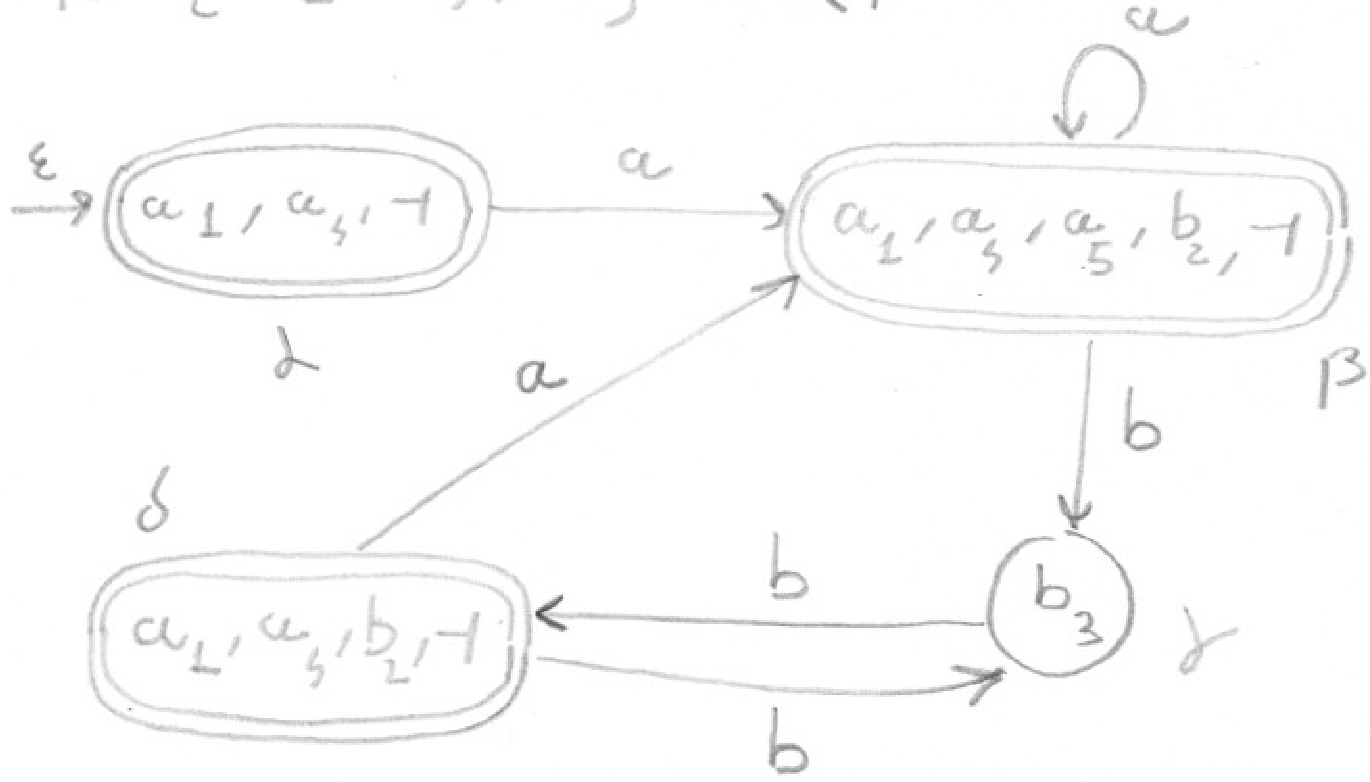
$2 = 1^*$

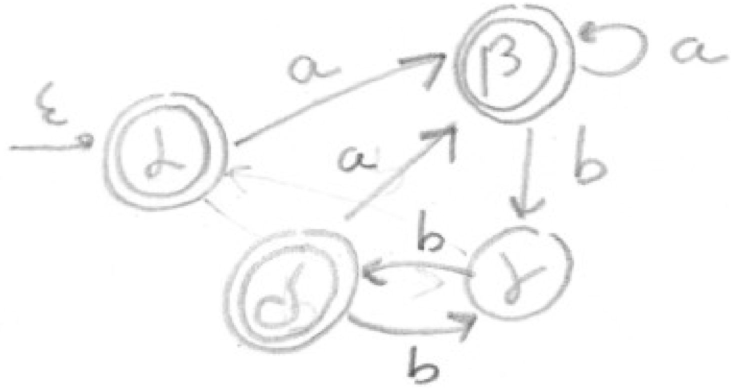
$1 = b_2 \cdot b_3$



$A = (\Sigma, Q, q_0, Q_F, \delta)$ ②

$q_0 = \{a_1, a_5, \dashv\} \in Q_F$





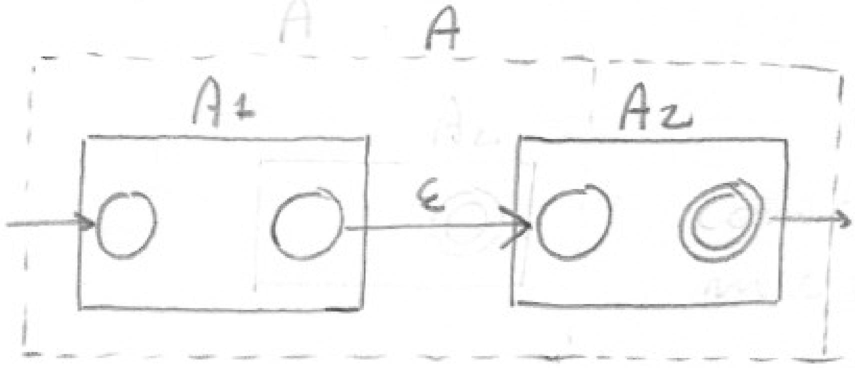
α β γ δ
A B C D

$$G \begin{cases} A \to \varepsilon \mid aB \\ B \to \varepsilon \mid aB \mid bC \\ C \to bD \\ D \to \varepsilon \mid aB \mid bC \end{cases}$$

G ¬ è ambigua
(invece R è
ambigua:
$a_1 a_1 \in L(R)$
$a_5 a_5 \in L(R)$)

Composizione modulare (Brzozowski)

$A_1 \cdot A_2 = A$

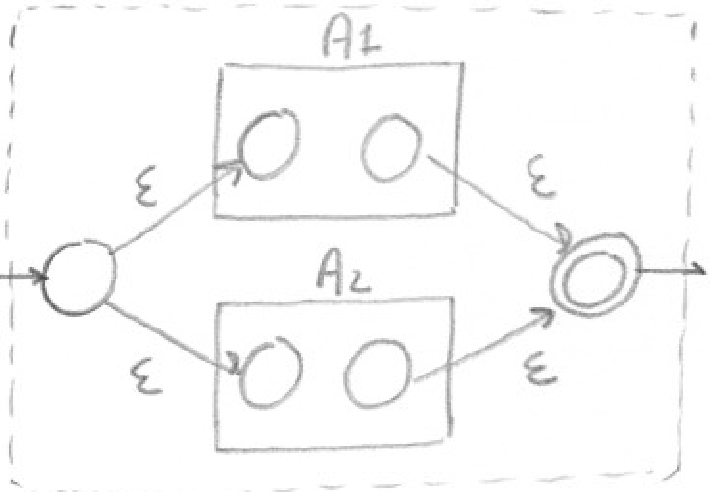


Concatenamento (1 nuovo ε-arco)

$L(A) = L(A_1) \cdot L(A_2)$

$A_1 \cup A_2$

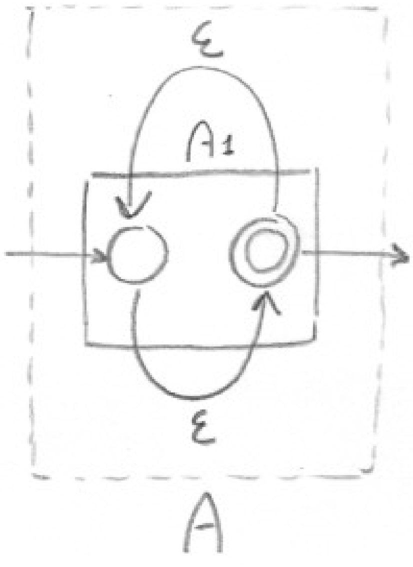
$L(A) = L(A_1) \cup L(A_2)$



Unione (2 nuovi stati) (4 nuovi ε-archi)

A_1^*

$L(A) = L(A_1)^*$



Iterazione (2 nuovi ε-archi)

$R = a(b \mid cc)^* cb$

Calcolo automa ¬deterministico

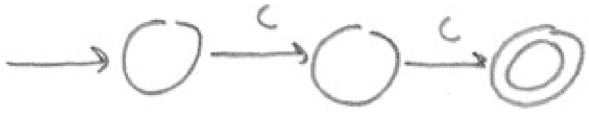
1

a

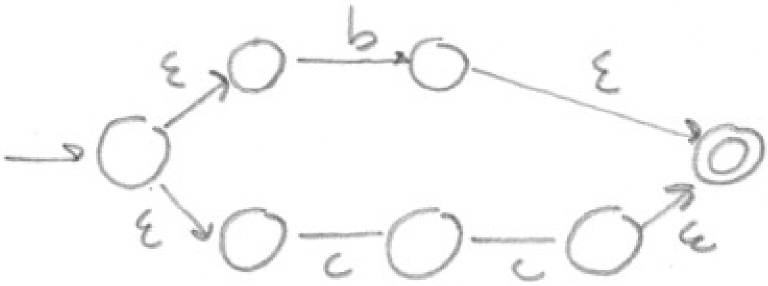
b

c

cc

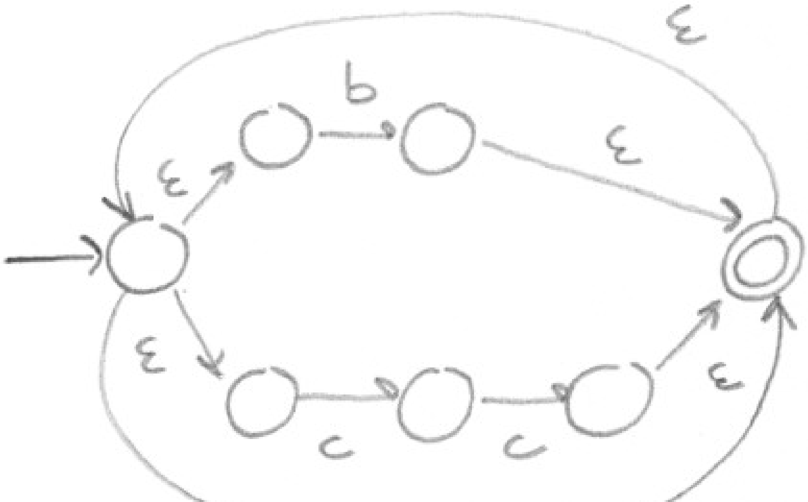


6

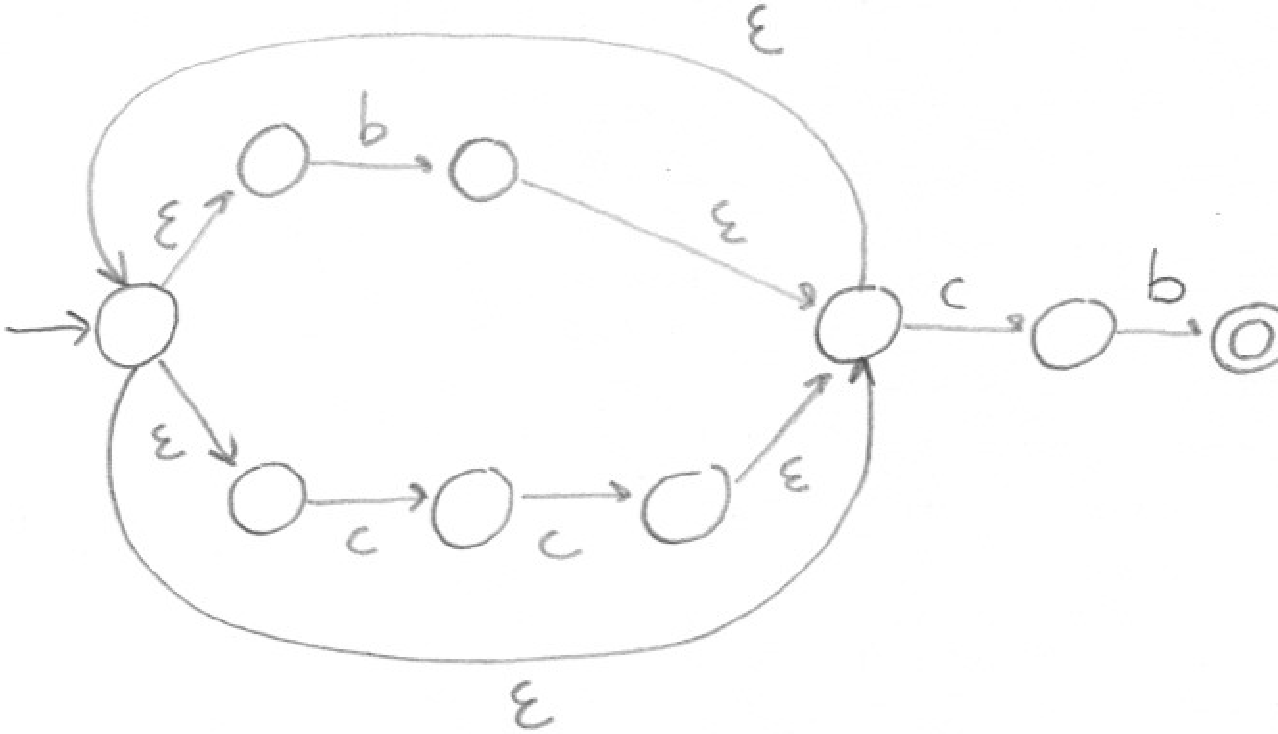


5

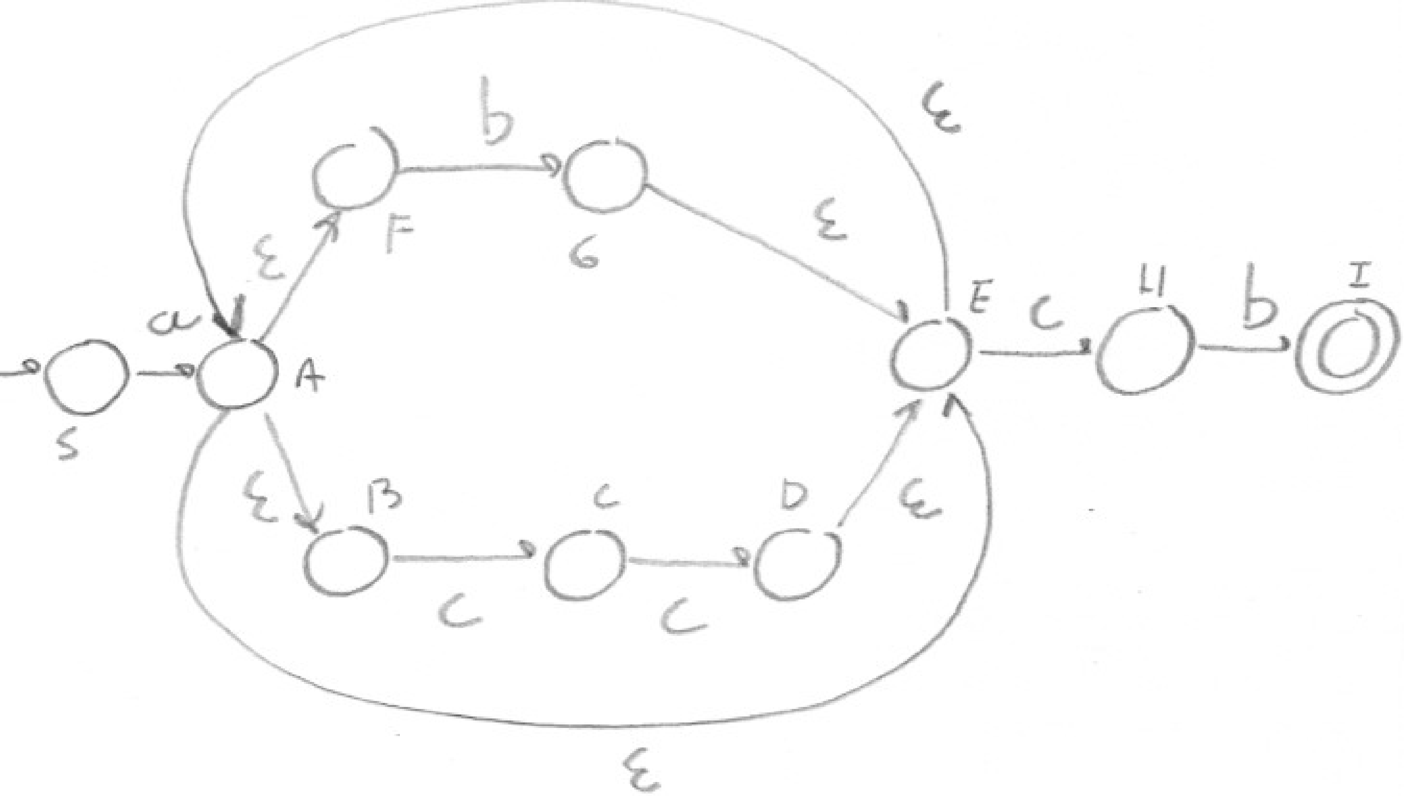
4



3



2



1

G:

$S \to a A$

$A \to B \mid F \mid E$

$B \to c C$

$C \to c D$

$D \to E$

$F \to b G$

$G \to E$

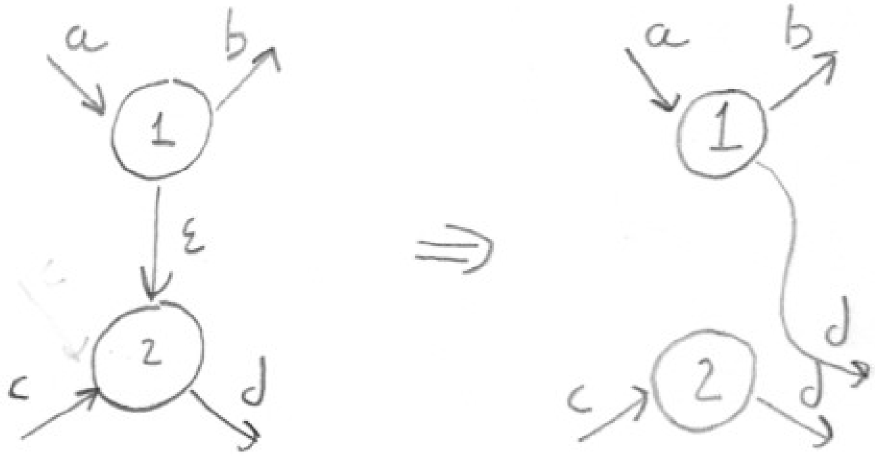
$E \to A \mid c H$

$H \to b I$

$I \to \varepsilon$

Eliminazione ε-transizioni

- Retrazione archi



con $d \in \Sigma \cup \varepsilon$

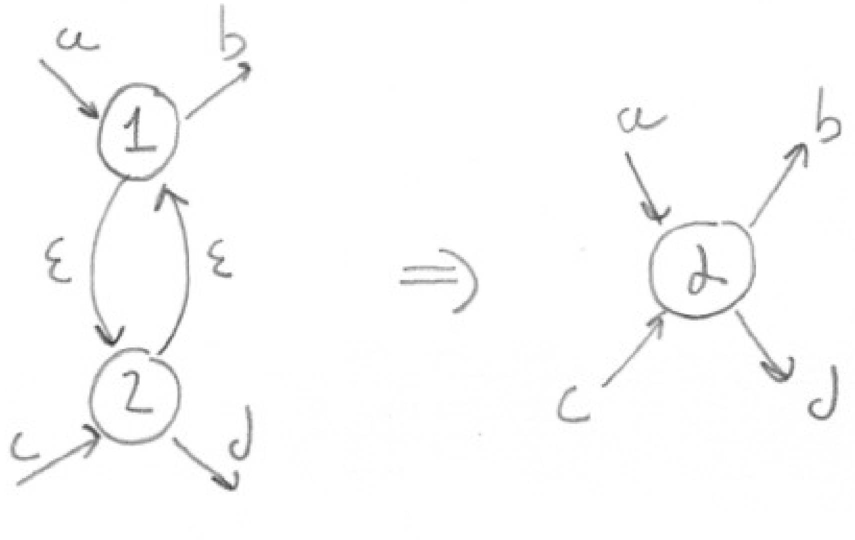
Inoltre, se 2 è finale, 1 diventa finale

- Propagazione archi

con $a \in \Sigma \cup \varepsilon$

Inoltre, se 1 è iniziale, 2 diventa iniziale

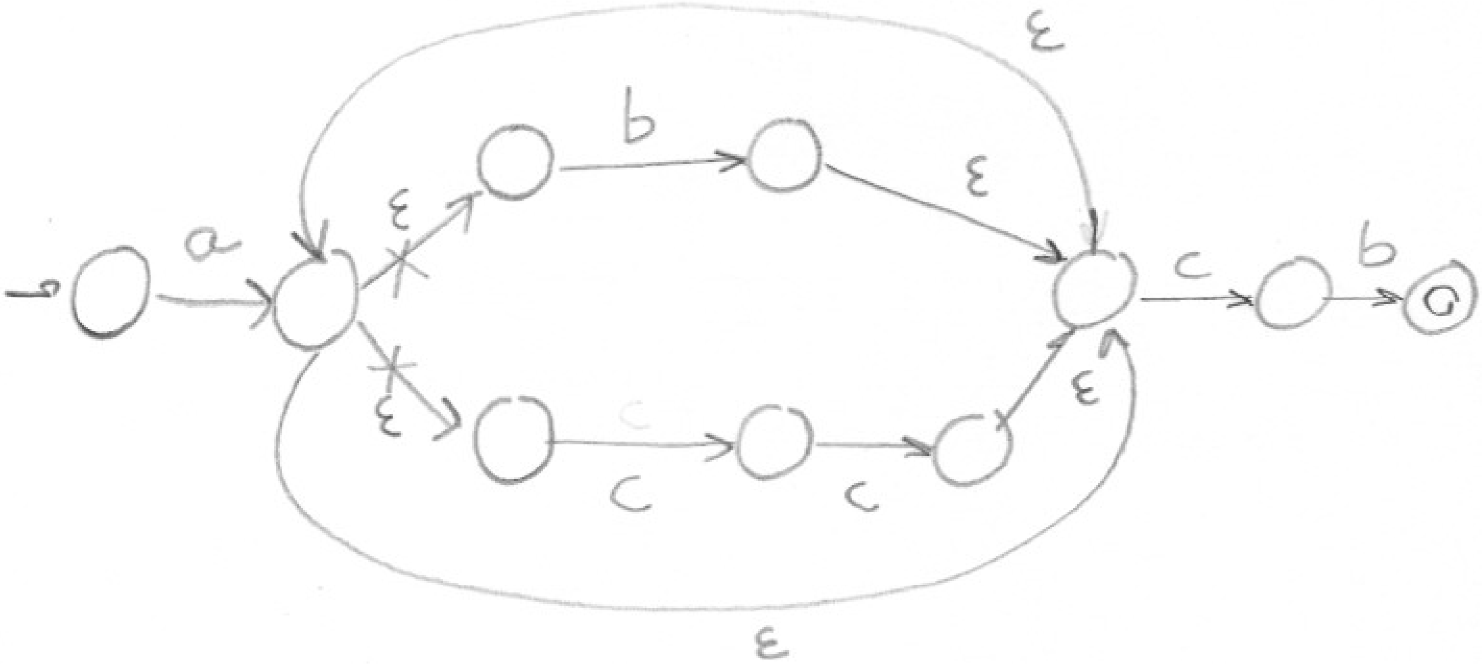
- Collasso degli ε-cicli



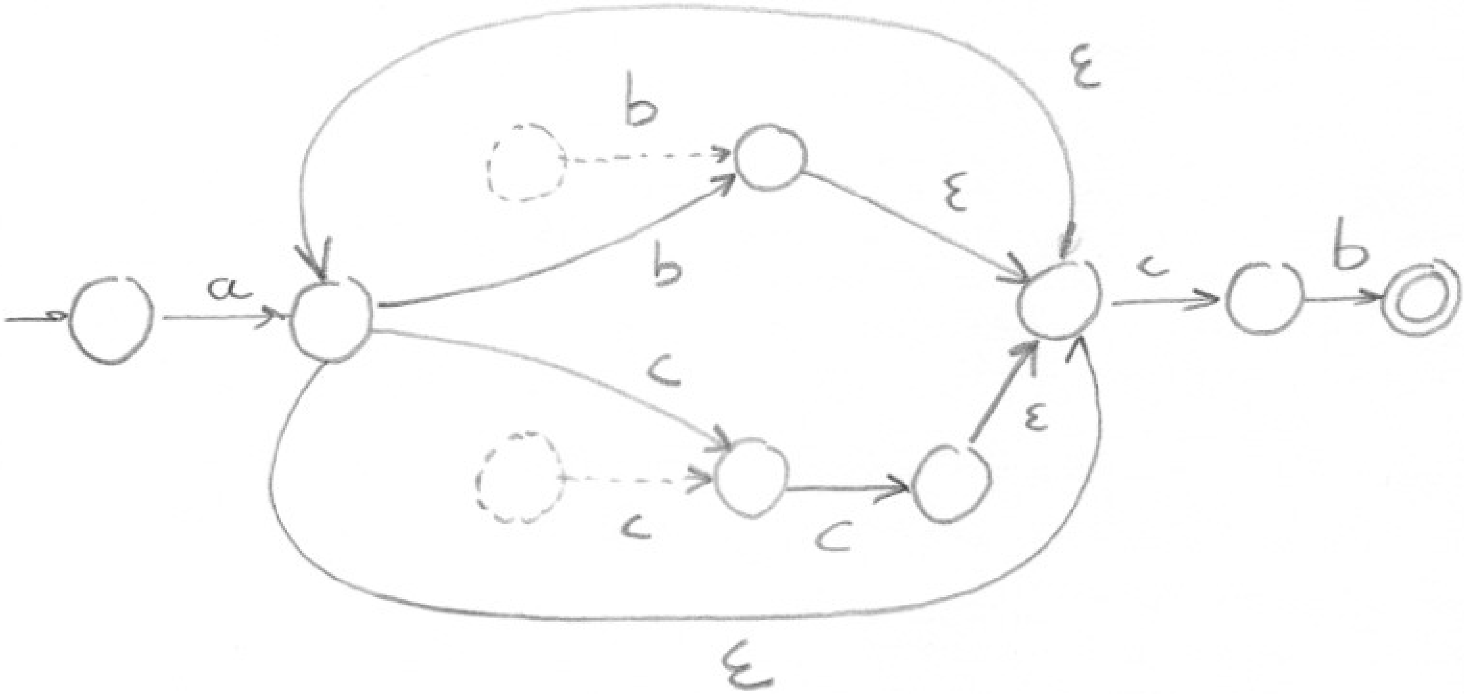
Se 1 iniziale
⇓
α iniziale

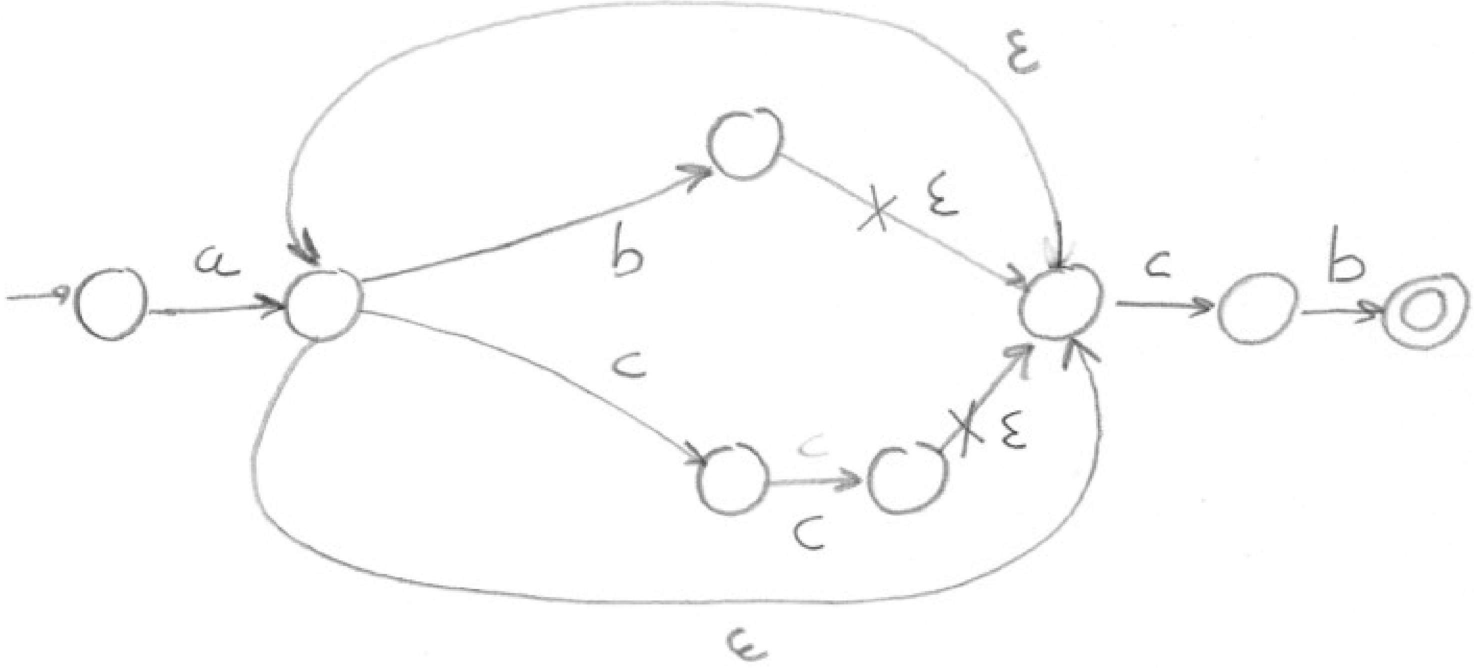
Se 1 finale
⇓
α finale

Determinizzazione Automa

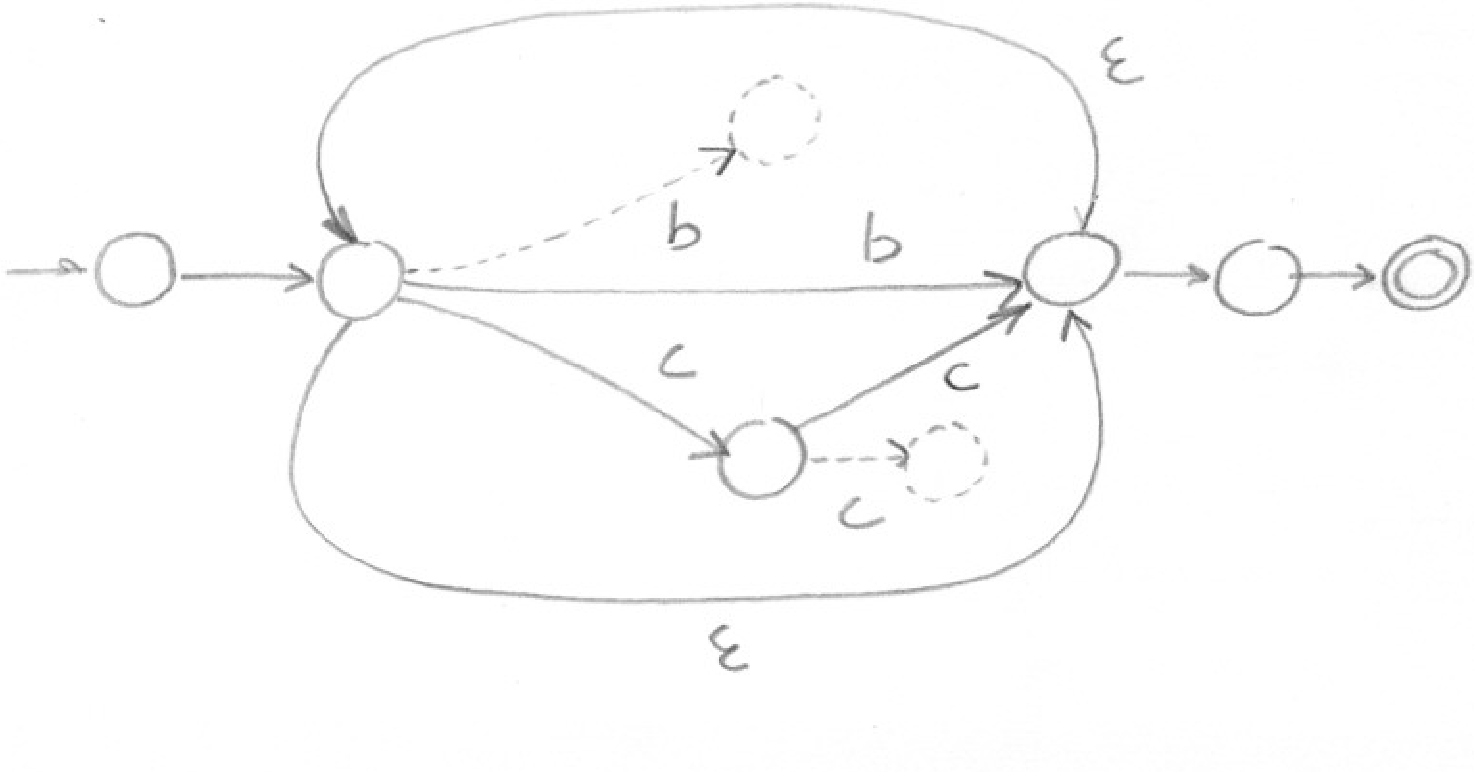


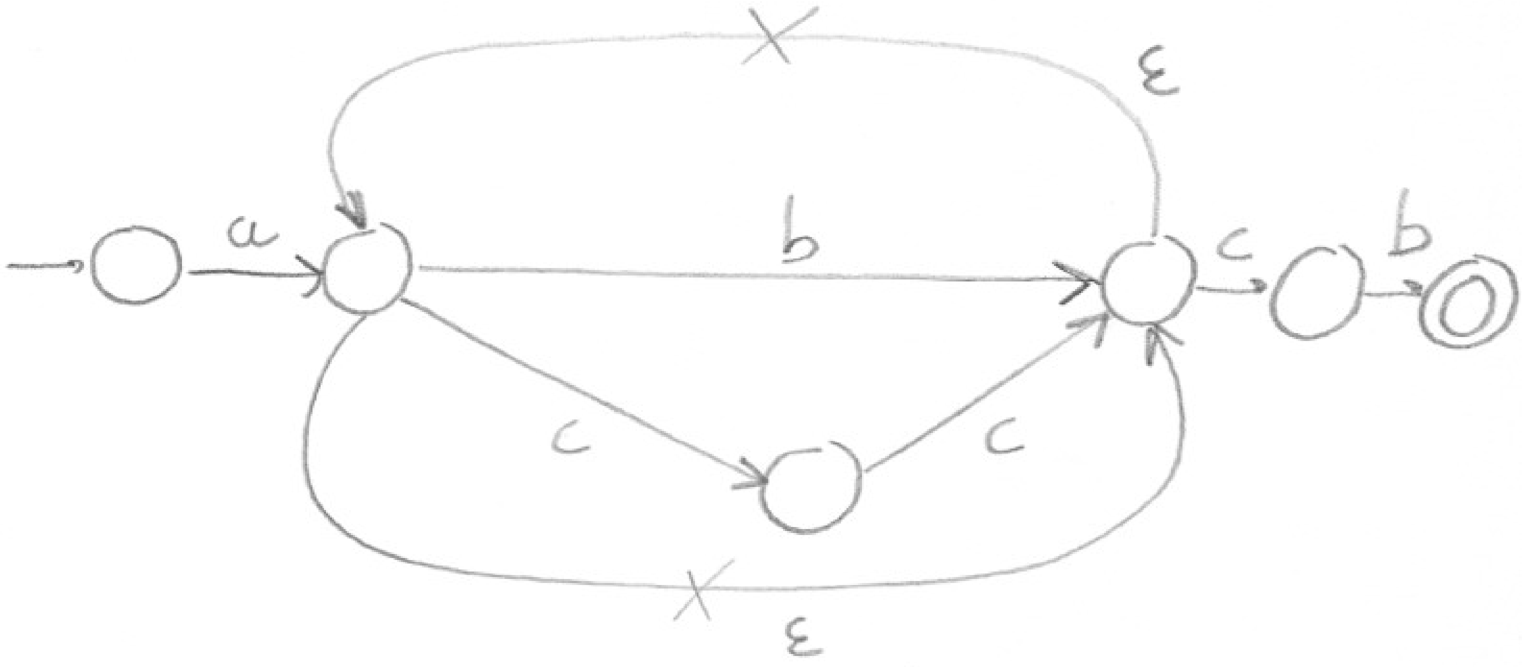
$\Downarrow$ propagazione



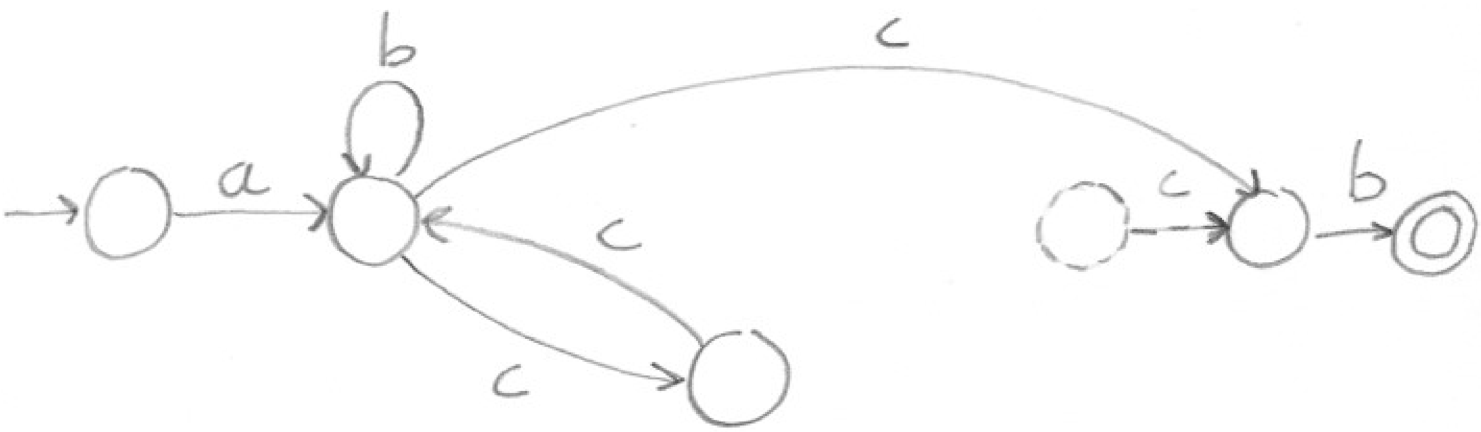


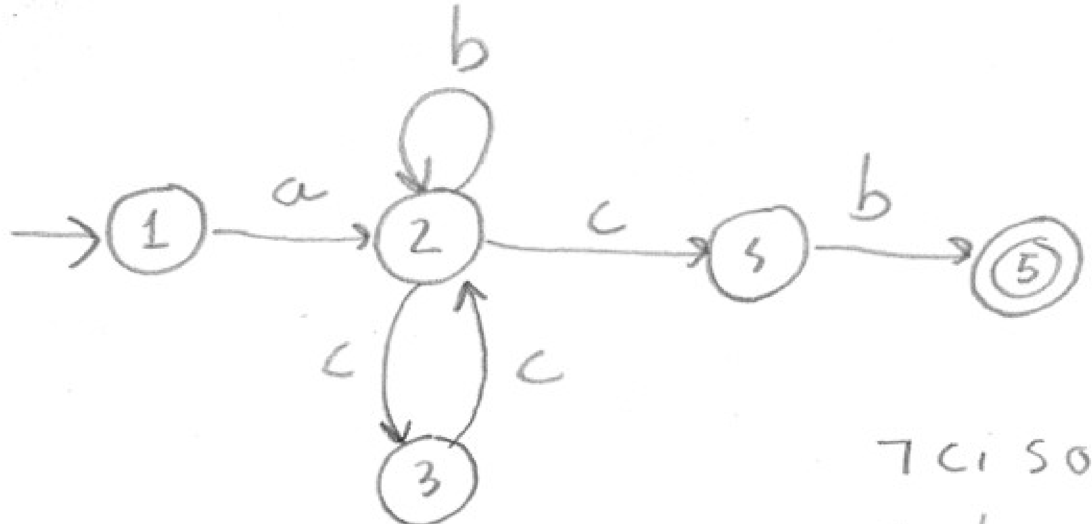
$\Downarrow$ propagazione





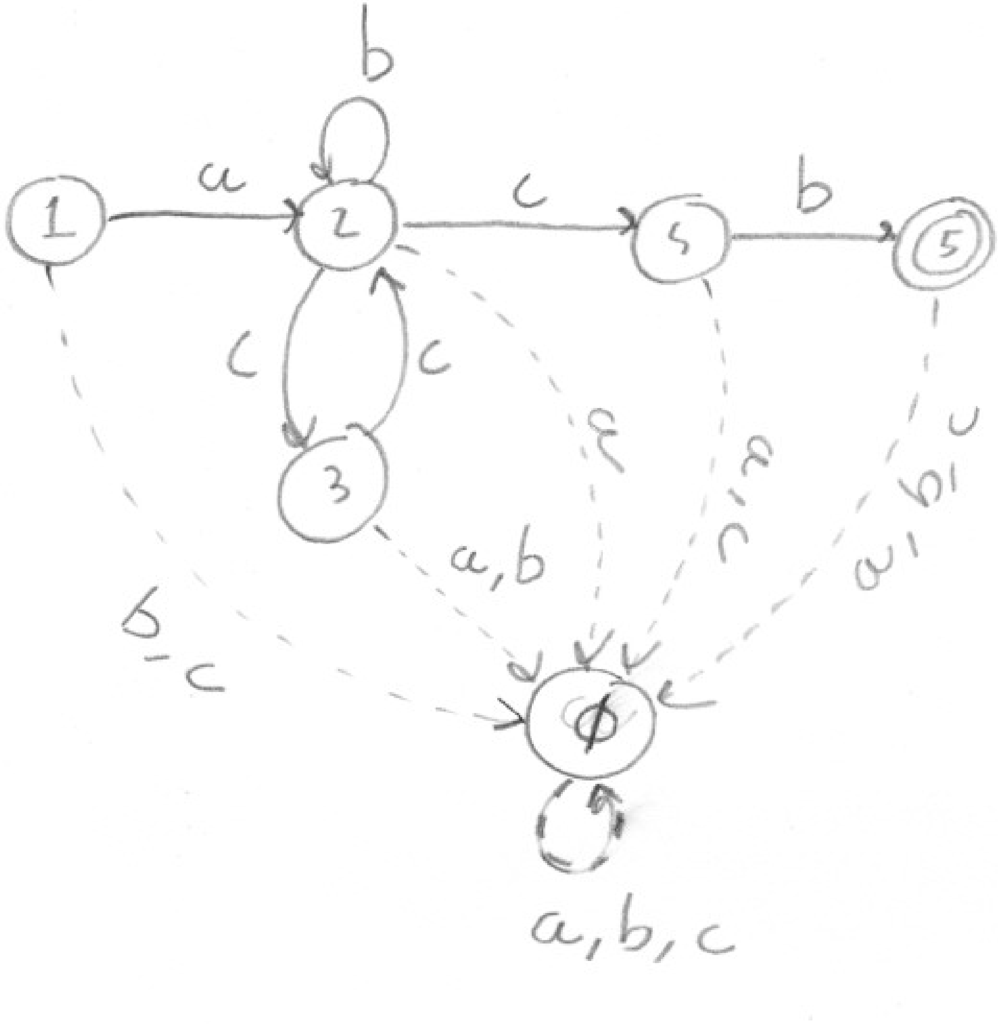
$\Downarrow$ collasso ε-ciclo

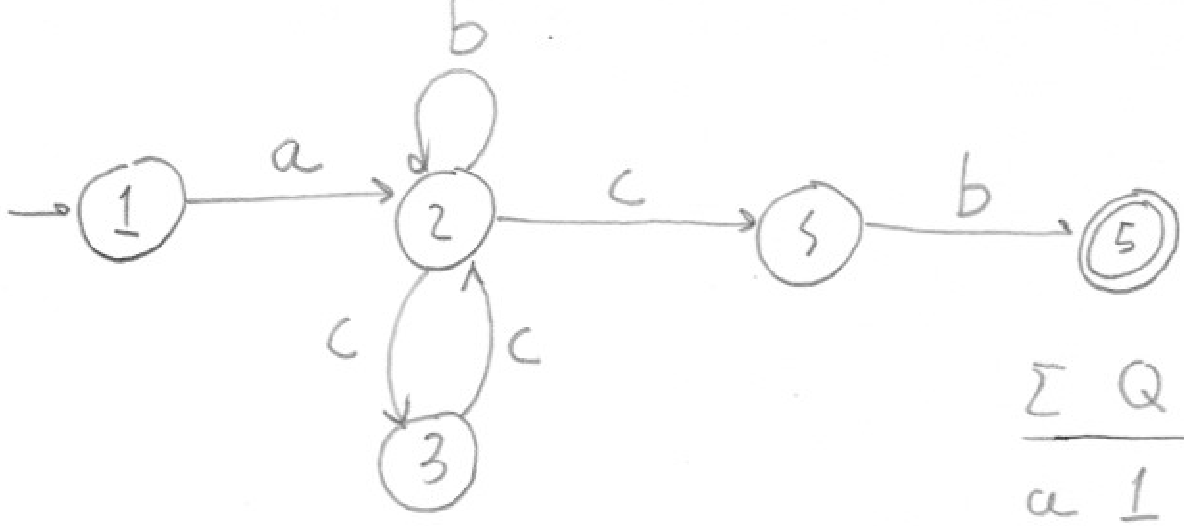


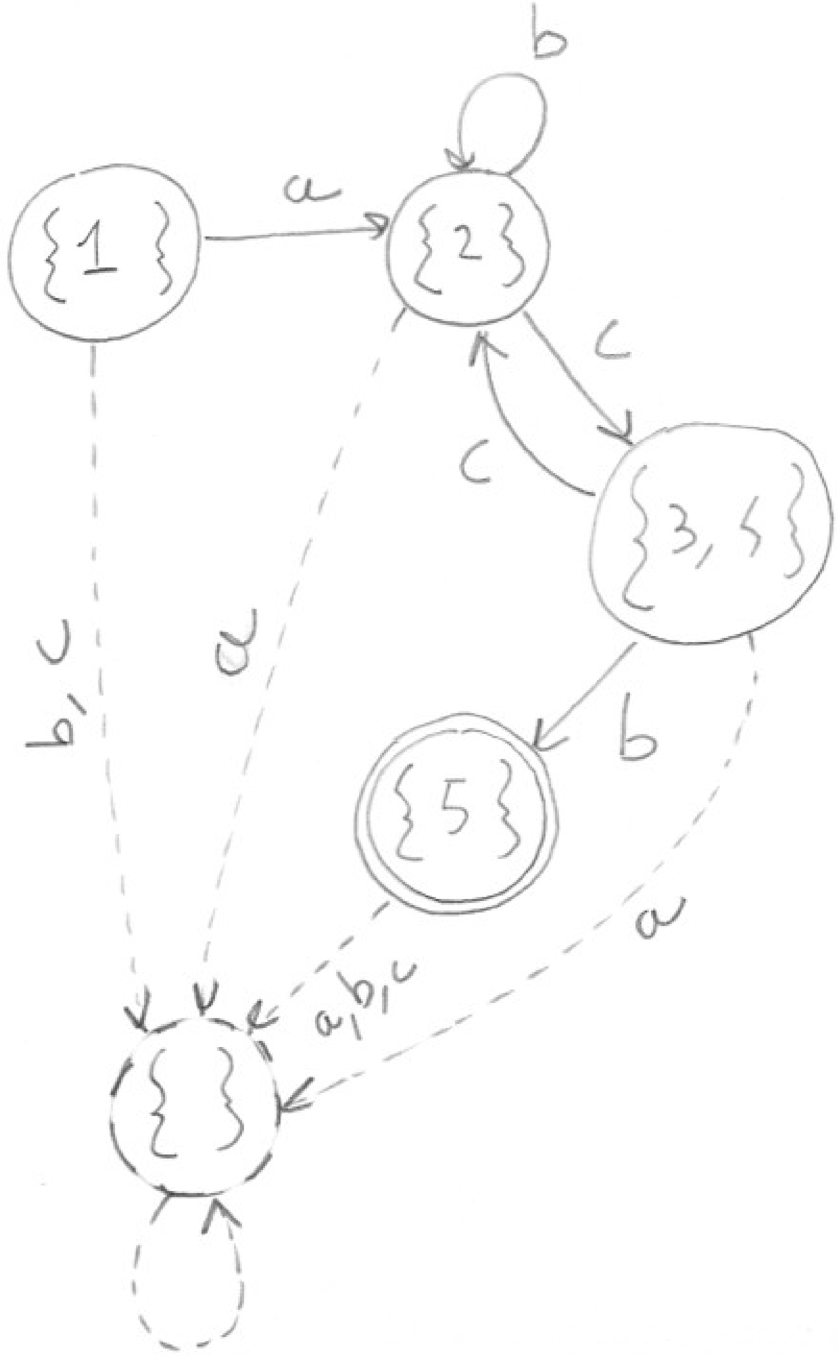


¬ci sono più
ε-transizioni

Se si preferisce . . .







δ

Σ	Q	℘(Q)
a	1	{2}
b	1	$\emptyset$ = { }
c	1	$\emptyset$
a	2	$\emptyset$
b	2	{2}
c	2	{3, 4}
a	3	$\emptyset$
b	3	$\emptyset$
c	3	{2}
a	4	$\emptyset$
b	4	{5}
c	4	$\emptyset$
a	5	$\emptyset$
b	5	$\emptyset$
c	5	$\emptyset$
a	$\emptyset$	$\emptyset$
b	$\emptyset$	$\emptyset$
c	$\emptyset$	$\emptyset$