
Análise Sintática

LR(k)

Análise Sintática LR(K)

O ponto fraco da técnica LL(K) é precisar prever que produção usar com base nos primeiros K *tokens* do lado direito da produção.

A técnica LR(K) posterga a decisão até ter visto todo o lado direito de uma produção, mais os k próximos *tokens* da entrada.

Left-to-right parsing, Rightmost-derivation, K-symbol lookahead

O *parser* tem uma pilha e a entrada.

Os primeiros k *tokens* da entrada formam o *lookahead*

LR Parsing

O *parser* possui uma pilha e a entrada

O primeiros K *tokens* da entrada formam o lookahead

Possui ações a serem executadas:

- SHIFT: move o primeiro *token* para o topo da pilha
- REDUCE:
 - Escolhe uma produção $X \rightarrow ABC$;
 - Desempilha C, B e A
 - Empilha X (GOTO)

LR Parsing

$X \rightarrow A B C$

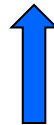
$A \rightarrow \mathbf{a}$

$B \rightarrow \mathbf{b}$

$C \rightarrow \mathbf{c}$

.
.
.
.
.
.
.

entrada: a b c



LR Parsing

$X \rightarrow \cdot A B C$

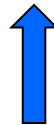
$A \rightarrow \mathbf{a}$

$B \rightarrow \mathbf{b}$

$C \rightarrow \mathbf{c}$

.
.
.
.
.
.
.

entrada: a b c



LR Parsing

$X \rightarrow \bullet A B C$

$A \rightarrow \bullet a$

$B \rightarrow b$

$C \rightarrow c$

.
.
.
.
.
.
.

entrada: a b c



LR Parsing

$X \rightarrow \cdot A B C$

$A \rightarrow \mathbf{a} \cdot$

$B \rightarrow \mathbf{b}$

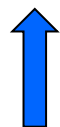
$C \rightarrow \mathbf{c}$

.
.
.
.
.
.
.
.

.
.
.
.
.
.
.
\mathbf{a}

push a (SHIFT)

entrada: a b c



LR Parsing

$X \rightarrow A \cdot B C$

$A \rightarrow \mathbf{a} \cdot$

$B \rightarrow \mathbf{b}$

$C \rightarrow \mathbf{c}$

.
.
.
.
.
.
.
\mathbf{a}

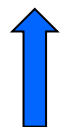
.
.
.
.
.
.
.
.

pop a (REDUCE)

.
.
.
.
.
.
.
A

push A (GOTO)

entrada: a b c



$A \rightarrow \mathbf{a}$

LR Parsing

$X \rightarrow A \cdot B C$

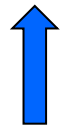
$A \rightarrow \textcolor{red}{a}$

$B \rightarrow \cdot \textcolor{red}{b}$

$C \rightarrow \textcolor{red}{c}$

.
.
.
.
.
.
A

entrada: a b c



$A \rightarrow \textcolor{red}{a}$

LR Parsing

$X \rightarrow A \cdot B C$

$A \rightarrow \mathbf{a}$

$B \rightarrow \mathbf{b} \cdot$

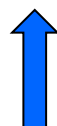
$C \rightarrow \mathbf{c}$

.
.
.
.
.
.
.
A

.
.
.
.
.
.
b
A

push b (SHIFT)

entrada: a b c



$A \rightarrow \mathbf{a}$

LR Parsing

$X \rightarrow AB \cdot C$

$A \rightarrow \mathbf{a}$

$B \rightarrow \mathbf{b} \cdot$

$C \rightarrow \mathbf{c}$

.
.
.
.
.
.
b
<i>A</i>

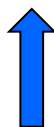
.
.
.
.
.
.
<i>A</i>

pop b (REDUCE)

.
.
.
.
.
.
<i>B</i>
<i>A</i>

push B (GOTO)

entrada: a b c



$B \rightarrow \mathbf{b}$

$A \rightarrow \mathbf{a}$

LR Parsing

$X \rightarrow AB \cdot C$

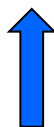
$A \rightarrow \mathbf{a}$

$B \rightarrow \mathbf{b}$

$C \rightarrow \cdot \mathbf{c}$

.
.
.
.
.
<i>B</i>
<i>A</i>

entrada: a b c



$B \rightarrow \mathbf{b}$

$A \rightarrow \mathbf{a}$

LR Parsing

$X \rightarrow AB \cdot C$

$A \rightarrow \mathbf{a}$

$B \rightarrow \mathbf{b}$

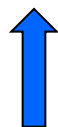
$C \rightarrow \mathbf{c} \cdot$

.
.
.
.
.
B
A

.
.
.
.
\mathbf{c}
B
A

push c (SHIFT)

entrada: a b c



$B \rightarrow \mathbf{b}$

$A \rightarrow \mathbf{a}$

LR Parsing

$X \rightarrow A B C \cdot$

$A \rightarrow \mathbf{a}$

$B \rightarrow \mathbf{b}$

$C \rightarrow \mathbf{c} \cdot$

.
.
.
.
\mathbf{c}
B
A

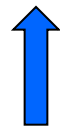
.
.
.
.
B
A

pop c (REDUCE)

.
.
.
.
C
B
A

push C (GOTO)

entrada: a b c



$C \rightarrow \mathbf{c}$

$B \rightarrow \mathbf{b}$

$A \rightarrow \mathbf{a}$

LR Parsing

$X \rightarrow A B C \cdot$

$A \rightarrow \mathbf{a}$

$B \rightarrow \mathbf{b}$

$C \rightarrow \mathbf{c}$

.
.
.
.
C
B
A

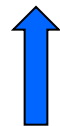
.
.
.
.
.
.
.

pop C
pop B
pop A
(REDUCE)

.
.
.
.
.
.
X

push X (GOTO)

entrada: a b c



$X \rightarrow A B C$

$C \rightarrow \mathbf{c}$

$B \rightarrow \mathbf{b}$

$A \rightarrow \mathbf{a}$

LR Parsing

$X \rightarrow A B C$

$C \rightarrow \mathbf{c}$

$B \rightarrow \mathbf{b}$

$A \rightarrow \mathbf{a}$

X

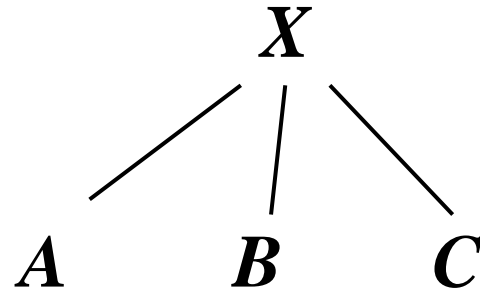
LR Parsing

$X \rightarrow A B C$ 

$C \rightarrow c$

$B \rightarrow b$

$A \rightarrow a$



$X \rightarrow A B C$

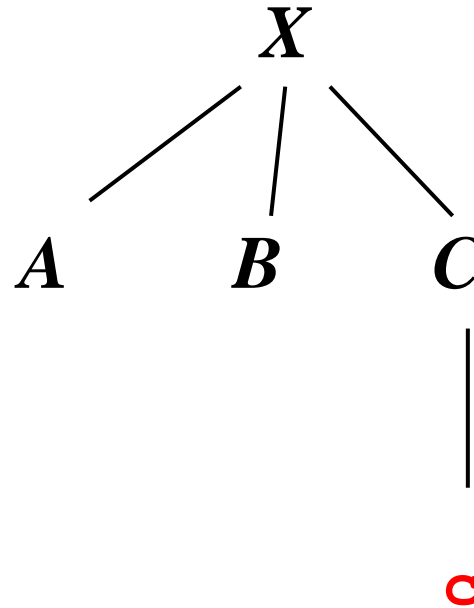
LR Parsing

$X \rightarrow A B C$

$C \rightarrow \mathbf{c}$ 

$B \rightarrow \mathbf{b}$

$A \rightarrow \mathbf{a}$



$X \rightarrow A B C \rightarrow A B \mathbf{c}$

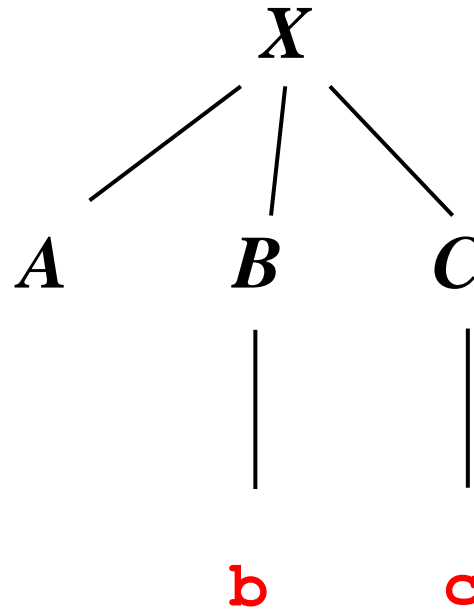
LR Parsing

$X \rightarrow A B C$

$C \rightarrow c$

$B \rightarrow b$ 

$A \rightarrow a$



$X \rightarrow A B C \rightarrow A B c \rightarrow A b c$

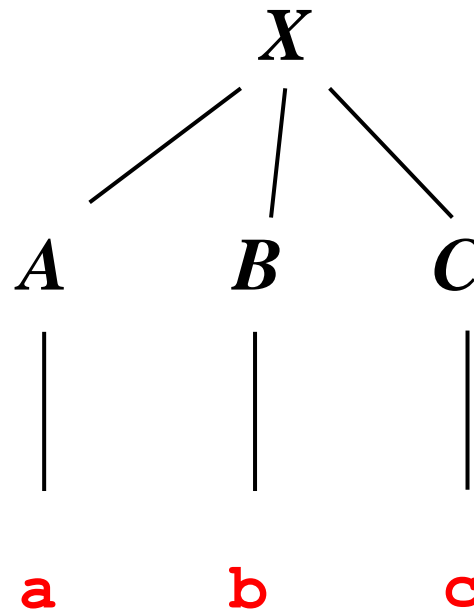
LR Parsing

$X \rightarrow A B C$

$C \rightarrow c$

$B \rightarrow b$

$A \rightarrow a$ 



$X \rightarrow A B C \rightarrow A B c \rightarrow A b c \rightarrow abc$

LR Parsing - Exemplo

0. $S' \rightarrow S\textcolor{red}{\$}$

1. $S \rightarrow S\textcolor{red}{; } S$

2. $S \rightarrow \textcolor{red}{id} \textcolor{red}{:=} E$

3. $S \rightarrow \textcolor{red}{print}(L)$

4. $E \rightarrow \textcolor{red}{id}$

5. $E \rightarrow \textcolor{red}{num}$

6. $E \rightarrow E\textcolor{red}{+} E$

7. $E \rightarrow (\textcolor{red}{S}, E)$

8. $L \rightarrow E$

9. $L \rightarrow L\textcolor{red}{,} E$

Derivação para:

`a := 7; b := c + (d := 5 + 6, d) $`

LR Parsing - Exemplo

0. $S' \rightarrow S\$$
1. $S \rightarrow S; S$
2. $S \rightarrow \text{id} := E$
3. $S \rightarrow \text{print}(L)$
4. $E \rightarrow \text{id}$
5. $E \rightarrow \text{num}$
6. $E \rightarrow E + E$
7. $E \rightarrow (S, E)$
8. $L \rightarrow E$
9. $L \rightarrow L, E$

Stack	Input	Action
1	a := 7 ; b := c + (d := 5 + 6 , d) \$	shift
1 id ₄	:= 7 ; b := c + (d := 5 + 6 , d) \$	shift
1 id ₄ := 6	7 ; b := c + (d := 5 + 6 , d) \$	shift
1 id ₄ := 6 num ₁₀	; b := c + (d := 5 + 6 , d) \$	reduce E → num
1 id ₄ := 6 E ₁₁	; b := c + (d := 5 + 6 , d) \$	reduce S → id := E
1 S ₂	; b := c + (d := 5 + 6 , d) \$	shift
1 S ₂ ; 3	b := c + (d := 5 + 6 , d) \$	shift
1 S ₂ ; 3 id ₄	:= c + (d := 5 + 6 , d) \$	shift
1 S ₂ ; 3 id ₄ := 6	c + (d := 5 + 6 , d) \$	shift
1 S ₂ ; 3 id ₄ := 6 id ₂₀	+ (d := 5 + 6 , d) \$	reduce E → id
1 S ₂ ; 3 id ₄ := 6 E ₁₁	+ (d := 5 + 6 , d) \$	shift
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16	(d := 5 + 6 , d) \$	shift
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8	d := 5 + 6 , d) \$	shift
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 id ₄	:= 5 + 6 , d) \$	shift
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 id ₄ := 6	5 + 6 , d) \$	shift
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 id ₄ := 6 num ₁₀	+ 6 , d) \$	reduce E → num
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 id ₄ := 6 E ₁₁	+ 6 , d) \$	shift
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 id ₄ := 6 E ₁₁ + 16	6 , d) \$	shift
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 id ₄ := 6 E ₁₁ + 16 num ₁₀	, d) \$	reduce E → num
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 id ₄ := 6 E ₁₁ + 16 E ₁₇	, d) \$	reduce E → E + E
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 id ₄ := 6 E ₁₁	, d) \$	reduce S → id := E
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 S ₁₂	, d) \$	shift
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 S ₁₂ , 18	d) \$	shift
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 S ₁₂ , 18 id ₂₀	) \$	reduce E → id
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 S ₁₂ , 18 E ₂₁	) \$	shift
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 (8 S ₁₂ , 18 E ₂₁) 22	\$	reduce E → (S, E)
1 S ₂ ; 3 id ₄ := 6 E ₁₁ + 16 E ₁₇	\$	reduce E → E + E
1 S ₂ ; 3 id ₄ := 6 E ₁₁	\$	reduce S → id := E
1 S ₂ ; 3 S ₅	\$	reduce S → S; S
1 S ₂	\$	accept

LR Parsing Engine

Como o *parser* sabe quando fazer um shift ou um reduce?

LR Parsing Engine

Como o *parser* sabe quando fazer um shift ou um reduce?

Usando um autômato de pilha!

As arestas são nomeadas com os símbolos que podem aparecer na pilha

4 tipos de ações:

s*n*: Shift para o estado *n*;

g*n*: Vá para o estado *n*;

r*k*: Reduza pela regra *k*;

a: Accept;

: Error (entrada em branco).

As arestas do DFA são as ações shift e goto

No exemplo anterior, cada número indica o estado destino

LR Parsing Engine

	id	num	print	;	,	+	:=	(	)	\$	<i>S</i>	<i>E</i>	<i>L</i>
1	s4		s7								g2		
2				s3						a			
3	s4		s7								g5		
4						s6							
5				r1	r1					r1			
6	s20	s10						s8				g11	
7								s9					
8	s4		s7								g12		
9	s20	s10						s8				g15	g14
10				r5	r5	r5			r5	r5			
11				r2	r2	s16				r2			
12				s3	s18								
13				r3	r3					r3			
14					s19				s13				
15					r8				r8				
16	s20	s10						s8				g17	
17				r6	r6	s16			r6	r6			
18	s20	s10						s8				g21	
19	s20	s10						s8				g23	
20				r4	r4	r4			r4	r4			
21								s22					
22				r7	r7	r7			r7	r7			
23					r9	s16			r9				

Geração de Parsers LR(0)

LR(0) são as gramáticas que podem ser analisadas olhando somente a pilha.

- $S' \rightarrow S\$$
 1. $S \rightarrow (L)$
 2. $S \rightarrow x$
 3. $L \rightarrow S$
 4. $L \rightarrow L, S$

Estados

- $S' \rightarrow S\$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

$$\begin{array}{l} S' \rightarrow .S\$ \\ S \rightarrow .x \\ S \rightarrow .(L) \end{array}^1$$

- *Estado Inicial*

$$S \rightarrow x.^2$$

- *Shift de “x” e “(“*
- Estado 2 permite reduce

$$\begin{array}{l} S \rightarrow (.L) \\ L \rightarrow .L, S \\ L \rightarrow .S \\ S \rightarrow .(L) \\ S \rightarrow .x \end{array}^3$$

$$S' \rightarrow S.^4$$

Goto Action:

- Imagine um shift de x ou “(“ no estado 1 seguido de redução pela produção de S correspondente.
- Todos os símbolos do lado direito da produção serão desempilhados e o parser vai executar um goto para S no estado 1.
- Isso se representa movendo-se o ponto para após o S e colocando este item em um novo estado (4)

$$\boxed{S' \rightarrow S.\4$

Algoritmos

- **Closure(I):** adiciona itens a um estado quando um “.” precede um não terminal
- **Goto(I, X):** movimenta o “.” para depois de X em todos os itens

```
Closure ( $I$ ) =  
  repeat  
    for any item  $A \rightarrow \alpha.X\beta$  in  $I$   
      for any production  $X \rightarrow \gamma$   
         $I \leftarrow I \cup \{X \rightarrow .\gamma\}$   
  until  $I$  does not change.  
  return  $I$ 
```

```
Goto ( $I, X$ ) =  
  set  $J$  to the empty set  
  for any item  $A \rightarrow \alpha.X\beta$  in  $I$   
    add  $A \rightarrow \alpha X.\beta$  to  $J$   
  return Closure ( $J$ )
```

Algoritmos

Construção do parser LR(0)

```
Initialize  $T$  to  $\{\mathbf{Closure}(\{S' \rightarrow .S\})\}$ 
Initialize  $E$  to empty.
repeat
  for each state  $I$  in  $T$ 
    for each item  $A \rightarrow \alpha.X\beta$  in  $I$ 
      let  $J$  be  $\mathbf{Goto}(I, X)$ 
       $T \leftarrow T \cup \{J\}$ 
       $E \leftarrow E \cup \{I \xrightarrow{X} J\}$ 
until  $E$  and  $T$  did not change in this iteration
```

```
 $R \leftarrow \{\}$ 
for each state  $I$  in  $T$ 
  for each item  $A \rightarrow \alpha.$ 
     $R \leftarrow R \cup \{I, A \rightarrow \alpha\}$ 
```

Exemplo

$$S' \rightarrow . S \$$$

- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo

$$S' \rightarrow . S \$$$

$$S \rightarrow . (L)$$

$$S \rightarrow . x$$

- $S' \rightarrow S \$$

1. $S \rightarrow (L)$

2. $S \rightarrow x$

3. $L \rightarrow S$

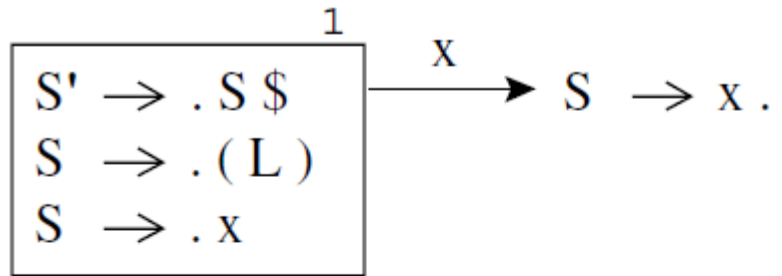
4. $L \rightarrow L, S$

Exemplo

$$\begin{array}{l} S' \rightarrow . S \$ \\ S \rightarrow . (L) \\ S \rightarrow . x \end{array}$$

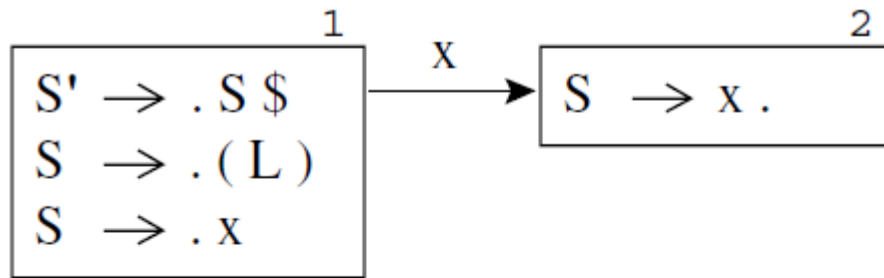
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



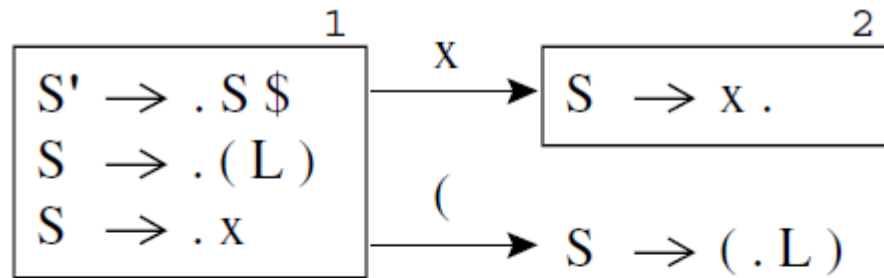
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



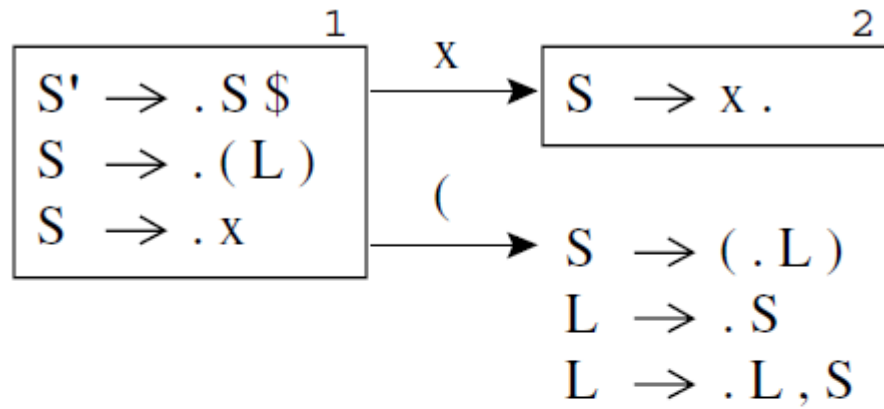
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



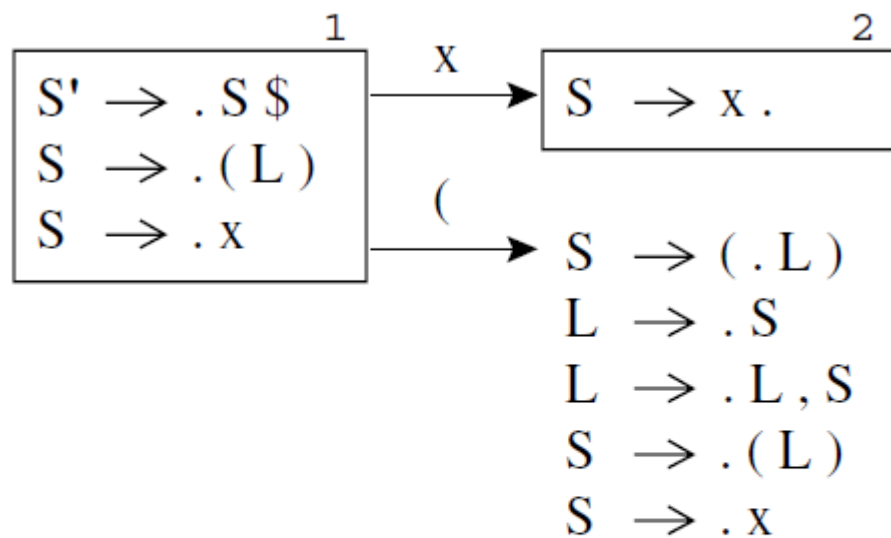
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



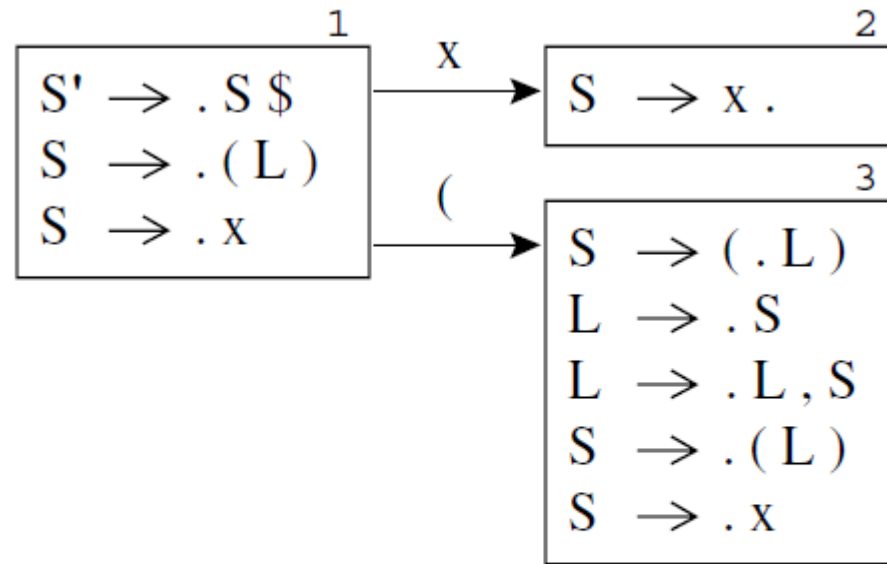
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



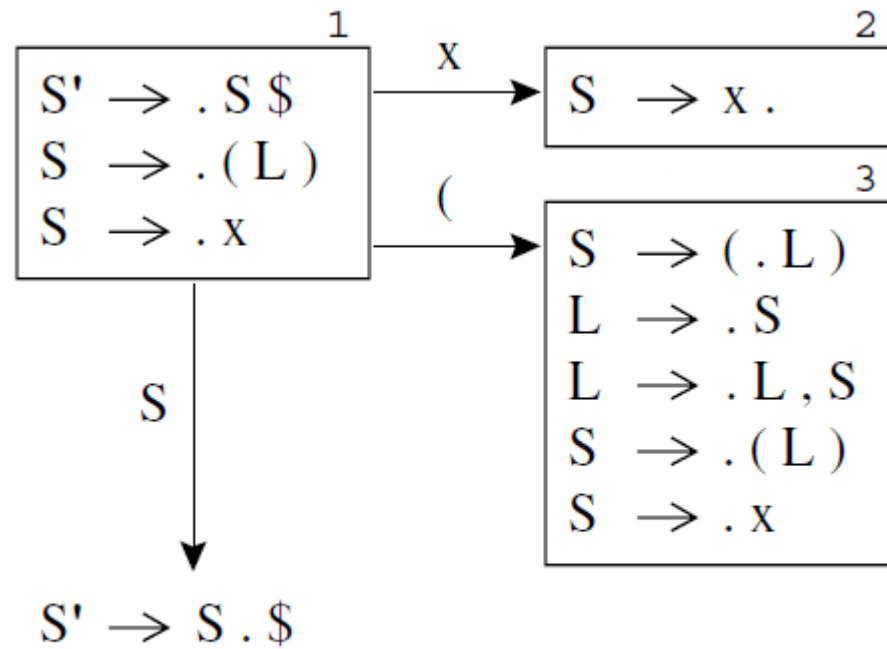
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



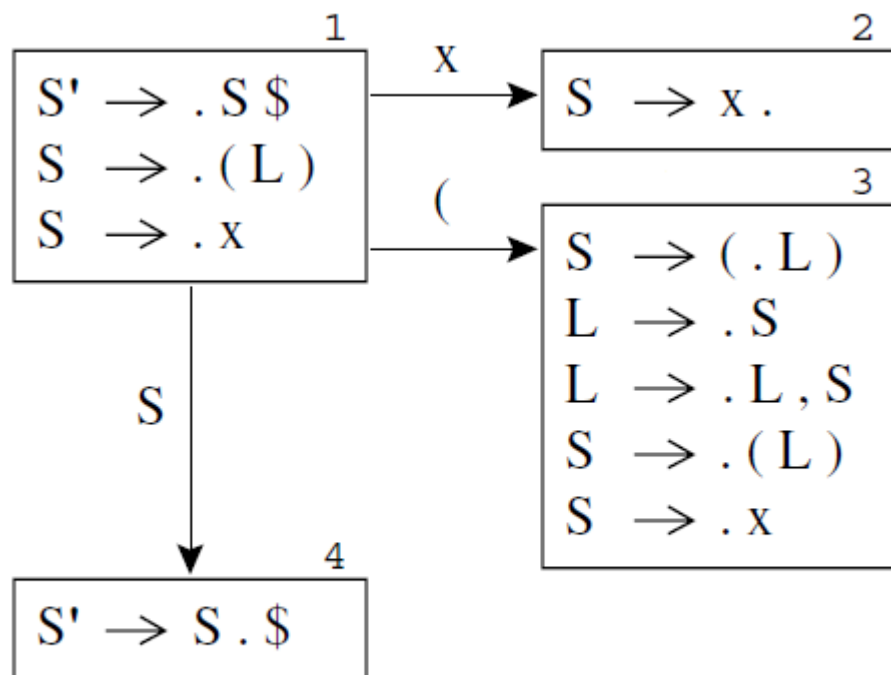
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



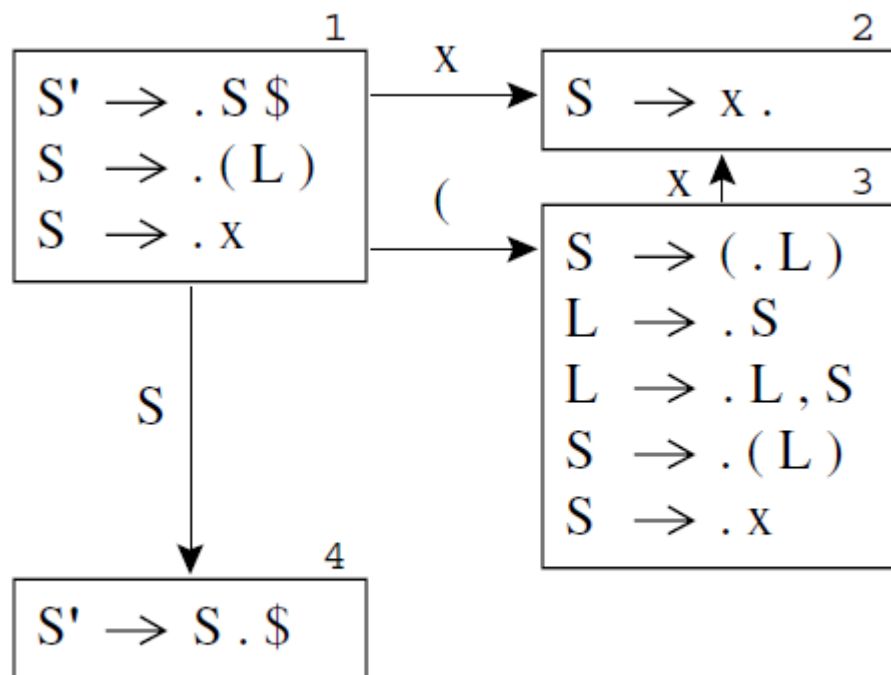
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



- $S' \rightarrow S\$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



- $S' \rightarrow S \$$

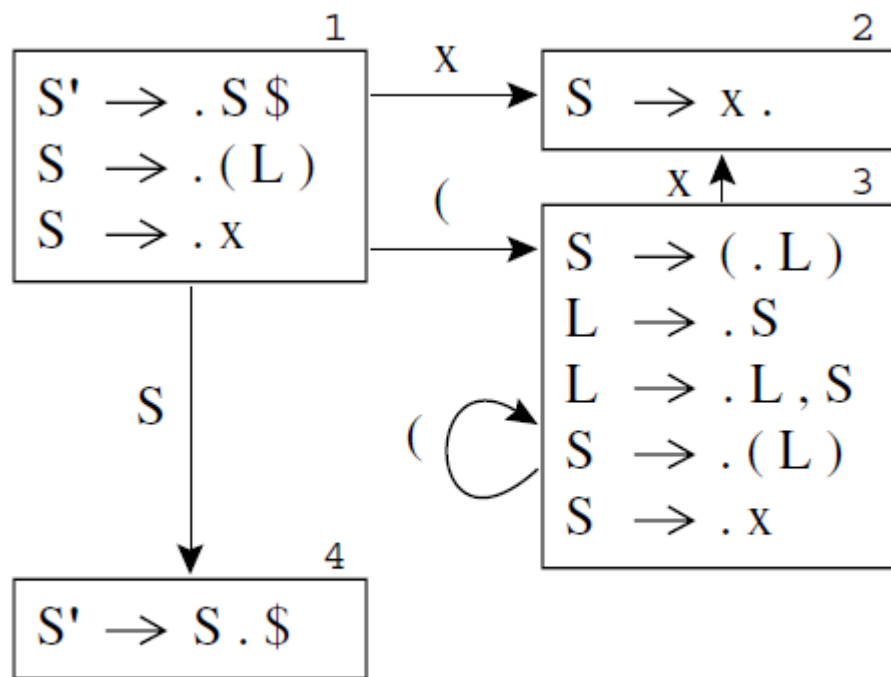
1. $S \rightarrow (L)$

2. $S \rightarrow x$

3. $L \rightarrow S$

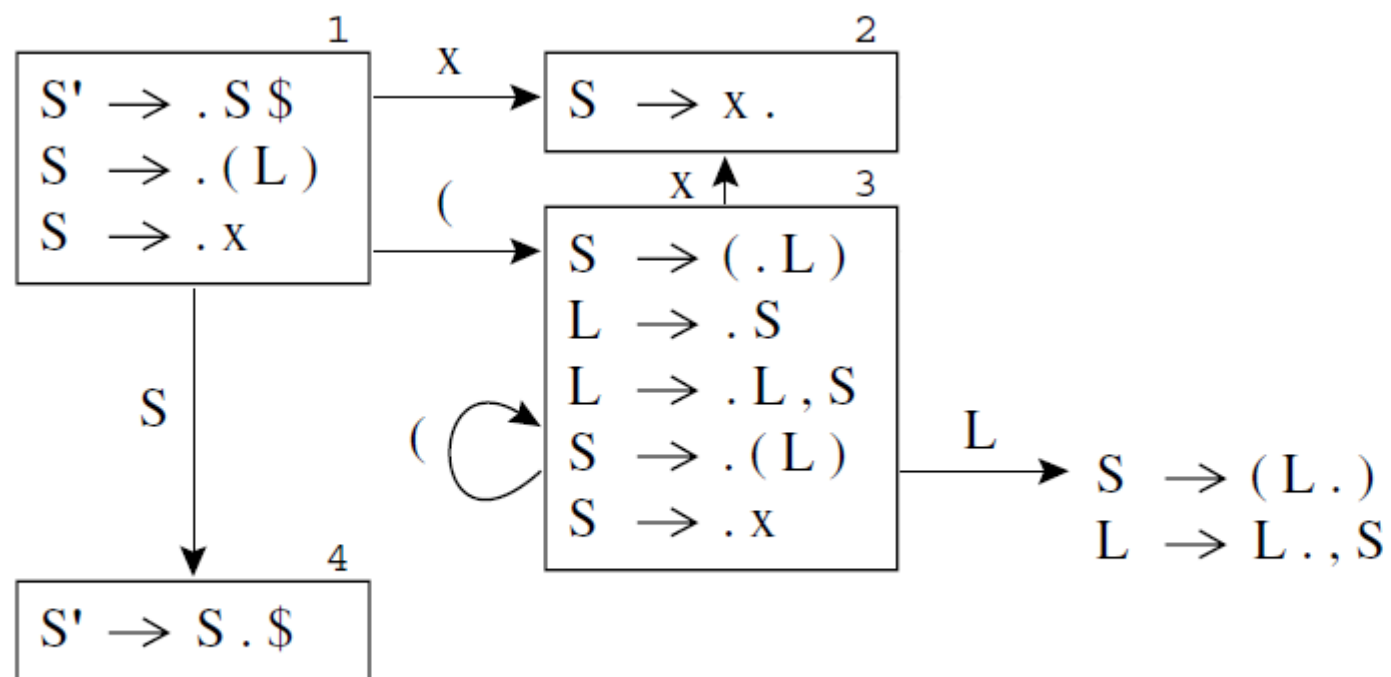
4. $L \rightarrow L, S$

Exemplo



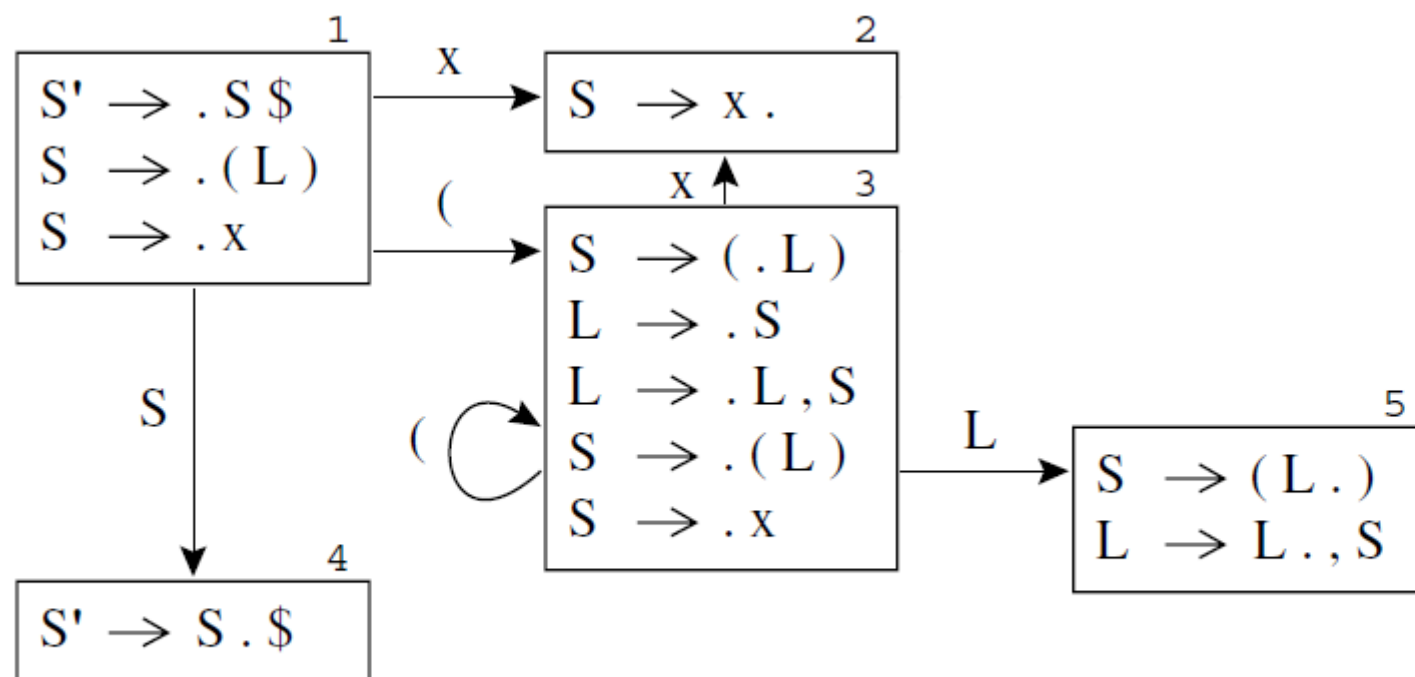
- $S' \rightarrow S\$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



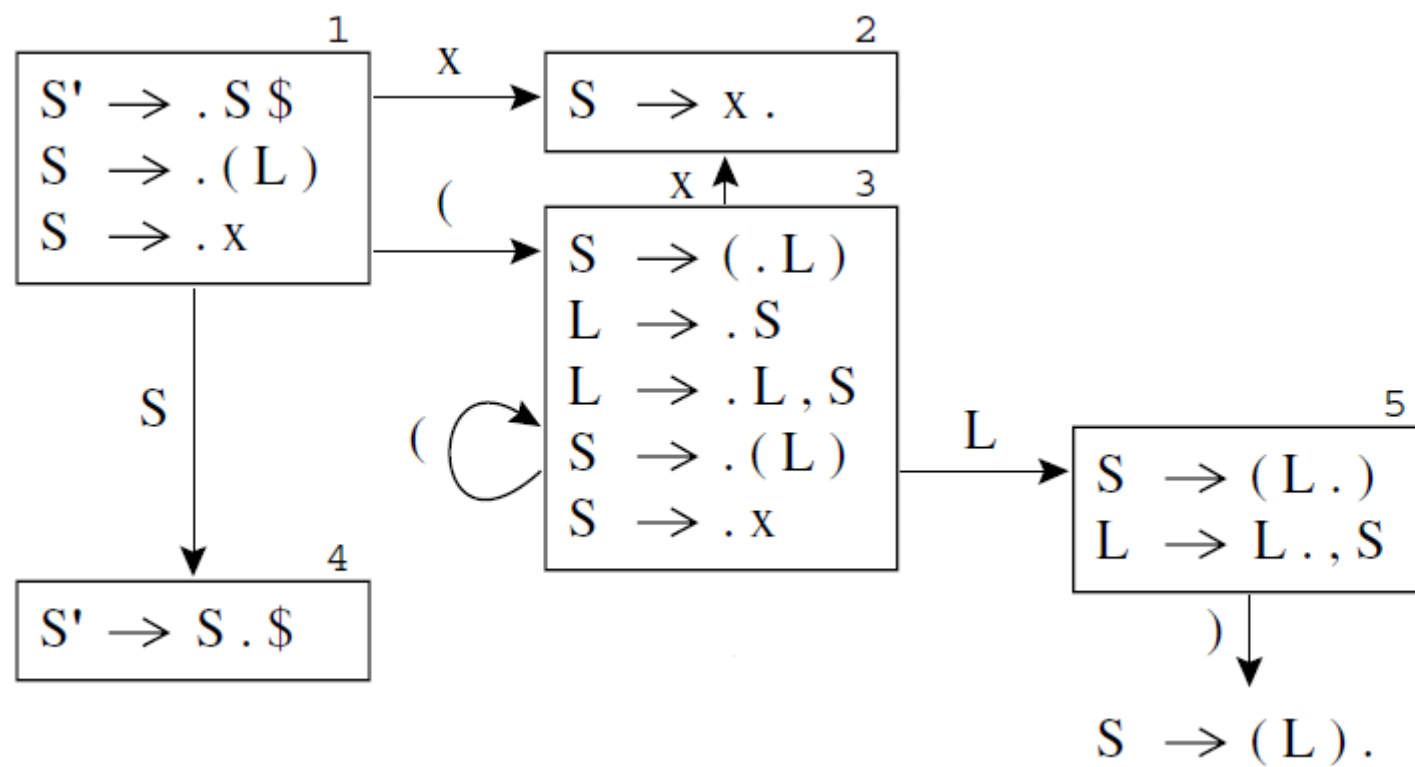
- $S' \rightarrow S\$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



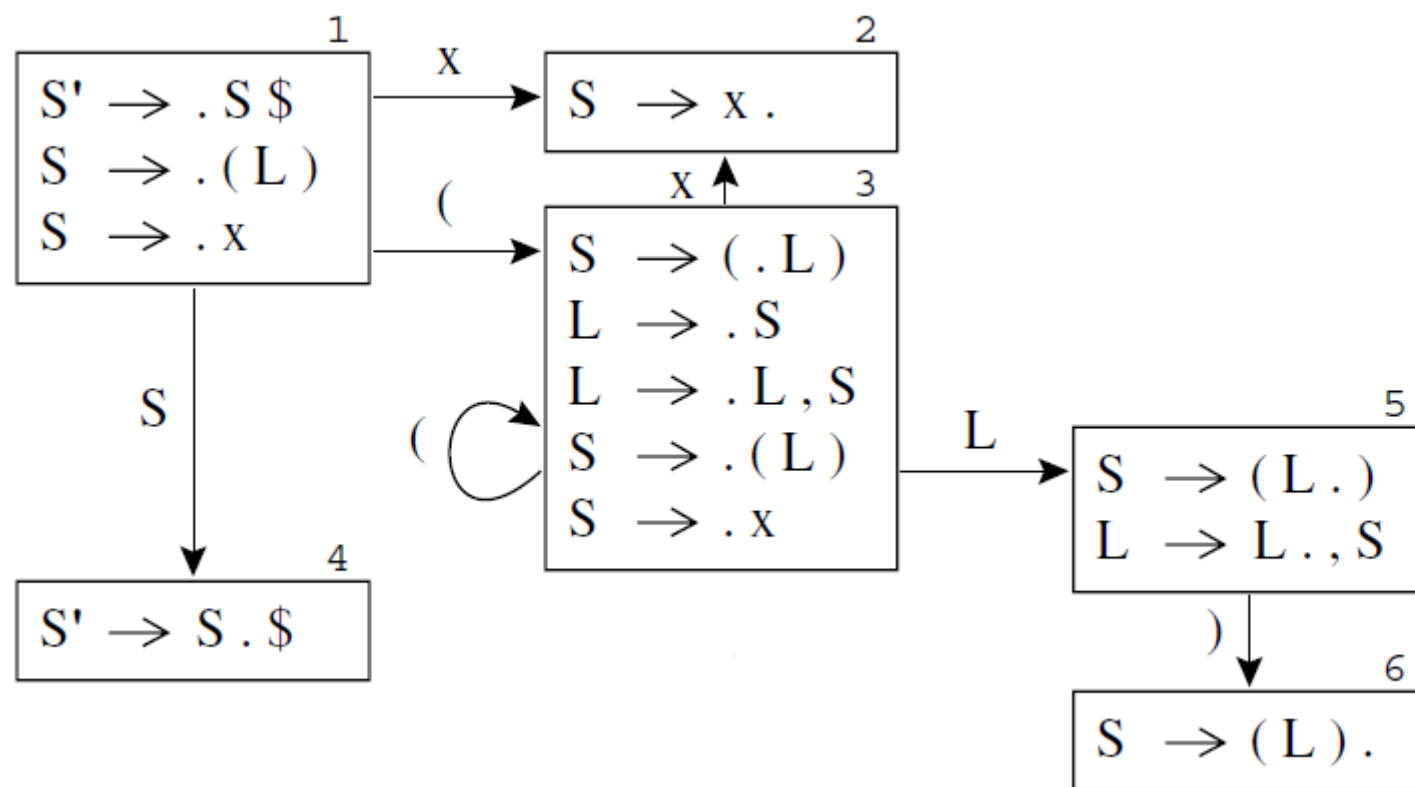
- $S' \rightarrow S\$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



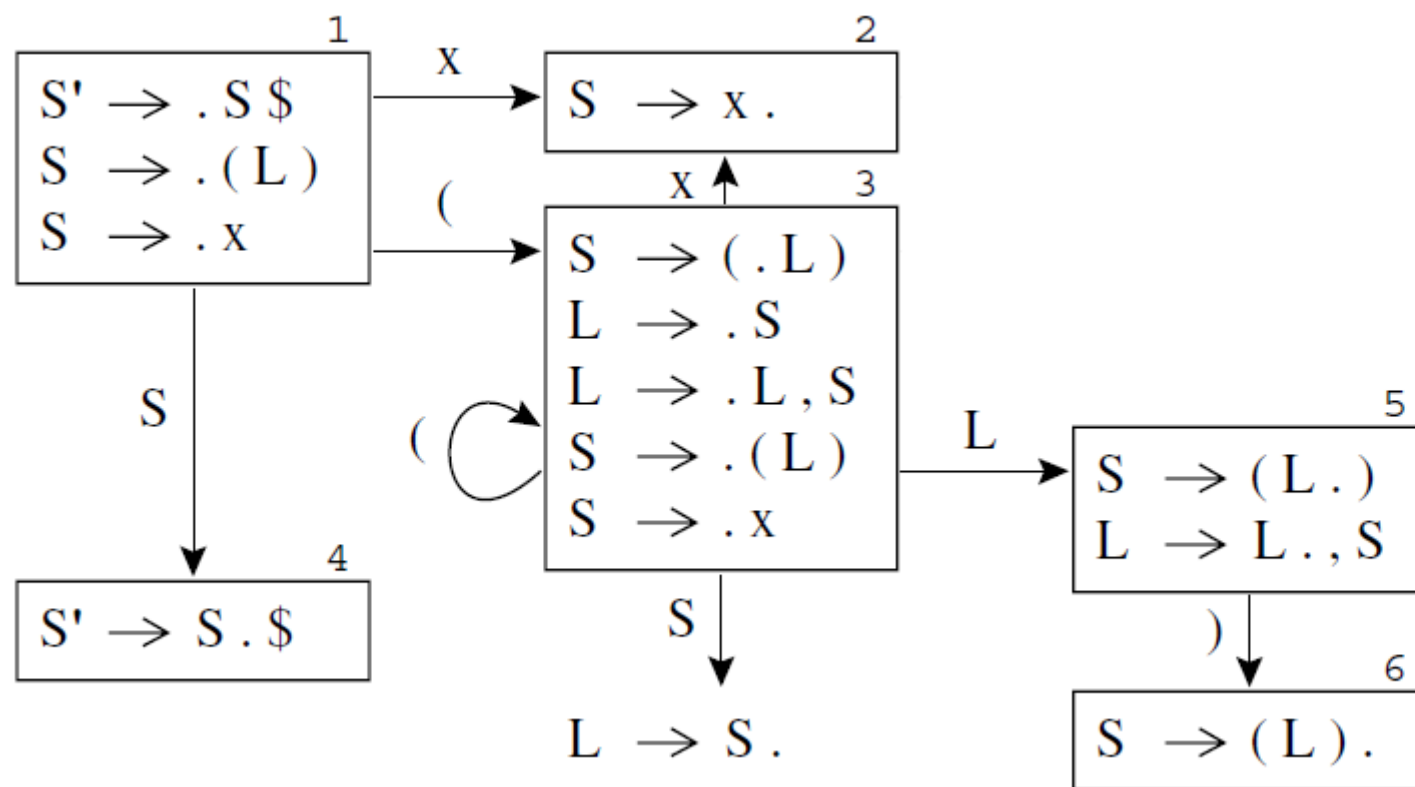
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



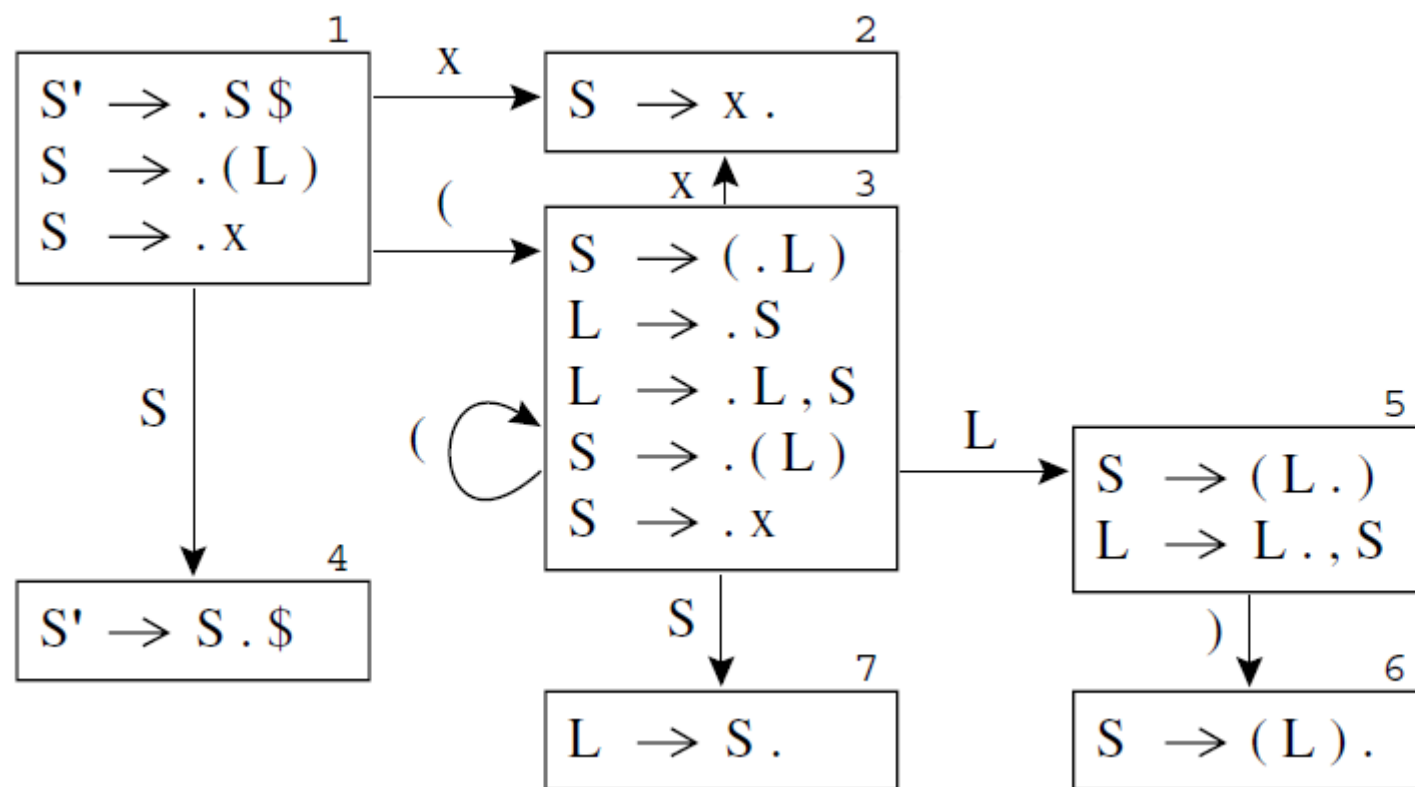
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow X$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



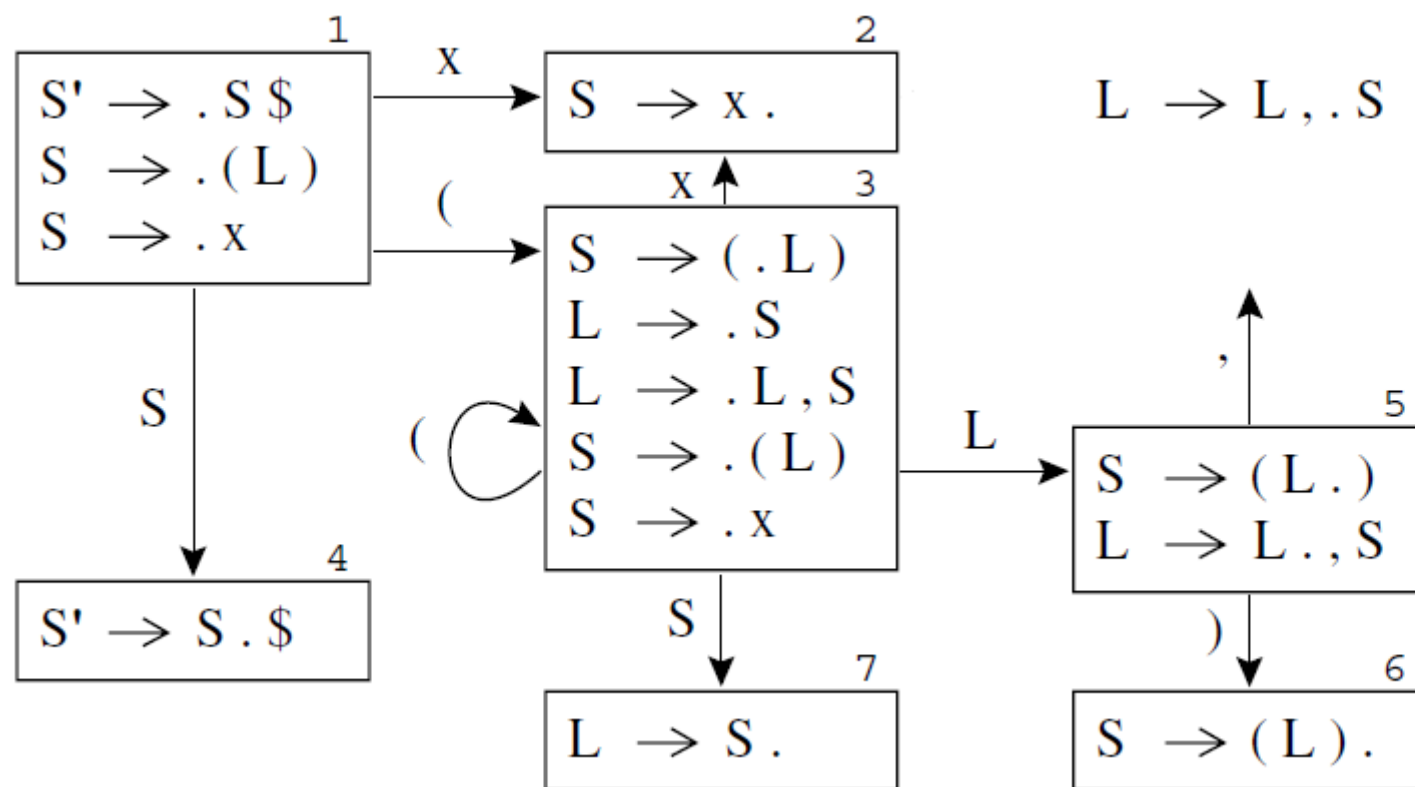
- $S' \rightarrow S\$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



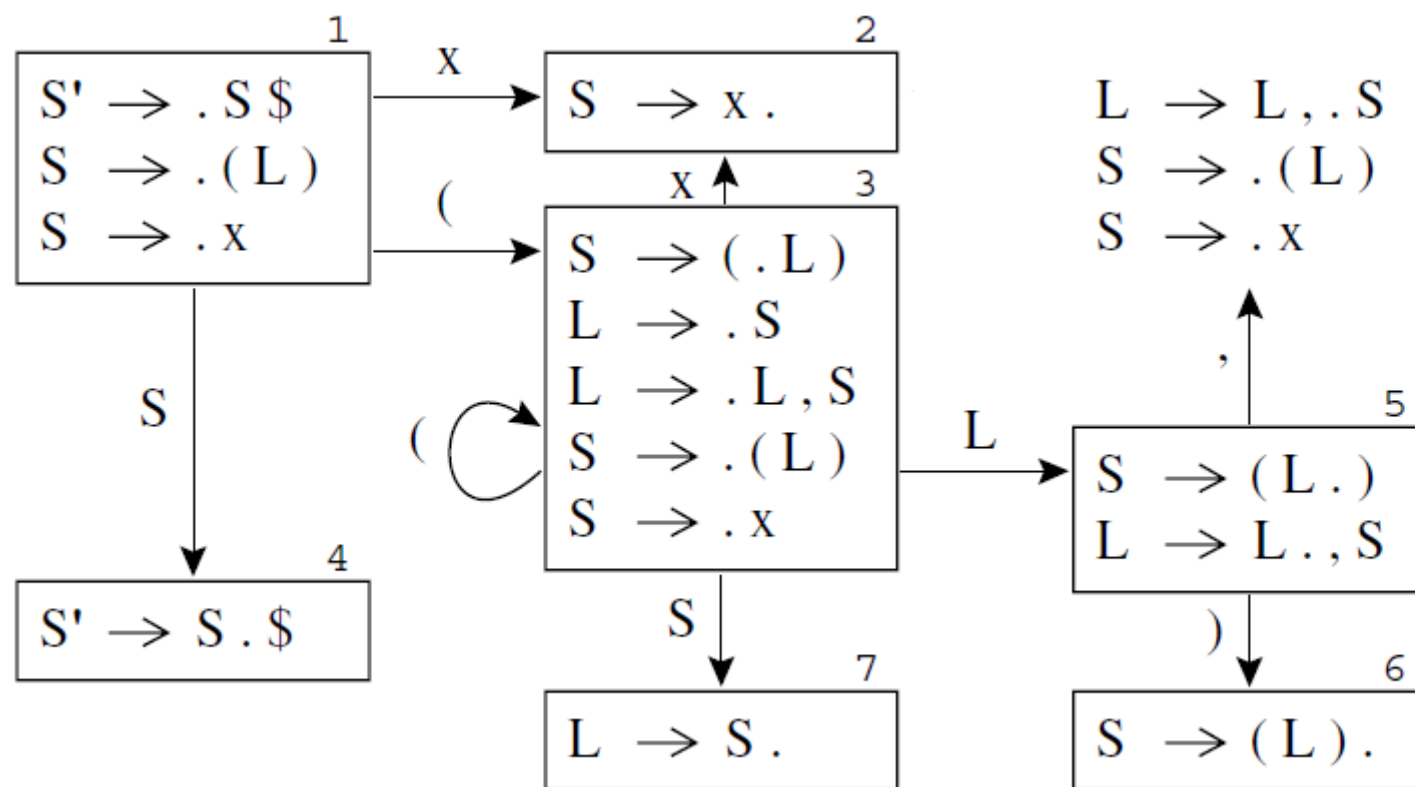
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



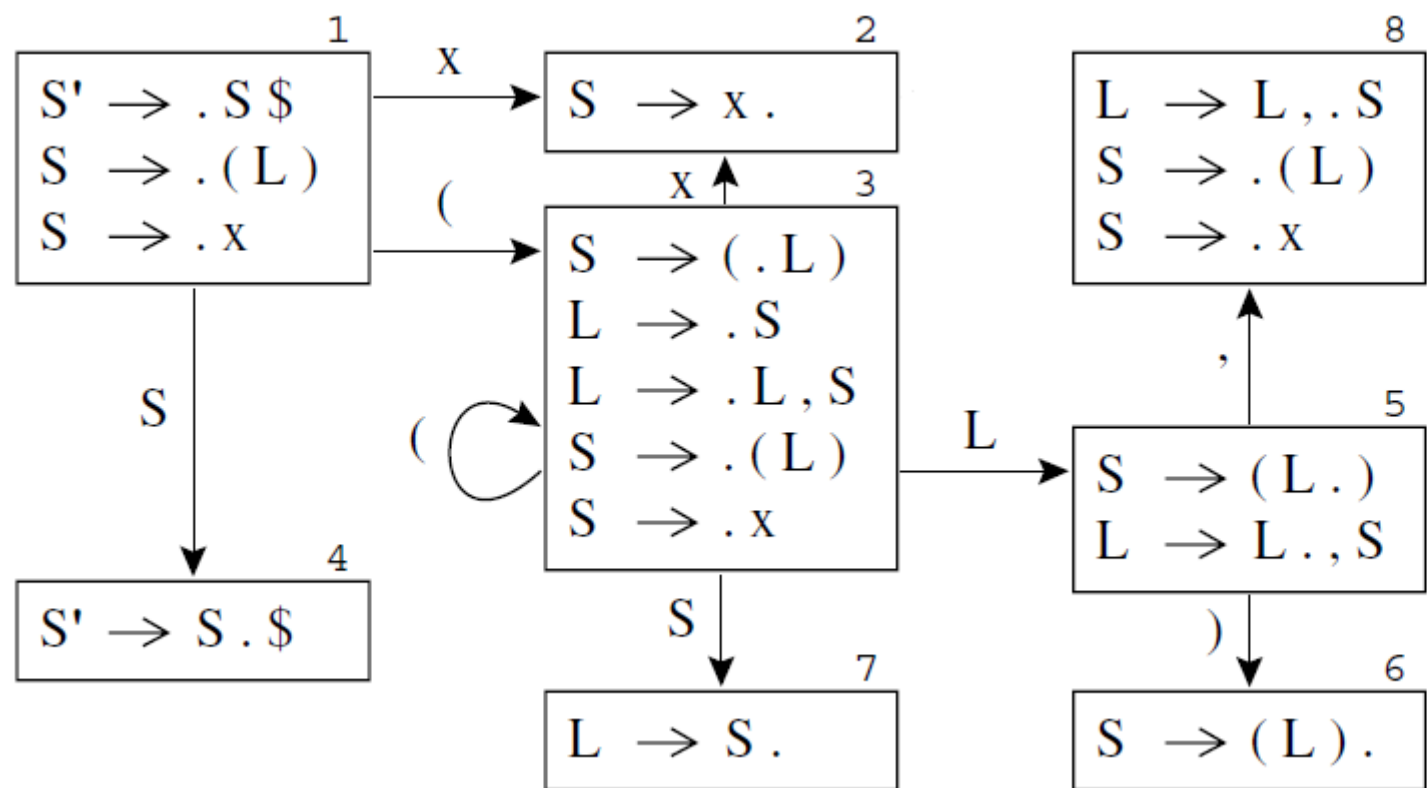
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



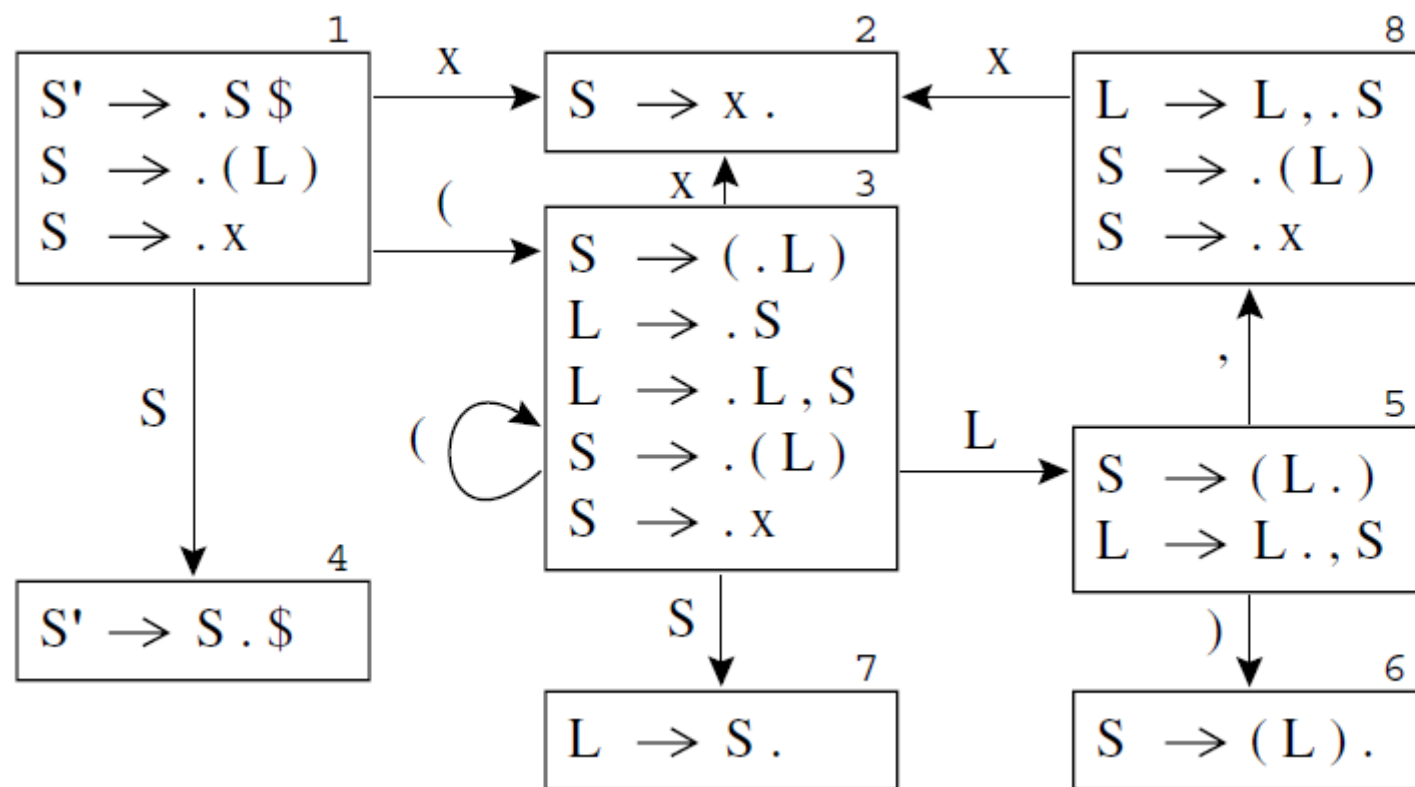
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow X$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



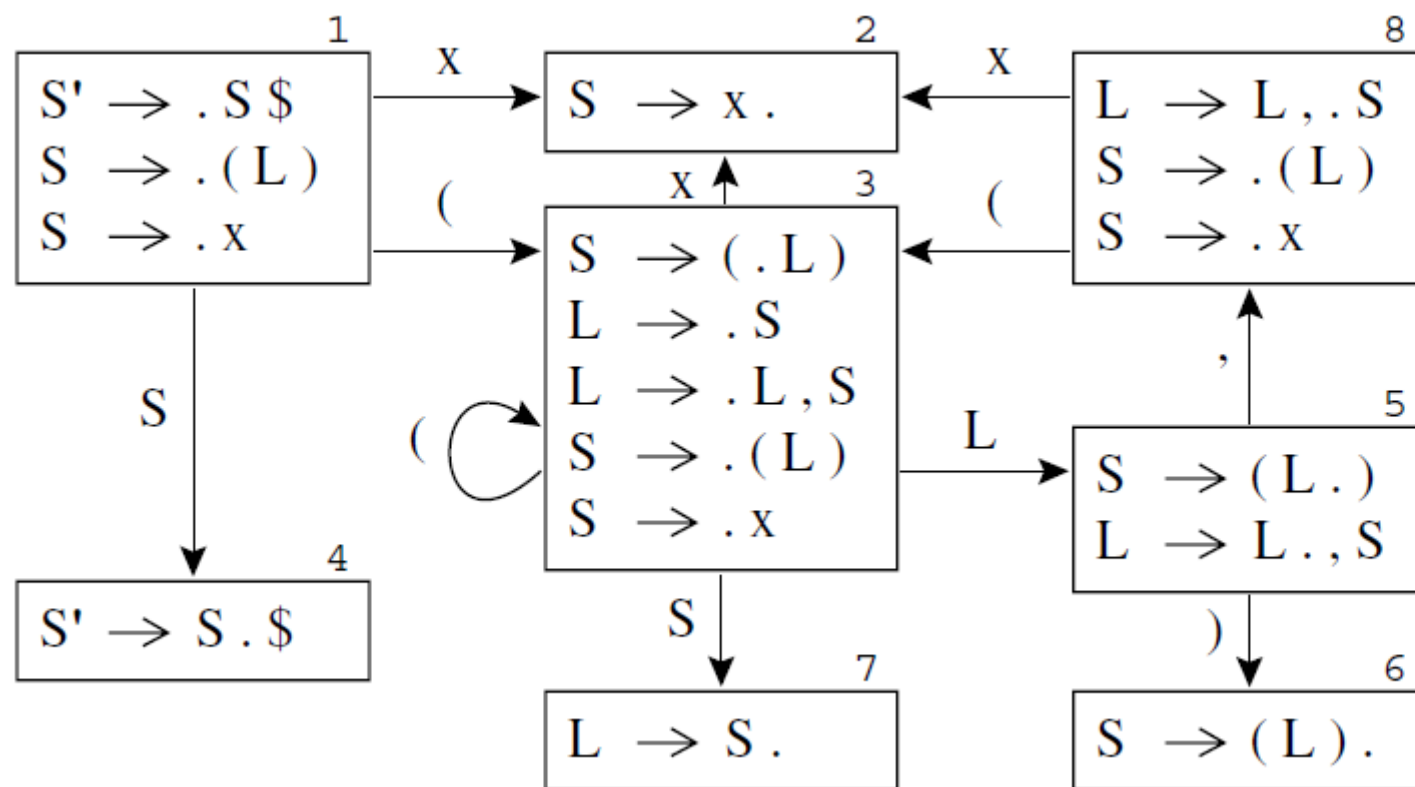
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow X$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



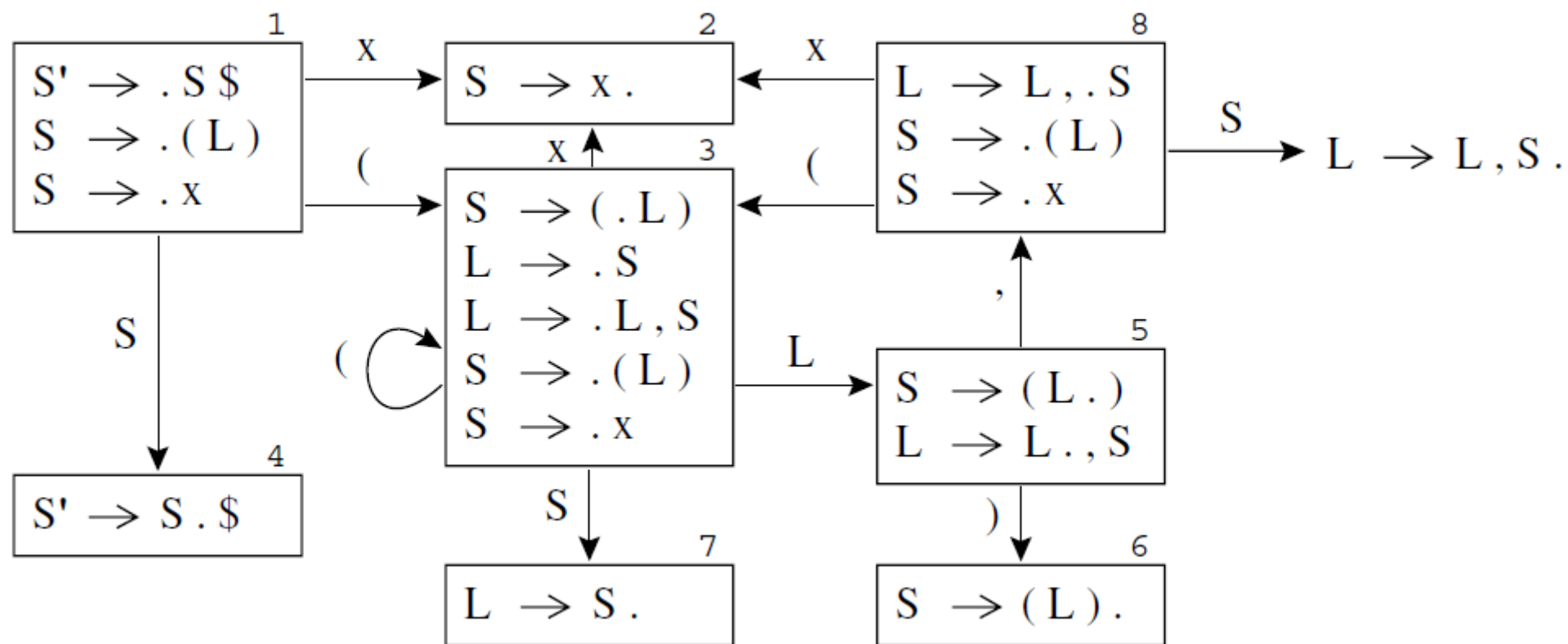
- $S' \rightarrow S\$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



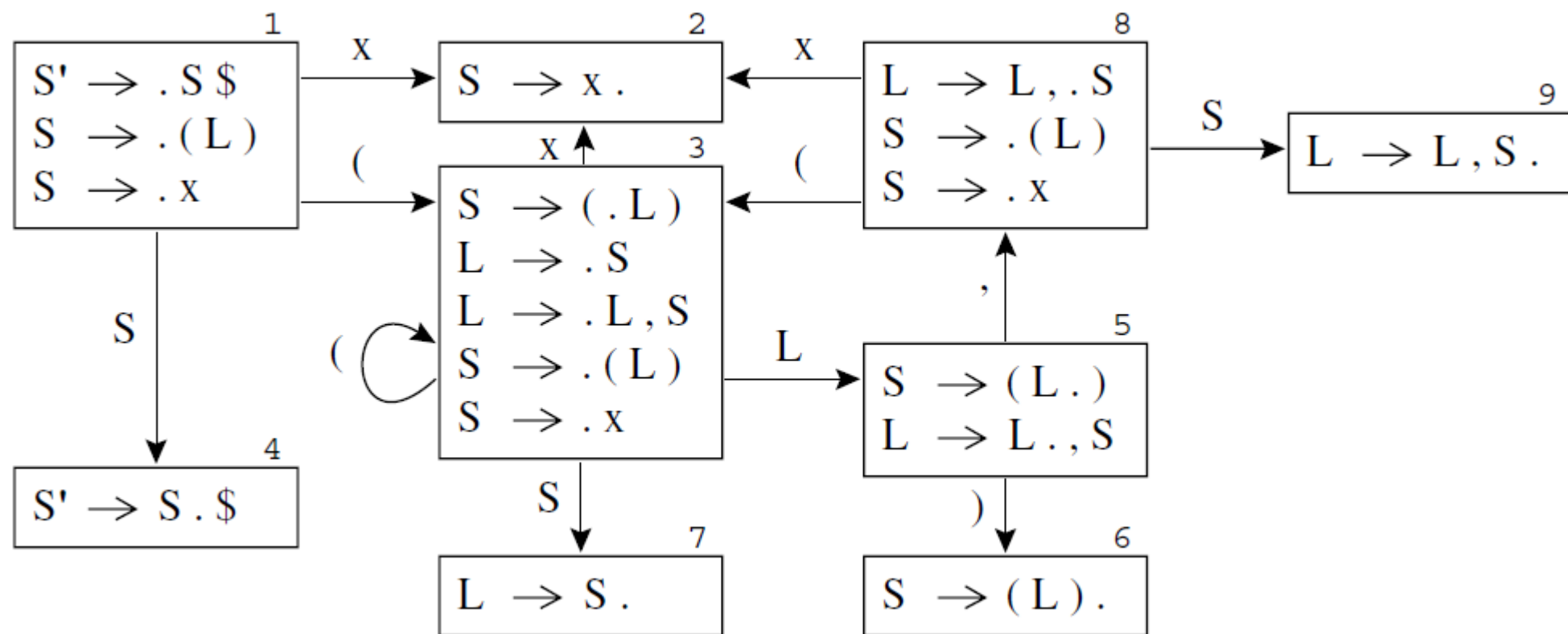
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



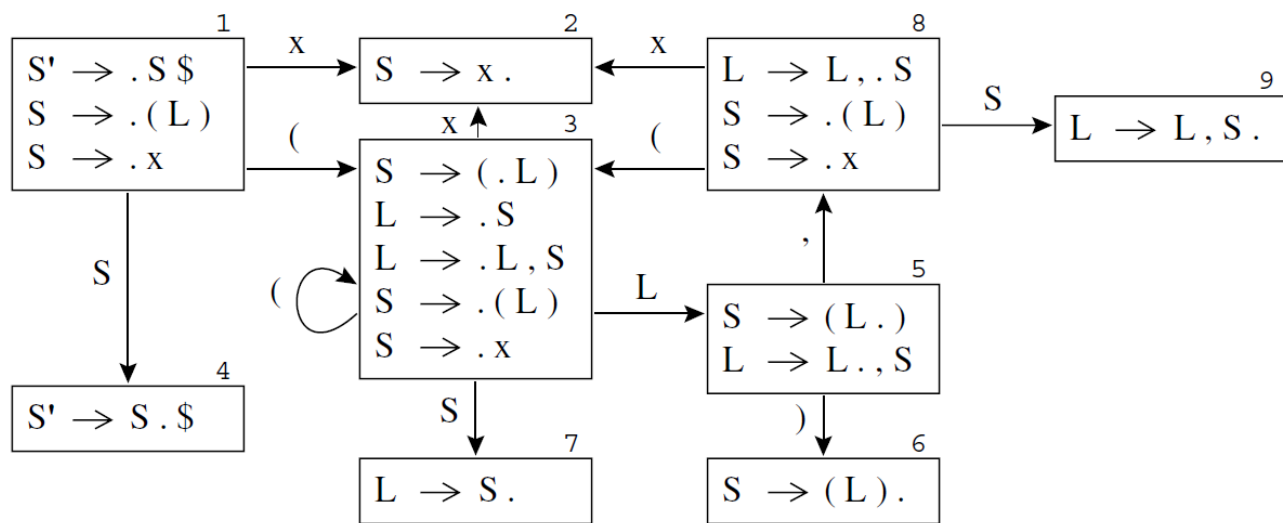
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



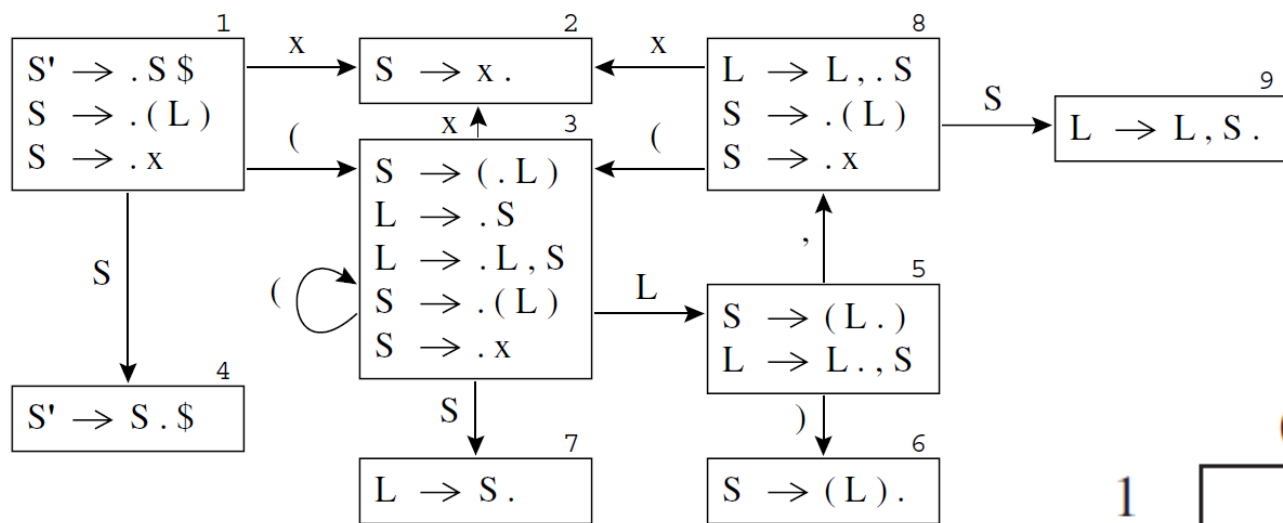
- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow X$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

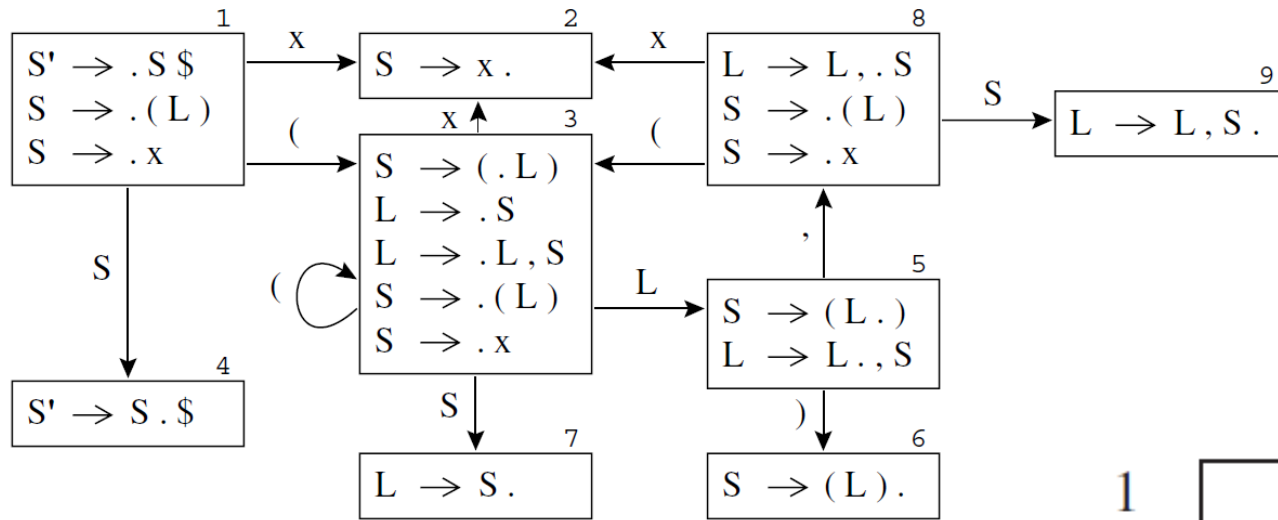
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	$($	$)$	x	$,$	$\$$	S	L
1							
2							
3							
4							
5							
6							
7							
8							
9							

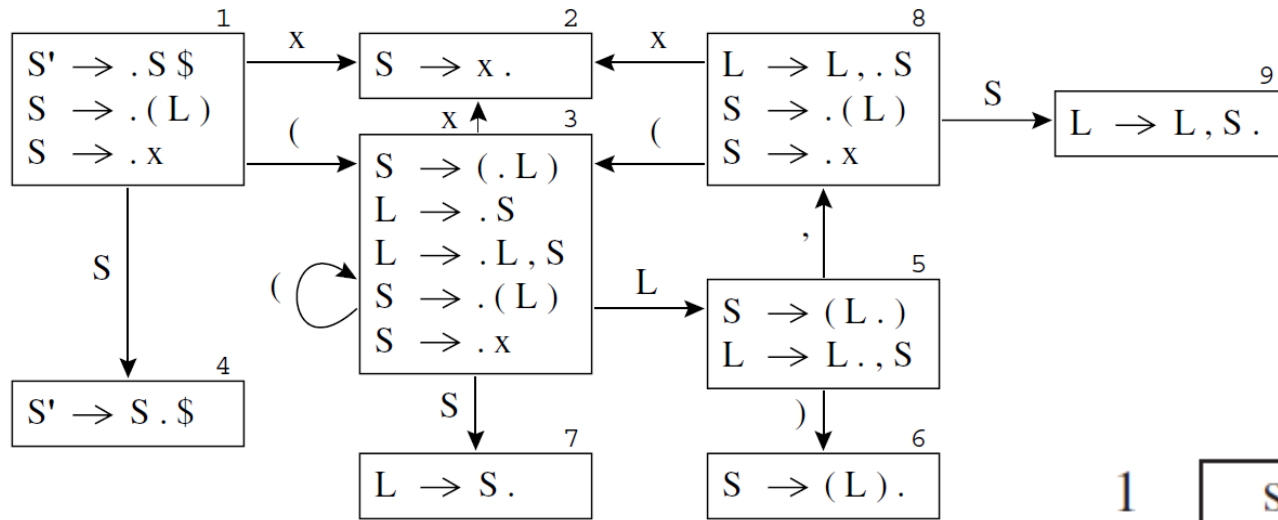
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	S	L
1			s2				
2							
3							
4							
5							
6							
7							
8							
9							

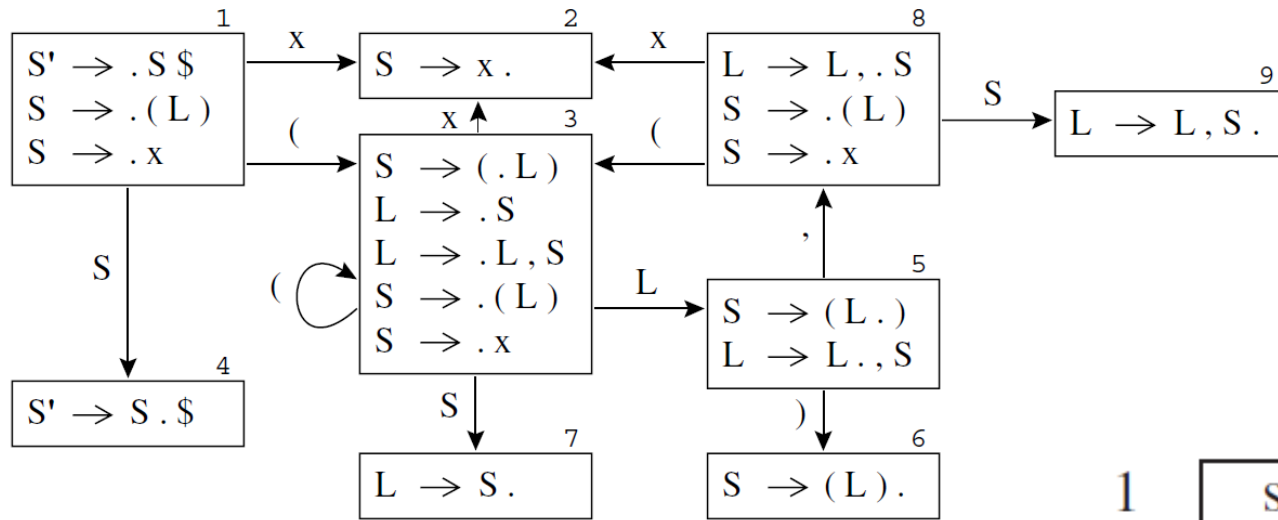
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	$($	$)$	x	$,$	$\$$	S	L
1	s3		s2				
2							
3							
4							
5							
6							
7							
8							
9							

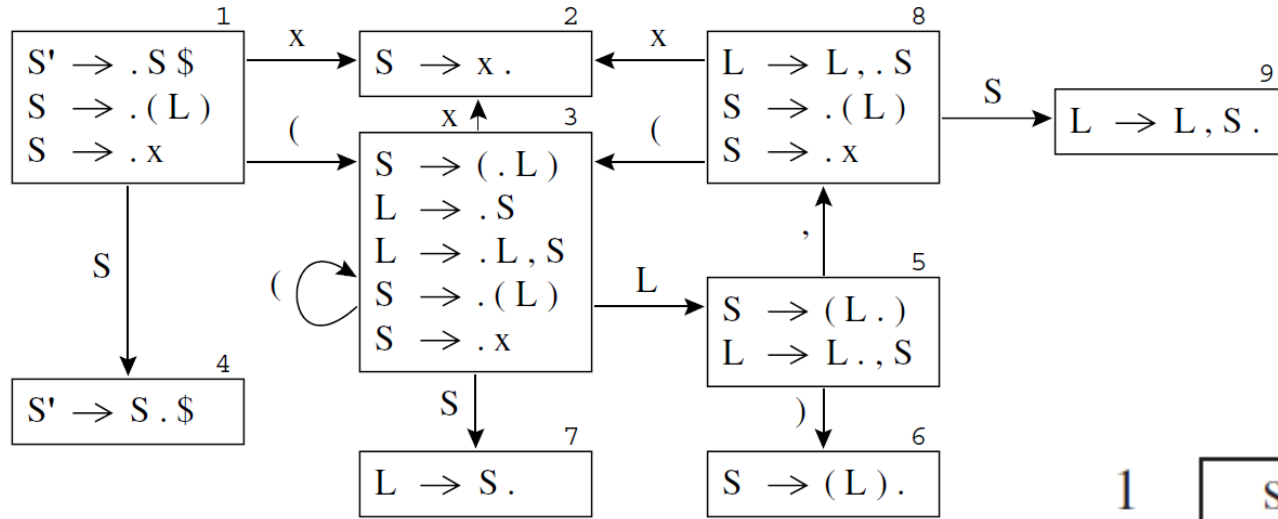
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2							
3							
4							
5							
6							
7							
8							
9							

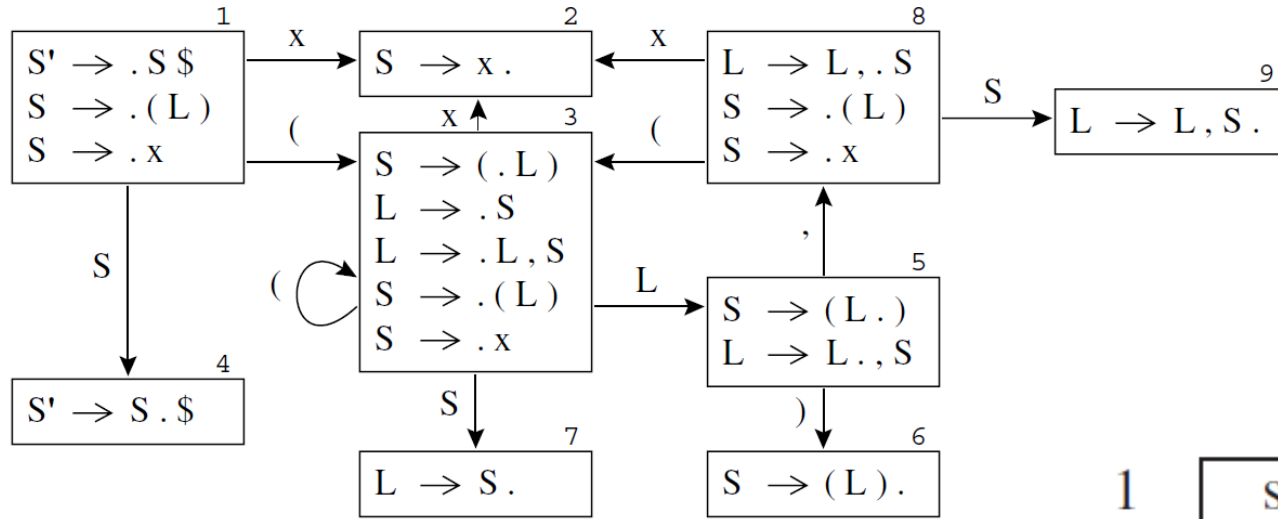
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3							
4							
5							
6							
7							
8							
9							

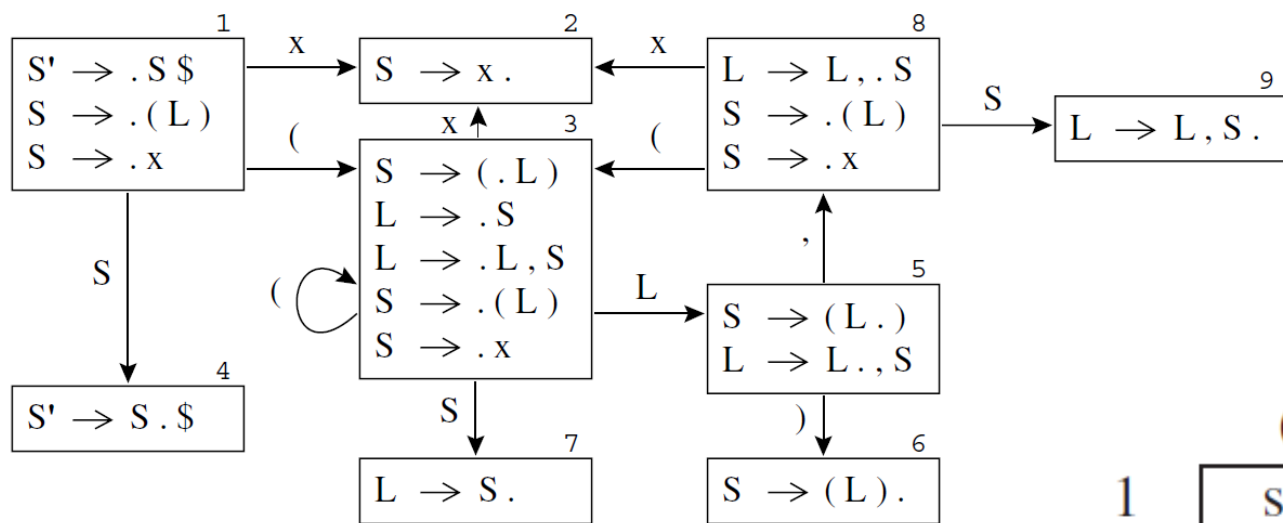
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3						
4							
5							
6							
7							
8							
9							

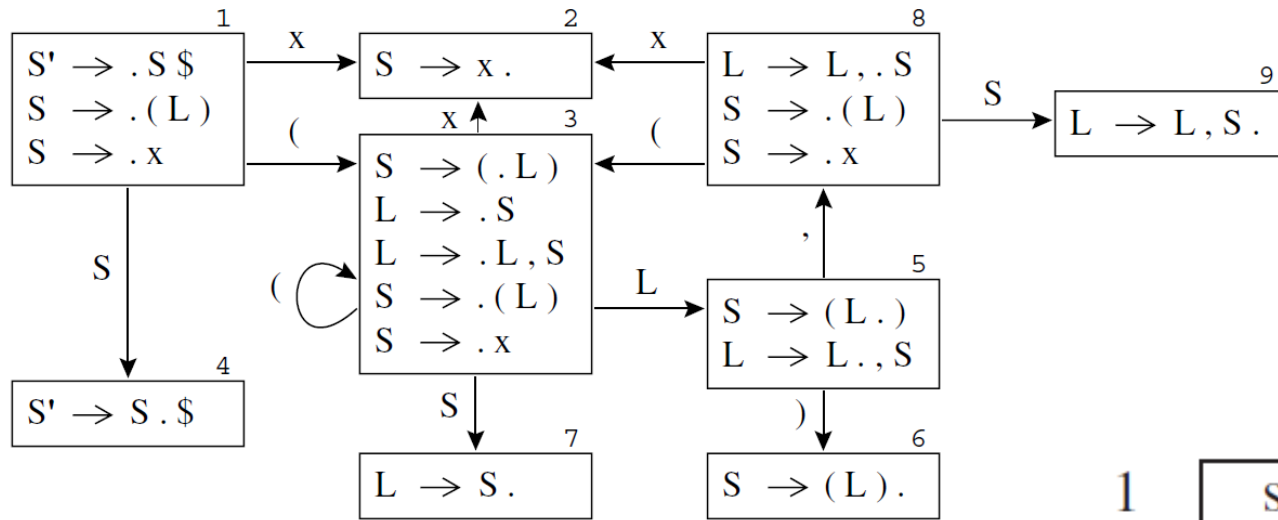
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	<i>S</i>	<i>L</i>
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2				
4							
5							
6							
7							
8							
9							

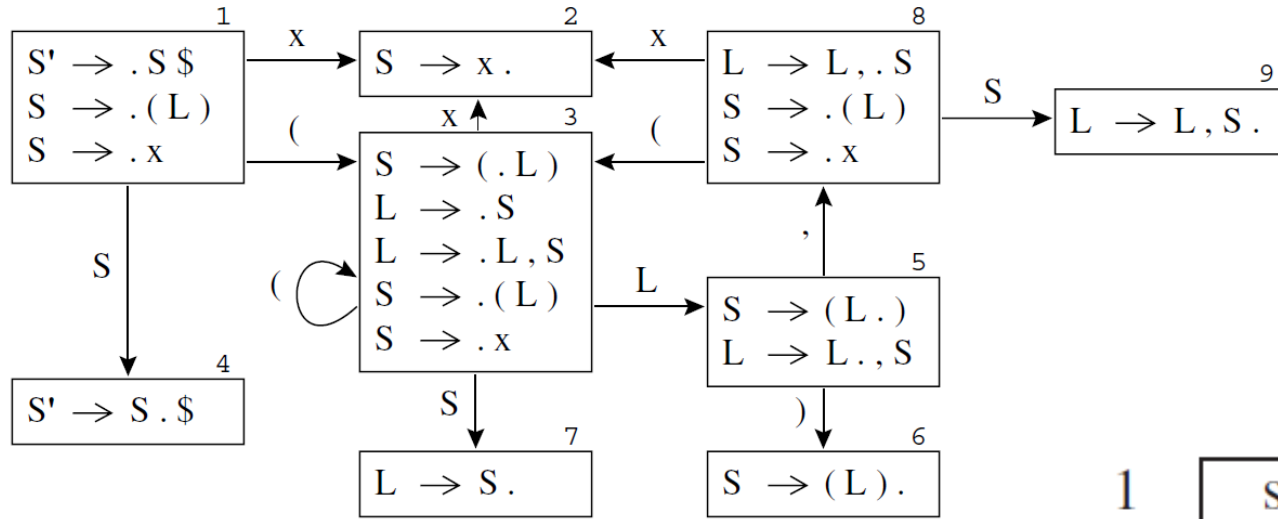
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	<i>S</i>	<i>L</i>
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	
4							
5							
6							
7							
8							
9							

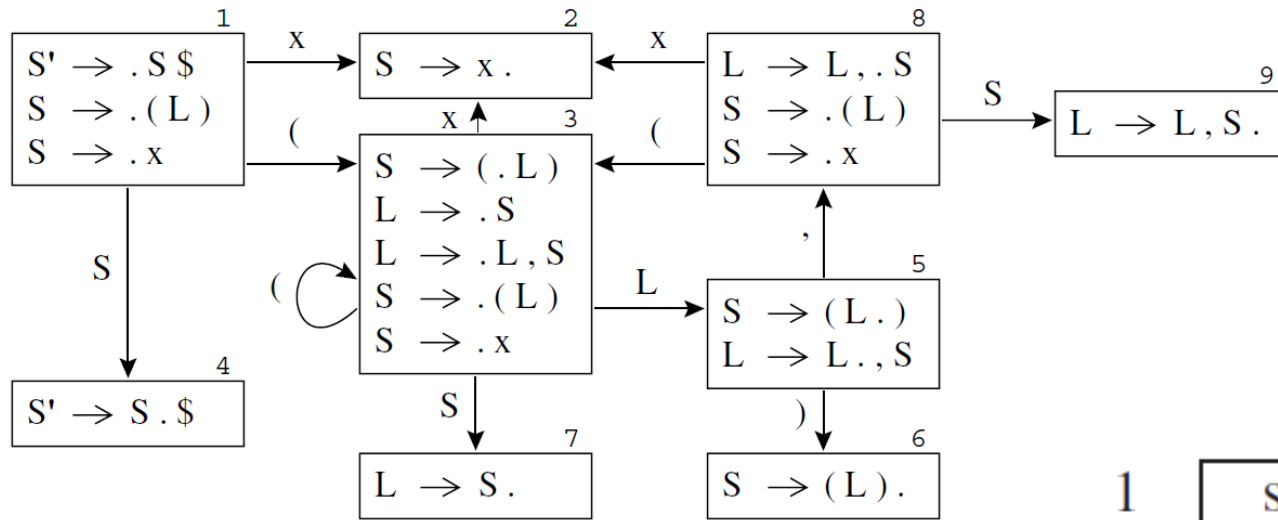
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	<i>S</i>	<i>L</i>
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4							
5							
6							
7							
8							
9							

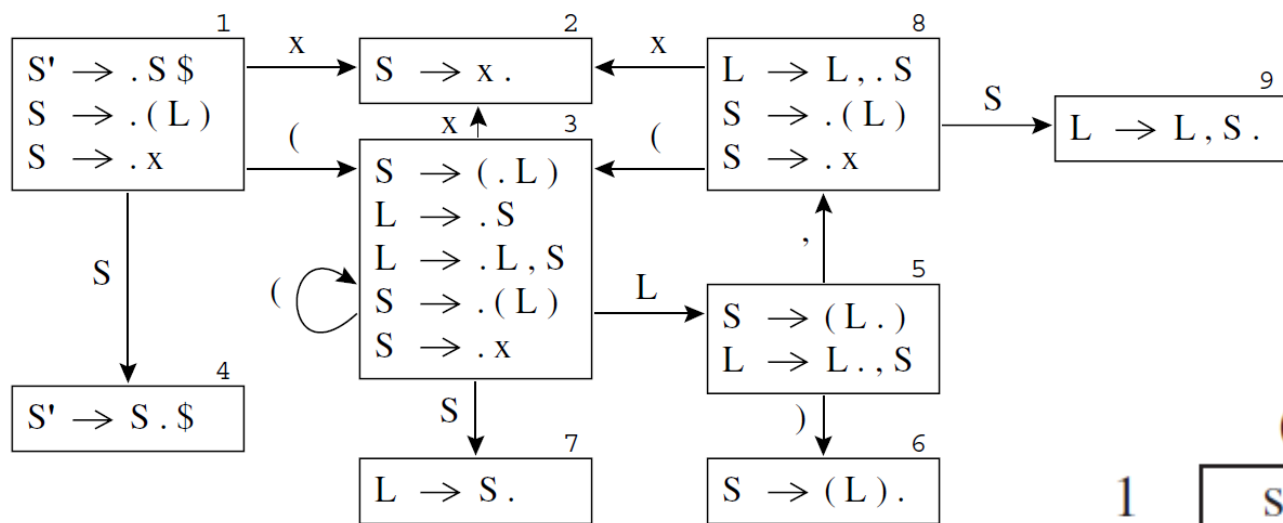
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	<i>S</i>	<i>L</i>
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5							
6							
7							
8							
9							

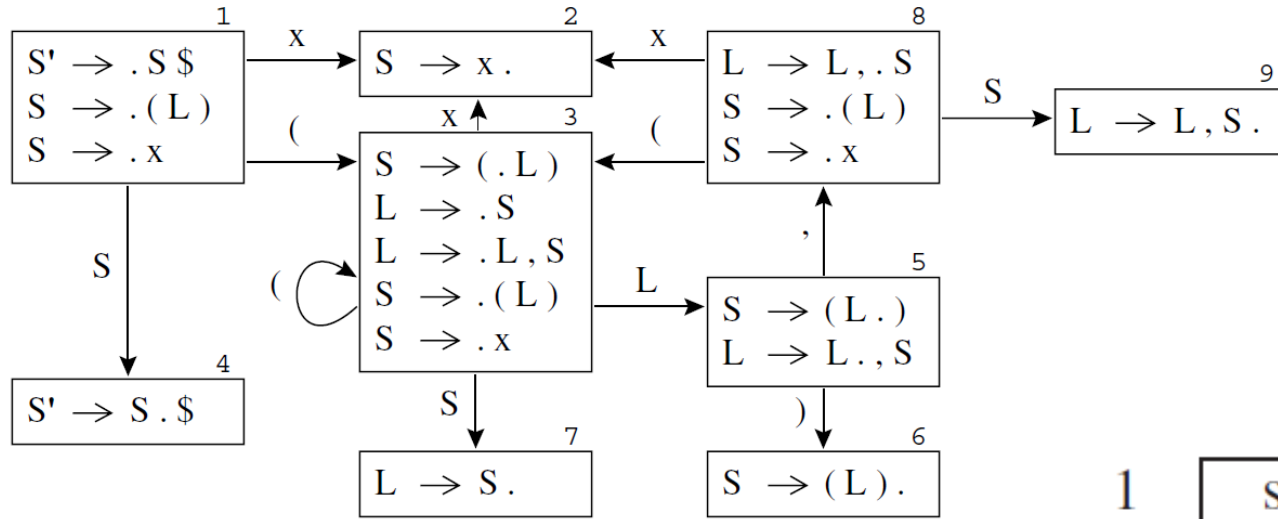
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	<i>S</i>	<i>L</i>
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6					
6							
7							
8							
9							

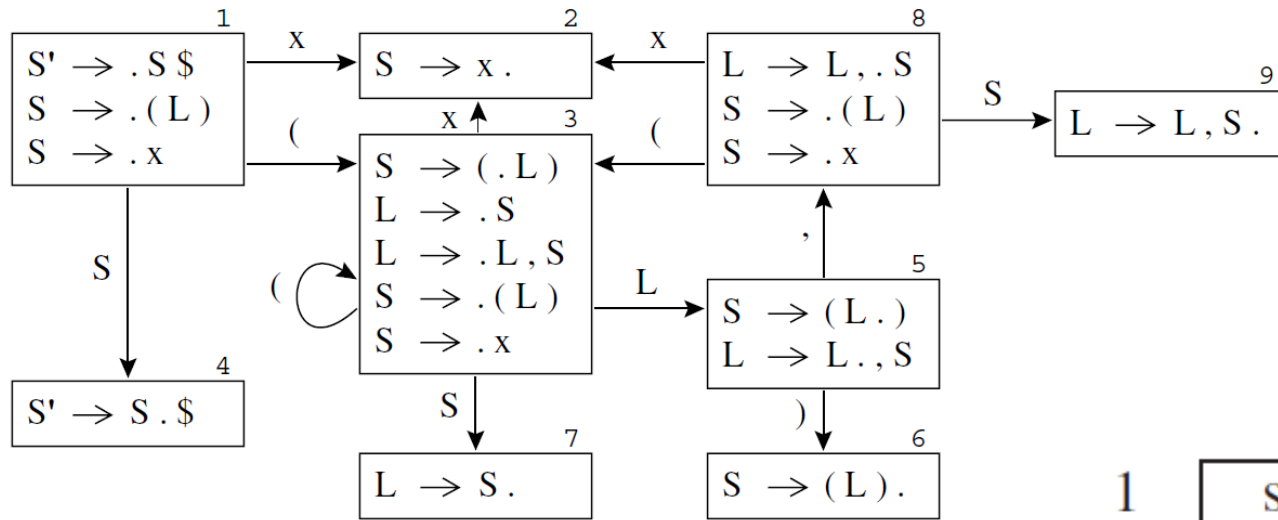
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	<i>S</i>	<i>L</i>
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6							
7							
8							
9							

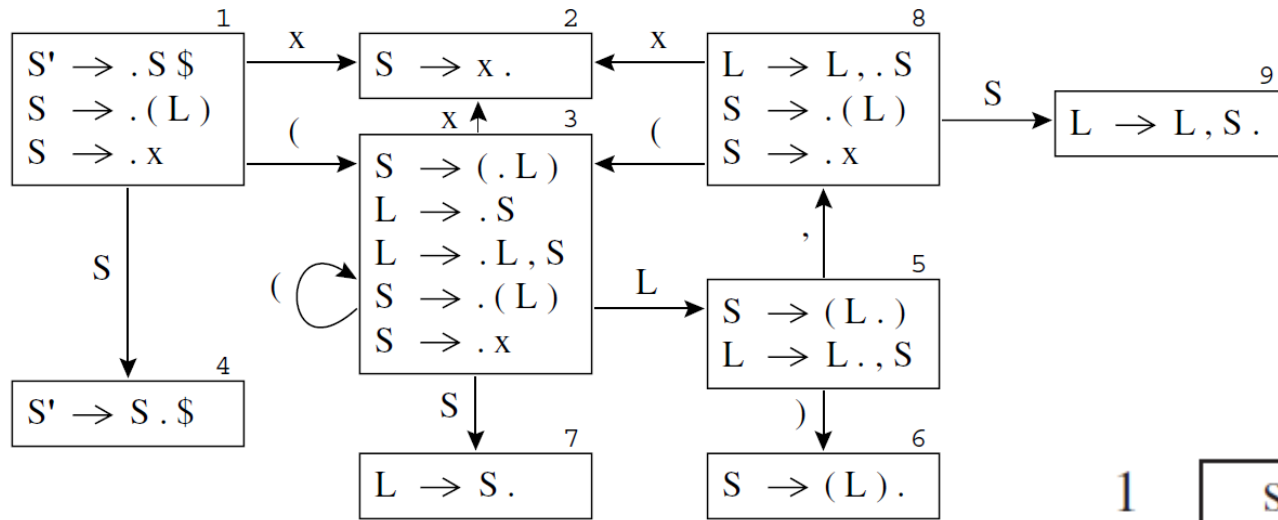
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	<i>S</i>	<i>L</i>
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7							
8							
9							

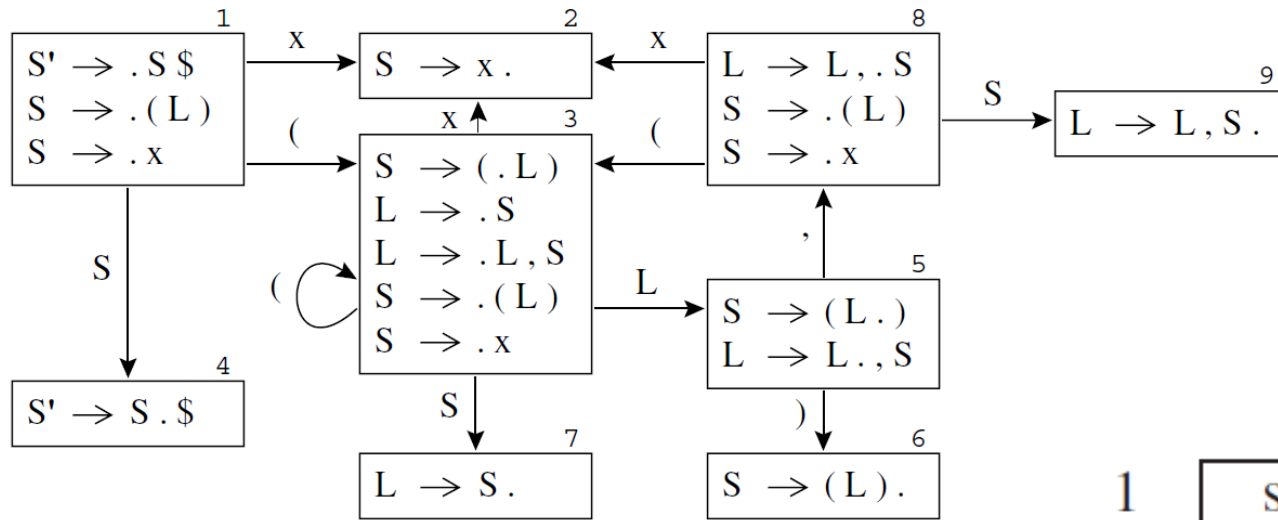
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	<i>S</i>	<i>L</i>
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8							
9							

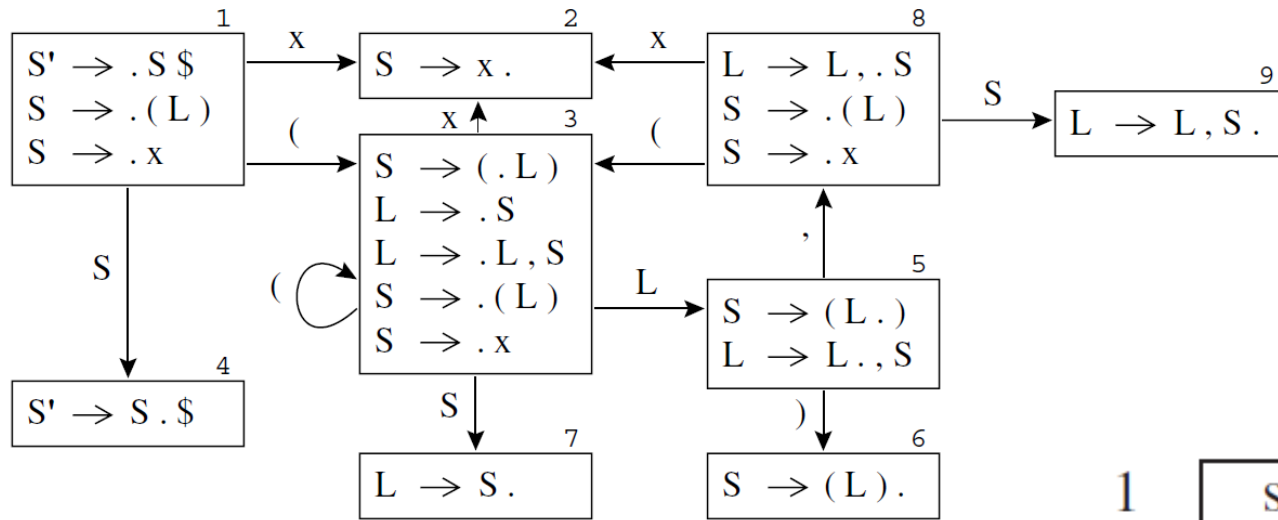
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3						
9							

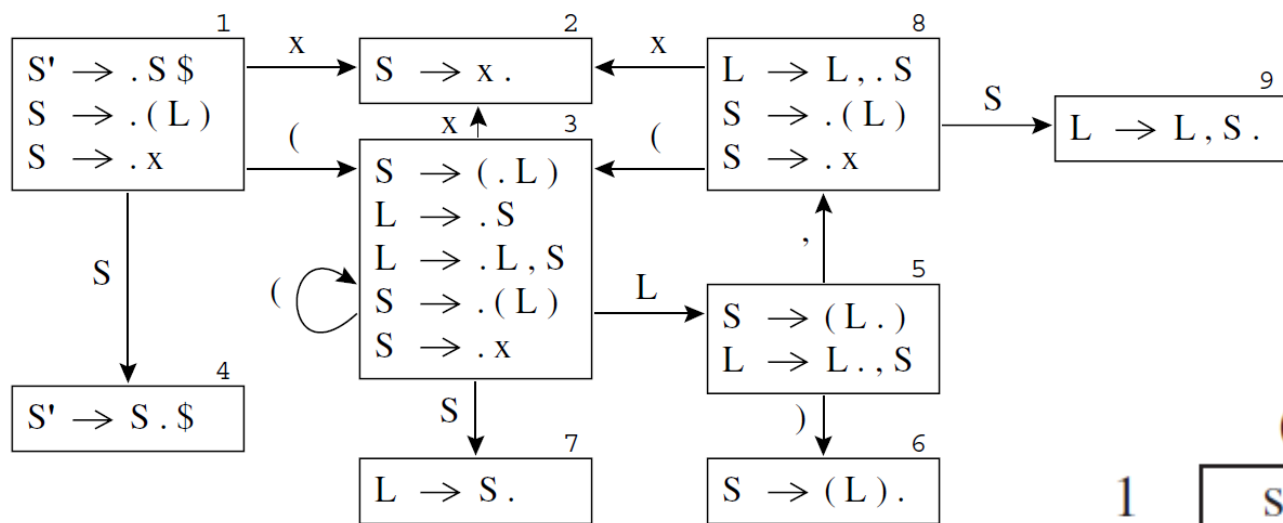
Exemplo



- $S' \rightarrow S\$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2				
9							

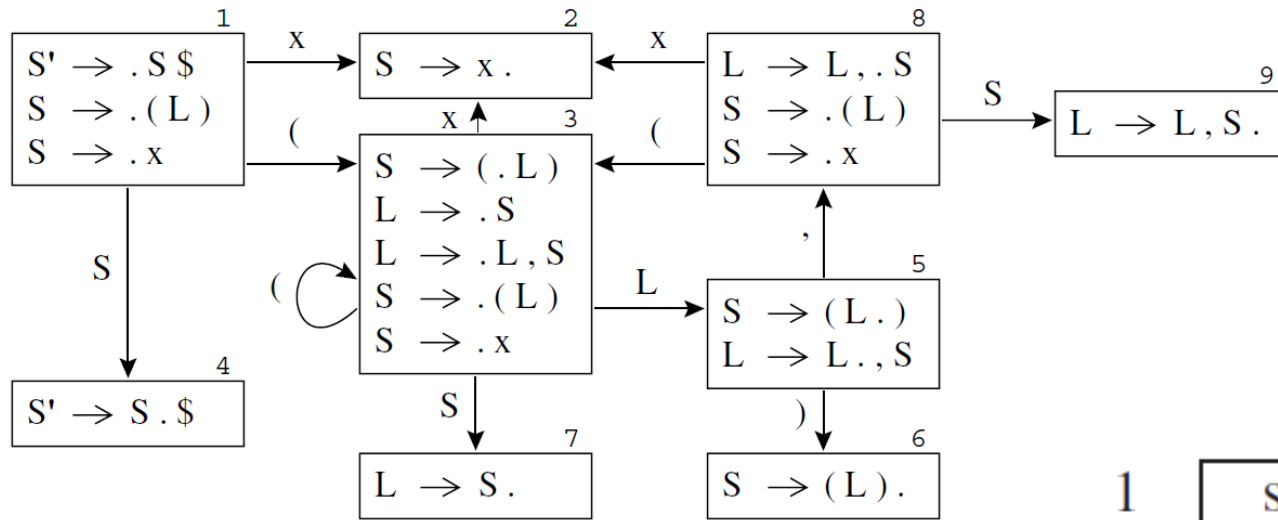
Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9							

Exemplo



- $S' \rightarrow S \$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Exemplo

	(	)	x	,	\$	<i>S</i>	<i>L</i>
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

- $S' \rightarrow S\$$
- 1. $S \rightarrow (L)$
- 2. $S \rightarrow x$
- 3. $L \rightarrow S$
- 4. $L \rightarrow L, S$

A cadeia abaixo pertence a linguagem
gerada pela gramática?

(x) \$

Exemplo

•	$S' \rightarrow S\$$
1.	$S \rightarrow (L)$
2.	$S \rightarrow x$
3.	$L \rightarrow S$
4.	$L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

Entrada | Ação

Exemplo

•	$S' \rightarrow S\$$
1.	$S \rightarrow (L)$
2.	$S \rightarrow x$
3.	$L \rightarrow S$
4.	$L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

1

Entrada | Ação

(x) \$ |

Exemplo

•	$S' \rightarrow S\$$
1.	$S \rightarrow (L)$
2.	$S \rightarrow x$
3.	$L \rightarrow S$
4.	$L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

1

1 (3

Entrada | Ação

(x) \$ | shift

x) \$ |

Exemplo

•	$S' \rightarrow S\$$
1.	$S \rightarrow (L)$
2.	$S \rightarrow x$
3.	$L \rightarrow S$
4.	$L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

1

1 (₃

1 (₃ x ₂

Entrada | Ação

(x) \$ | shift

x) \$ | shift

) \$ |

Exemplo

- $S' \rightarrow S\$$

1.

$S \rightarrow (L)$

2.

$S \rightarrow x$

3.

$L \rightarrow S$

4.

$L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

1
1 (₃
1 (₃x₂
1 (₃S

Entrada | Ação

(x) \$ | shift
x) \$ | shift
) \$ | Reduce S-> x
) \$ |

Exemplo

•	$S' \rightarrow S\$$
1.	$S \rightarrow (L)$
2.	$S \rightarrow x$
3.	$L \rightarrow S$
4.	$L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

1

1 (₃

1 (₃ x ₂

1 (₃ S ₇

Entrada | Ação

(x) \$ | shift

x) \$ | shift

) \$ | Reduce S -> x

) \$ |

Exemplo

•	$S' \rightarrow S\$$
1.	$S \rightarrow (L)$
2.	$S \rightarrow x$
3.	$L \rightarrow S$
4.	$L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

1

1 (3

1 (3 x 2

1 (3 S 7

1 (3 L

Entrada | Ação

(x) \$ | shift

x) \$ | shift

) \$ | Reduce S -> x

) \$ | Reduce L -> S

) \$ |

Exemplo

•	$S' \rightarrow S\$$
1.	$S \rightarrow (L)$
2.	$S \rightarrow x$
3.	$L \rightarrow S$
4.	$L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

1

1 (3

1 (3 x 2

1 (3 S 7

1 (3 L 5

Entrada | Ação

(x) \$ | shift

x) \$ | shift

) \$ | Reduce S-> x

) \$ | Reduce L-> S

) \$ |

Exemplo

- $S' \rightarrow S\$$

1. $S \rightarrow (L)$

2. $S \rightarrow x$

3. $L \rightarrow S$

4. $L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

1
1 (₃
1 (₃ x ₂
1 (₃ S ₇
1 (₃ L ₅
1 (₃ L ₅) ₆

Entrada | Ação

(x) \$ | shift
x) \$ | shift
) \$ | Reduce S-> x
) \$ | Reduce L-> S
) \$ | shift
\$ |

Exemplo

- $S' \rightarrow S\$$
 1. $S \rightarrow (L)$
 2. $S \rightarrow x$
 3. $L \rightarrow S$
 4. $L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

1
 1 (₃
 1 (₃ x ₂
 1 (₃ S ₇
 1 (₃ L ₅
 1 (₃ L ₅) ₆
 1 S

Entrada | Ação

(x) \$ | shift
 x) \$ | shift
) \$ | Reduce S-> x
) \$ | Reduce L-> S
) \$ | shift
 \$ | Reduce S-> (L)
 \$ |

Exemplo

•	$S' \rightarrow S\$$
1.	$S \rightarrow (L)$
2.	$S \rightarrow x$
3.	$L \rightarrow S$
4.	$L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

1
1 (₃
1 (₃ x ₂
1 (₃ S ₇
1 (₃ L ₅
1 (₃ L ₅) ₆
1 S ₄

Entrada | Ação

(x) \$ | shift
x) \$ | shift
) \$ | Reduce S-> x
) \$ | Reduce L-> S
) \$ | shift
\$ | Reduce S-> (L)
\$ |

Exemplo

•	$S' \rightarrow S\$$
1.	$S \rightarrow (L)$
2.	$S \rightarrow x$
3.	$L \rightarrow S$
4.	$L \rightarrow L, S$

	(	)	x	,	\$	S	L
1	s3		s2			g4	
2	r2	r2	r2	r2	r2		
3	s3		s2			g7	g5
4					a		
5		s6		s8			
6	r1	r1	r1	r1	r1		
7	r3	r3	r3	r3	r3		
8	s3		s2			g9	
9	r4	r4	r4	r4	r4		

Pilha

1
1 (₃
1 (₃ x ₂
1 (₃ S ₇
1 (₃ L ₅
1 (₃ L ₅) ₆
1 S ₄

Entrada | Ação

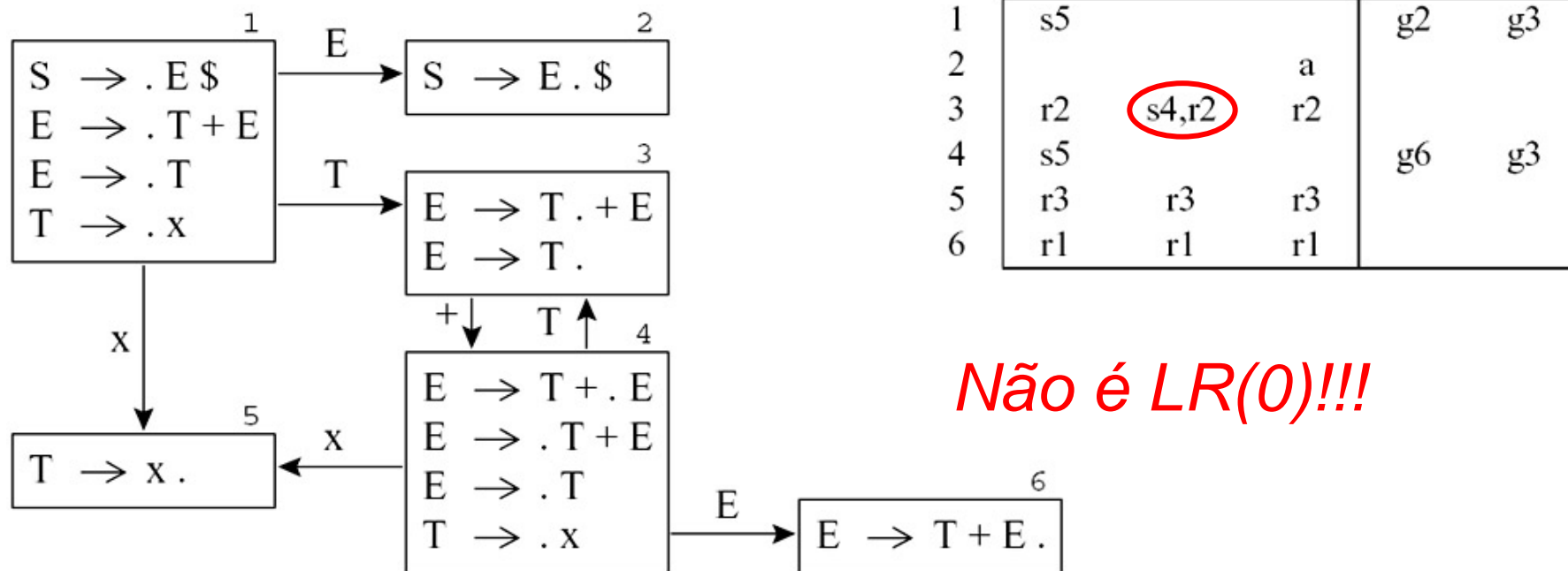
(x) \$ | shift
x) \$ | shift
) \$ | Reduce S-> x
) \$ | Reduce L-> S
) \$ | shift
\$ | Reduce S-> (L)
\$ | accept

Tente construir um *parser* LR(0)

- $S \rightarrow E \$$
- 1. $E \rightarrow T + E$
- 2. $E \rightarrow T$
- 3. $T \rightarrow x$

Tente construir um *parser* LR(0)

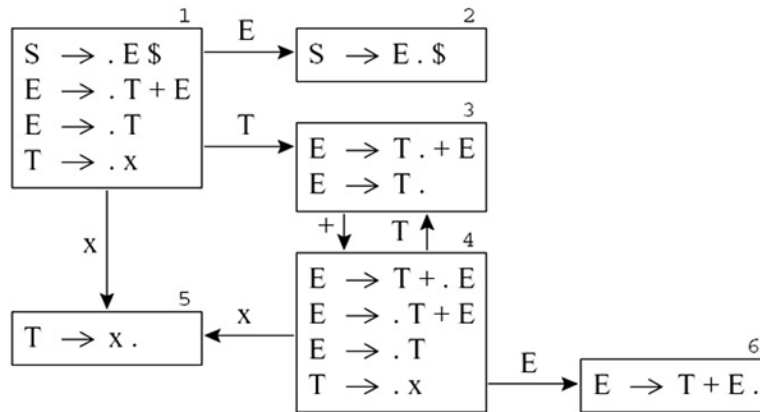
- $S \rightarrow E \$$
- 1. $E \rightarrow T + E$
- 2. $E \rightarrow T$
- 3. $T \rightarrow x$



Não é LR(0)!!!

SLR Parser (Simple LR)

Colocar reduções somente onde indicado pelo conjunto FOLLOW



- $S \rightarrow E\$$
- 1. $E \rightarrow T + E$
- 2. $E \rightarrow T$
- 3. $T \rightarrow x$

Follow(E) = { \$ }
Follow(T) = { +, \$ }

	x	+	\$	E	T
1	s5			g2	g3
2			a		
3		s4	r2		
4	s5			g6	g3
5		r3	r3		
6			r1		

É SLR!!!

Lista de Exercícios

Lista 12

- Exercícios teóricos