Análise Sintática
LR(1) e LALR

Exemplo

- $S' \rightarrow S\ \$$
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

A gramática é LR(0) ou SLR ?

Exemplo

- $S' \rightarrow S\ \$$
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

A gramática é LR(0) ou SLR ?

Não!!!

LR(1)

Mais poderoso do que SLR

A maioria das linguagens de programação é LR(1)

Algoritmo similar a LR(0), mas agora incorpora o lookahead.

Item: ($A \rightarrow \alpha.\beta, x$) — **Lookahead**

Lookahead

$S \rightarrow A\$$

$A \rightarrow E{+}{+}$

$A \rightarrow E{-}{-}$

$E \rightarrow id$

$E \rightarrow num$

Follow(E) = { ++, --}

Item: ($A \rightarrow \alpha.\beta, x$) —— **Lookahead**

Algoritmos – Closure(I) e Goto(I,X)

```
Closure(I) =
 repeat
  for any item A → (α.Xβ,z) in I
    for any production X → γ
      for any w ϵ FIRST(βz)
        I ← I ∪ {X → .γ,w}
 until I does not change.
 return I

Goto(I, X) =
  set J to the empty set
  for any item A → (α.Xβ,z) in I
    add A → (αX.β,z) to J
  return Closure(J)
```

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

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

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

$S' \rightarrow . S\ \$$

Cadeia: $

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

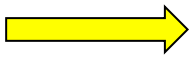
$$S' \rightarrow . S\ \$$$
$$S \rightarrow . V = E\ \$$$
$$S \rightarrow . E\ \$$$

Cadeia: $

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$



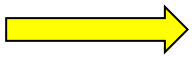
$$
\begin{array}{lll}
S' \rightarrow . \ S\ \$ & & \\
S \rightarrow . \ V = E & \$ & \\
S \rightarrow . \ E & \$ &
\end{array}
$$

Cadeia: =E$

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$



$$
\begin{array}{lll}
S' \rightarrow . \ S\ \$ & & \\
S \rightarrow . \ V = E & \$ & \\
S \rightarrow . \ E & \$ & \\
V \rightarrow . \ \mathrm{x} & = & \\
V \rightarrow . * E & = &
\end{array}
$$

Cadeia: =E$

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

$$
\begin{array}{lll}
S' \rightarrow . \ S\ \$ & & \\
S \rightarrow . \ V = E & \$ & \\
S \rightarrow . \ E & \$ & \\
V \rightarrow . \ \mathrm{x} & = & \\
V \rightarrow . * E & = &
\end{array}
$$

Cadeia: $

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

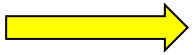
$S' \rightarrow . S\ \$$		
$S \rightarrow . V = E$		$\$$
$S \rightarrow . E$		$\$$
$V \rightarrow . \mathrm{x}$		$=$
$V \rightarrow . * E$		$=$
$E \rightarrow . V$		$\$$

Cadeia: $

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$



$$
\begin{array}{lll}
S' \rightarrow . \ S\ \$ & & \\
S \rightarrow . \ V = E & & \$ \\
S \rightarrow . \ E & & \$ \\
V \rightarrow . \ \mathrm{x} & & = \\
V \rightarrow . * E & & = \\
E \rightarrow . \ V & & \$
\end{array}
$$

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

$$
\begin{array}{lll}
S' \rightarrow . \ S\ \$ & & \\
S \rightarrow . \ V = E & & \$ \\
S \rightarrow . \ E & & \$ \\
V \rightarrow . \ \mathrm{x} & & = \\
V \rightarrow . * E & & = \\
E \rightarrow . \ V & & \$
\end{array}
$$

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

$S' \rightarrow . S$		$\$$
$S \rightarrow . V = E$		$\$$
$S \rightarrow . E$		$\$$
$V \rightarrow .$ x		$=$
$V \rightarrow . * E$		$=$
$E \rightarrow . V$		$\$$

Cadeia: $

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

$S' \rightarrow . S$		$
$S \rightarrow . V = E$		$
$S \rightarrow . E$		$
$V \rightarrow .$ x		=
$V \rightarrow . * E$		=
$E \rightarrow . V$		$
$V \rightarrow .$ x		$
$V \rightarrow . * E$		$

Cadeia: $

LR(1)

- $S' \rightarrow S\ \$$

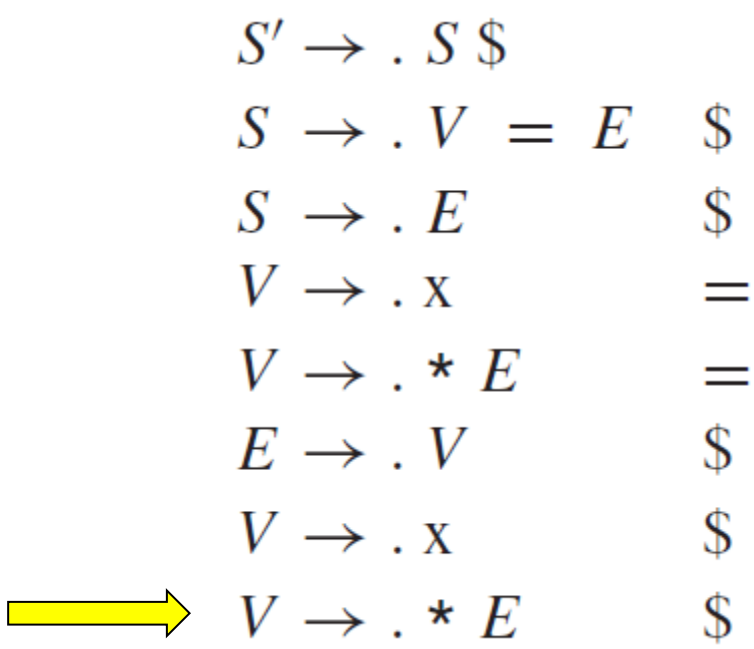
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

S'	$\rightarrow$	. S		$\$$
S	$\rightarrow$	. V	$=$ E	$\$$
S	$\rightarrow$	. E		$\$$
V	$\rightarrow$	. x		$=$
V	$\rightarrow$	. * E		$=$
E	$\rightarrow$	. V		$\$$
V	$\rightarrow$	. x		$\$$
V	$\rightarrow$	. * E		$\$$

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$



$$
\begin{array}{lll}
S' \rightarrow . \ S\ \$ & & \\
S \rightarrow . \ V = E & & \$ \\
S \rightarrow . \ E & & \$ \\
V \rightarrow . \ \mathrm{x} & & = \\
V \rightarrow . * E & & = \\
E \rightarrow . \ V & & \$ \\
V \rightarrow . \ \mathrm{x} & & \$ \\
V \rightarrow . * E & & \$
\end{array}
$$

LR(1)

- $S' \rightarrow S\ \$$

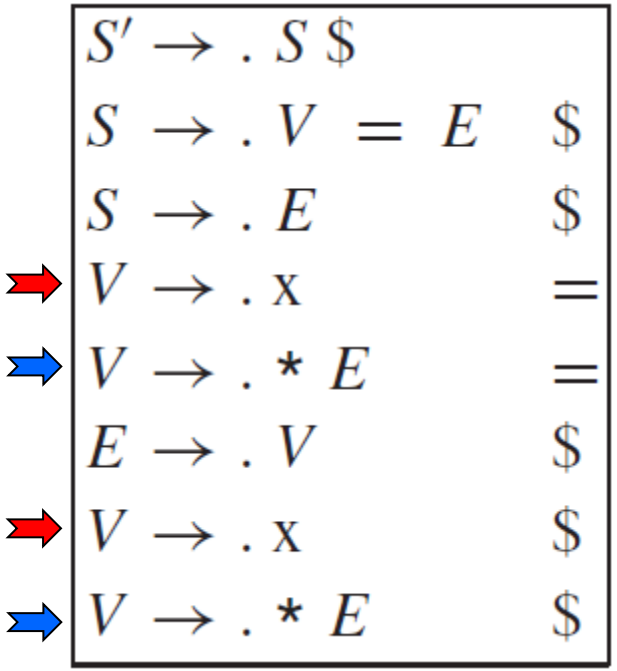
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

S'	$\rightarrow$	. S		$\$$
S	$\rightarrow$	. V	$= E$	$\$$
S	$\rightarrow$	. E		$\$$
V	$\rightarrow$	. x		$=$
V	$\rightarrow$	. * E		$=$
E	$\rightarrow$	. V		$\$$
V	$\rightarrow$	. x		$\$$
V	$\rightarrow$	. * E		$\$$

LR(1)

- $S' \rightarrow S\ \$$

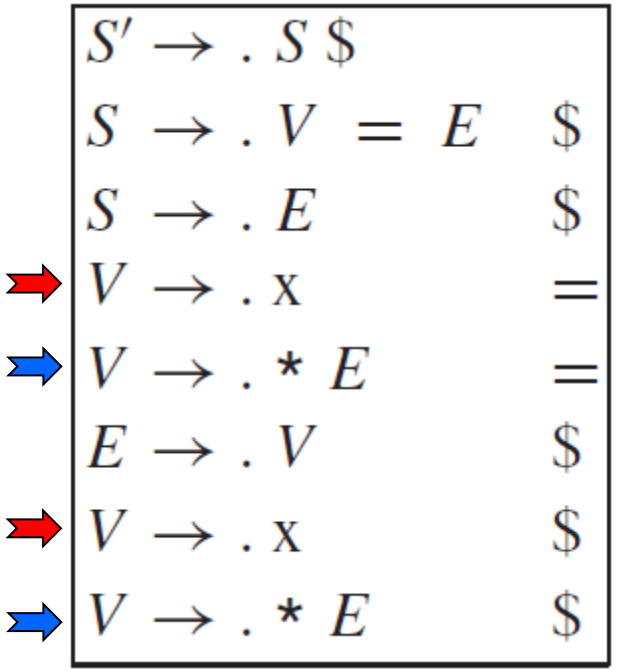
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

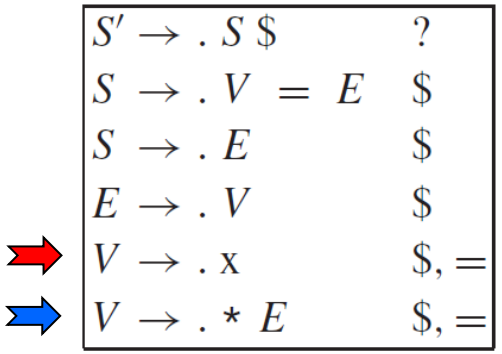


LR(1)

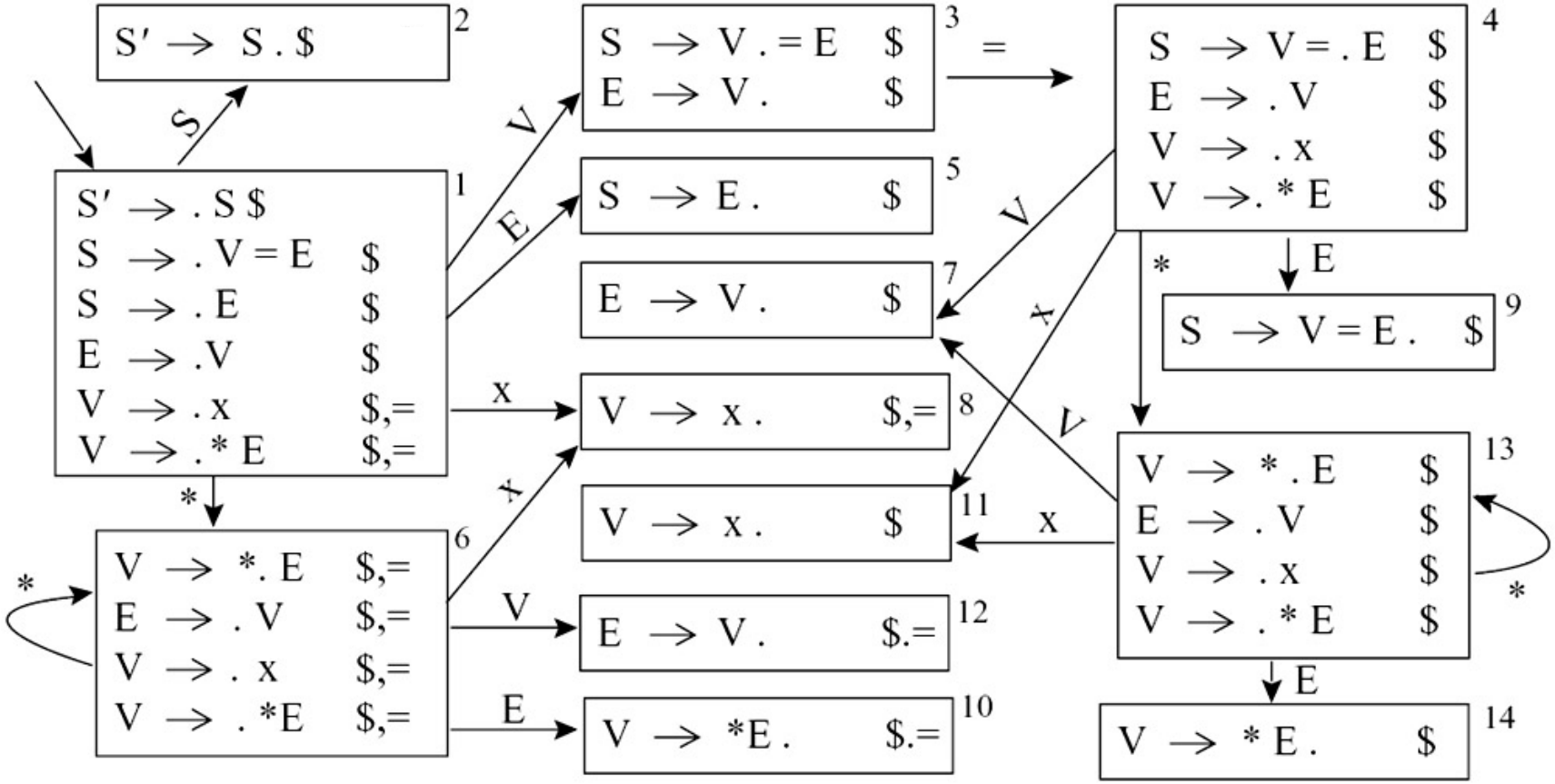
- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$



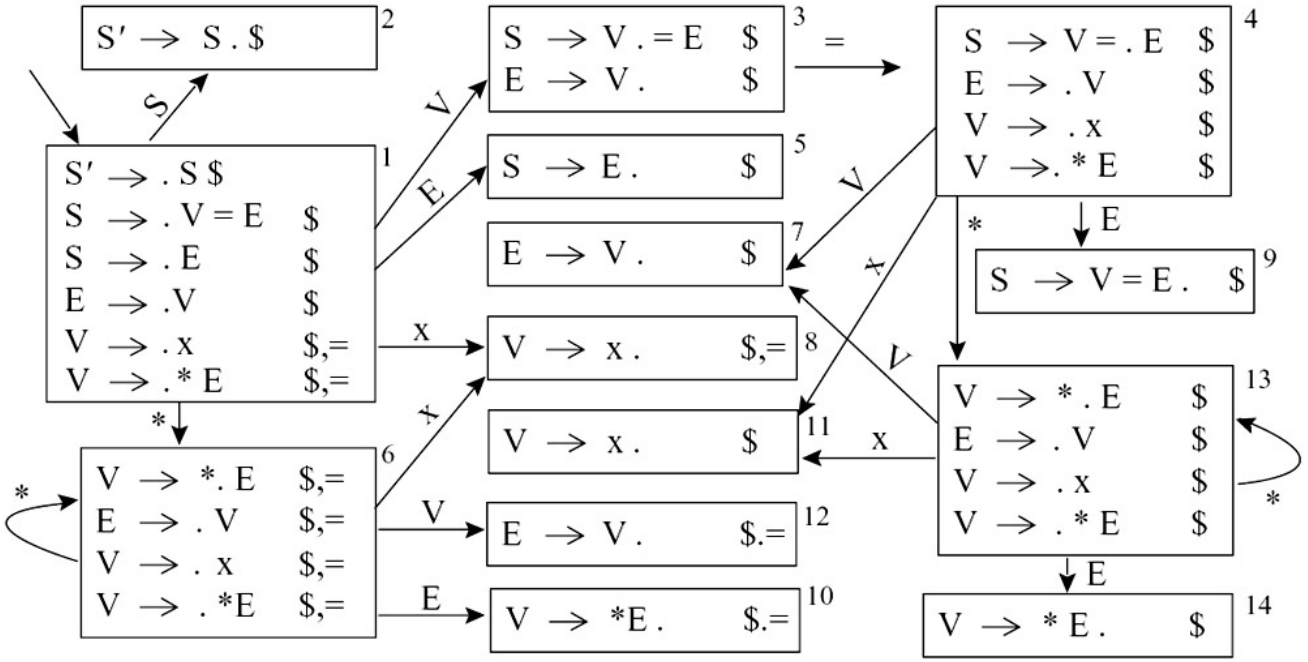


LR(1)



- $S' \rightarrow S\ \$$
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

LR(1)



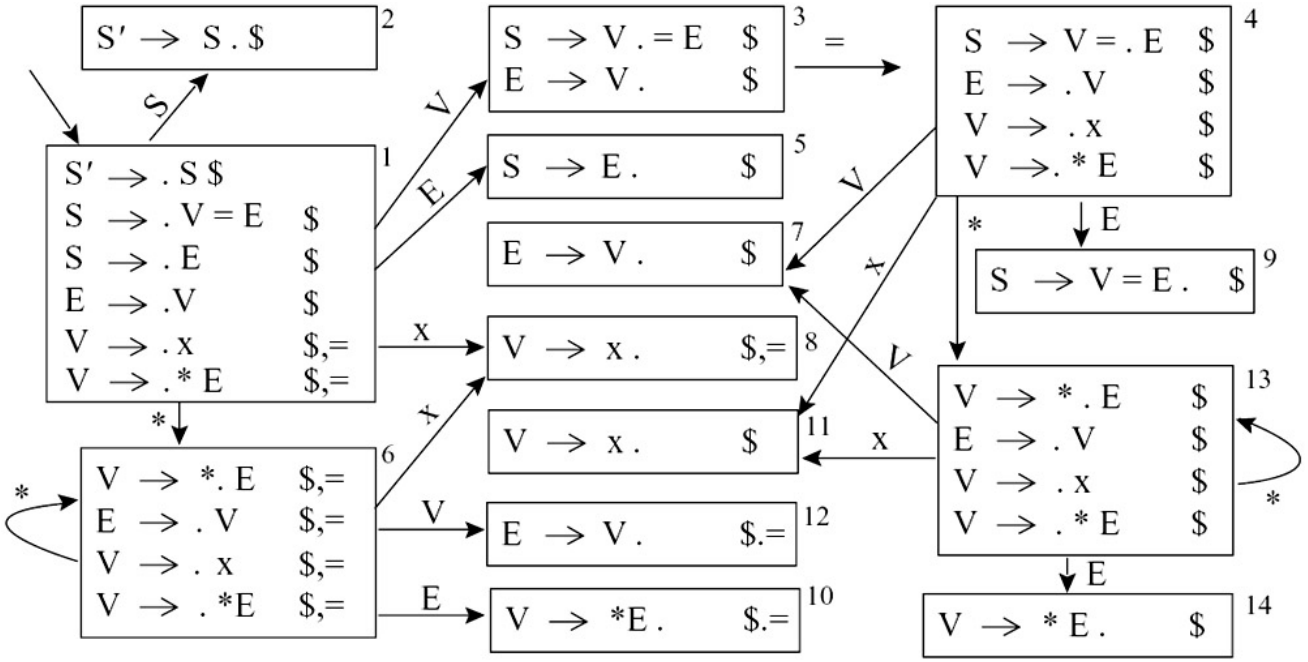
	x	*	=	$	S	E	V
1	s8	s6			g2	g5	g3
2				a			
3			s4				
4	s11	s13				g9	g7
5							
6	s8	s6				g10	g12
7							
8							
9							
10							
11							
12							
13	s11	s13				g14	g7
14							

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

LR(1)

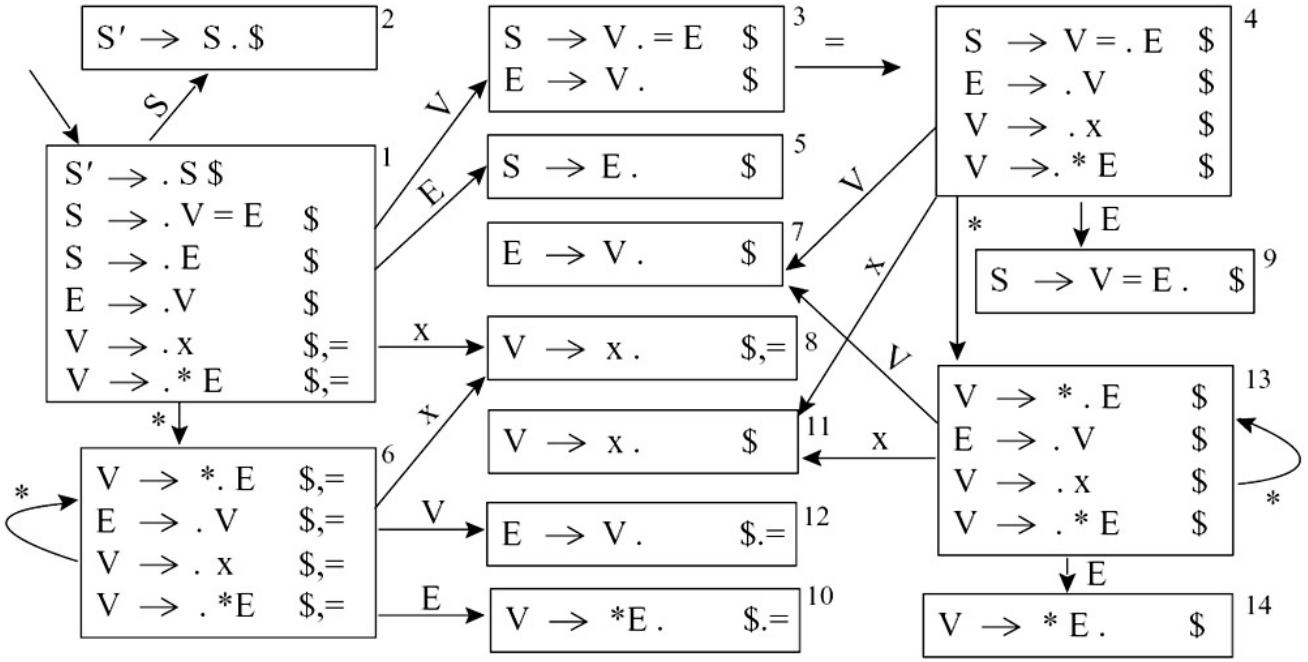


- $S' \rightarrow S\ \$$
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

	x	*	=	$	S	E	V
1	s8	s6			g2	g5	g3
2				a			
3			s4	r3			
4	s11	s13				g9	g7
5							
6	s8	s6				g10	g12
7							
8							
9							
10							
11							
12							
13	s11	s13				g14	g7
14							

LR(1)

LR(1)



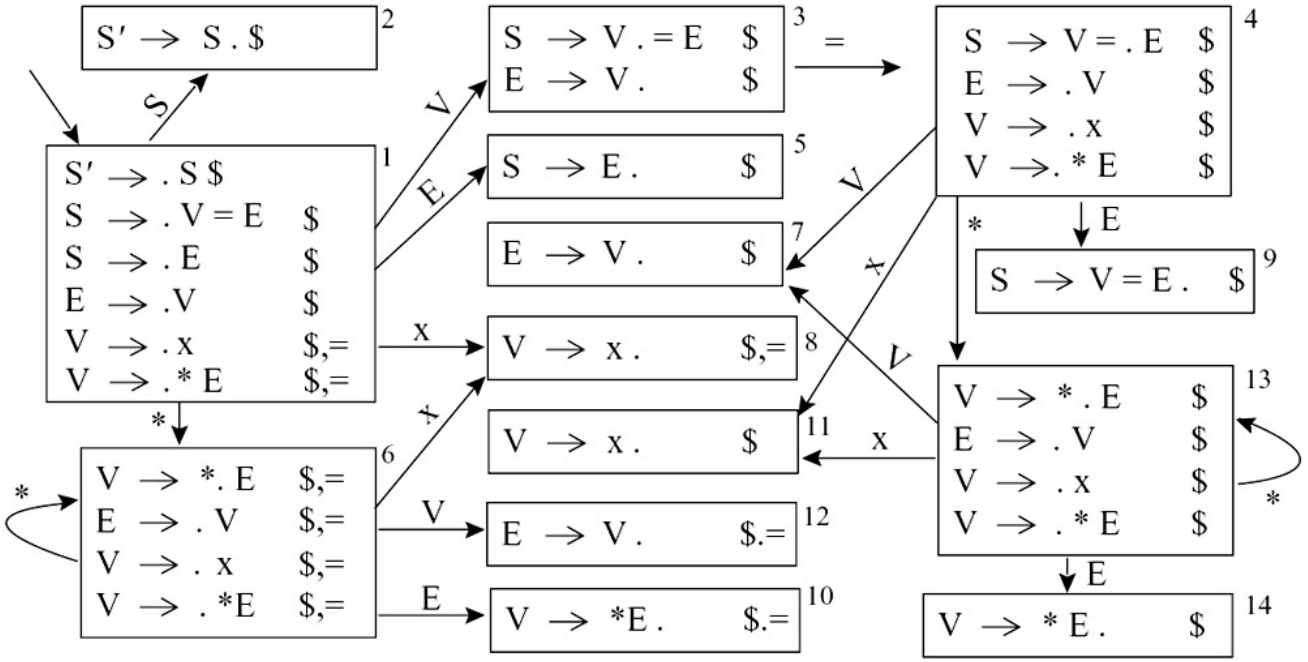
	x	*	=	$	S	E	V
1	s8	s6			g2	g5	g3
2				a			
3			s4	r3			
4	s11	s13				g9	g7
5				r2			
6	s8	s6				g10	g12
7							
8							
9							
10							
11							
12							
13	s11	s13				g14	g7
14							

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

LR(1)

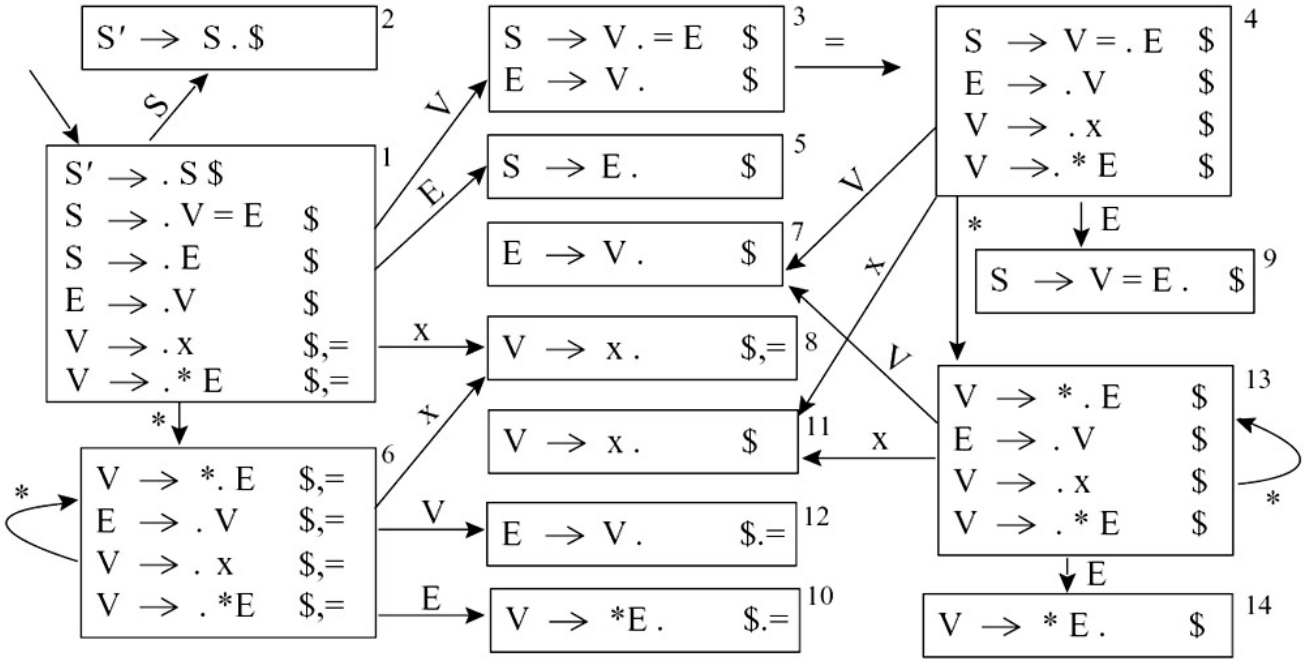


- $S' \rightarrow S\ \$$
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

	x	*	=	$	S	E	V
1	s8	s6			g2	g5	g3
2				a			
3			s4	r3			
4	s11	s13				g9	g7
5				r2			
6	s8	s6				g10	g12
7				r3			
8							
9							
10							
11							
12							
13	s11	s13				g14	g7
14							

LR(1)

LR(1)



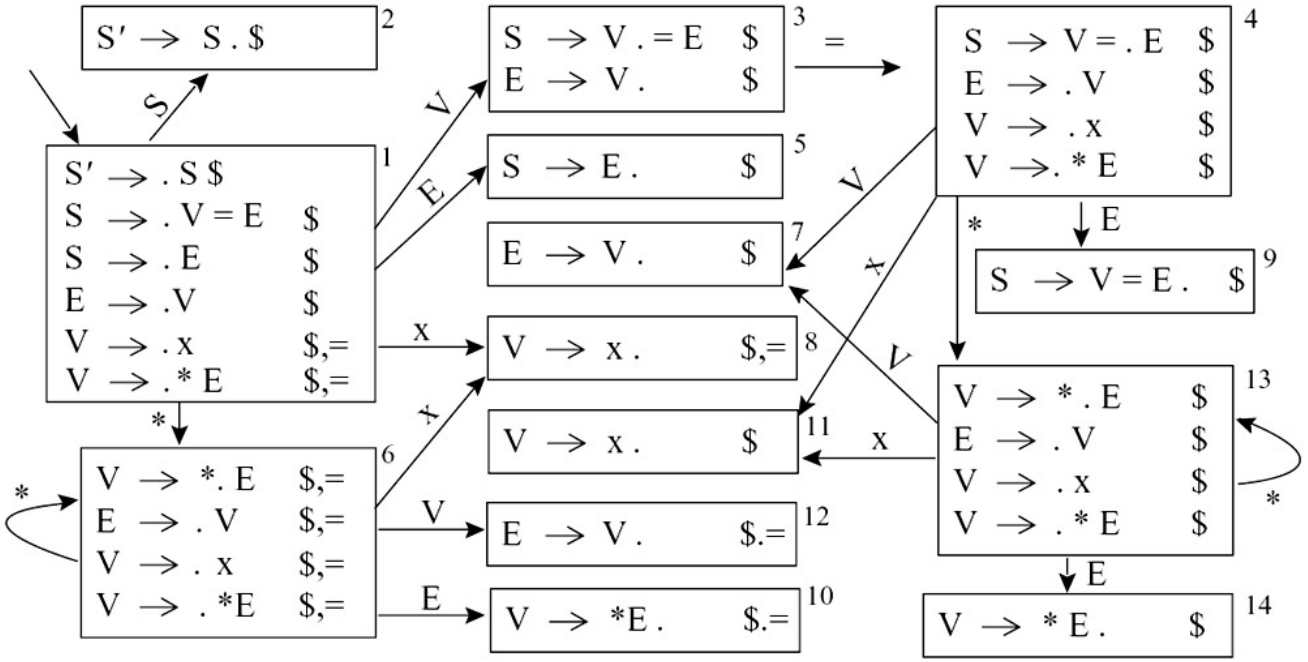
	x	*	=	$	S	E	V
1	s8	s6			g2	g5	g3
2				a			
3			s4	r3			
4	s11	s13				g9	g7
5				r2			
6	s8	s6				g10	g12
7				r3			
8			r4	r4			
9							
10							
11							
12							
13	s11	s13				g14	g7
14							

LR(1)

- $S' \rightarrow S\ \$$

1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

LR(1)

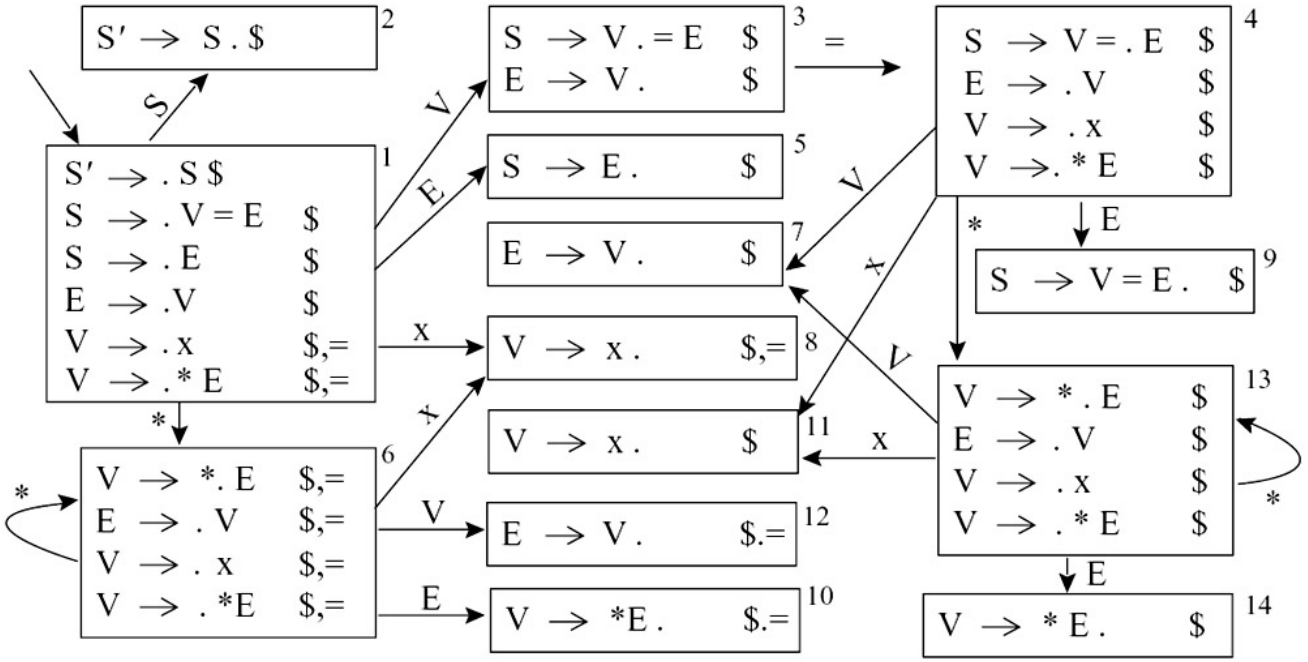


	x	*	=	$	S	E	V
1	s8	s6			g2	g5	g3
2				a			
3			s4	r3			
4	s11	s13				g9	g7
5				r2			
6	s8	s6				g10	g12
7				r3			
8			r4	r4			
9				r1			
10							
11							
12							
13	s11	s13				g14	g7
14							

LR(1)

- $S' \rightarrow S\ \$$
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

LR(1)

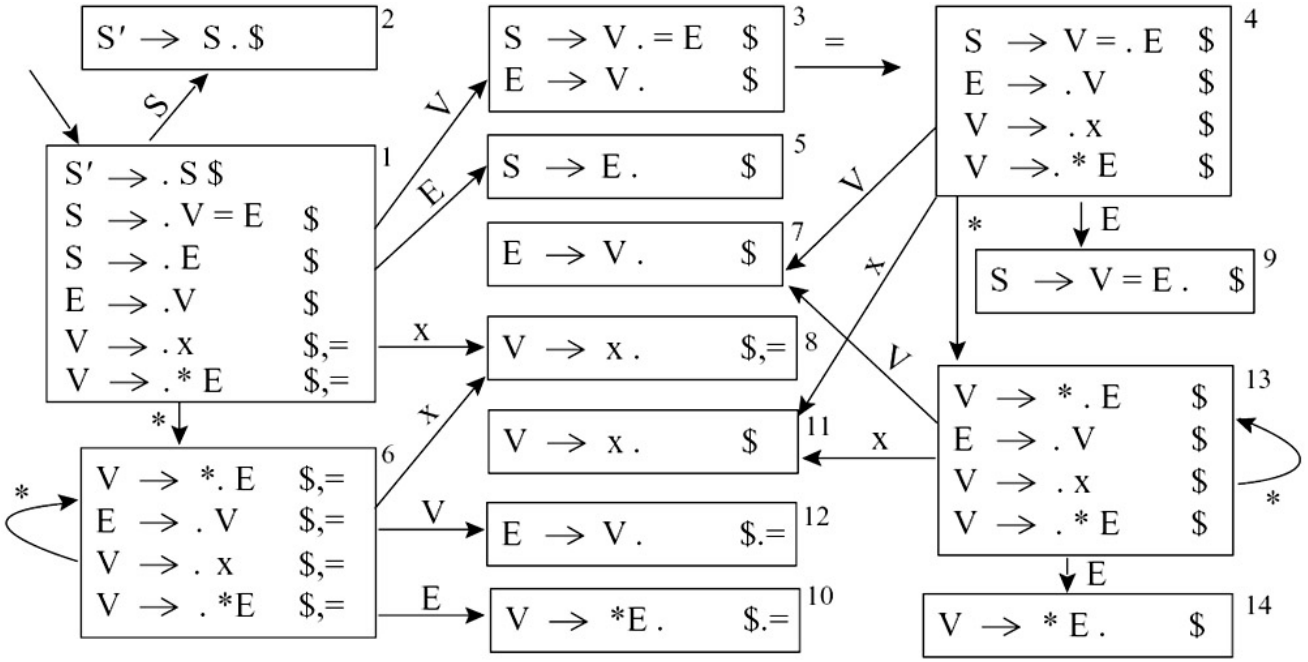


- $S' \rightarrow S\ \$$
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

	x	*	=	$	S	E	V
1	s8	s6			g2	g5	g3
2				a			
3			s4	r3			
4	s11	s13				g9	g7
5				r2			
6	s8	s6				g10	g12
7				r3			
8			r4	r4			
9				r1			
10			r5	r5			
11							
12							
13	s11	s13				g14	g7
14							

LR(1)

LR(1)

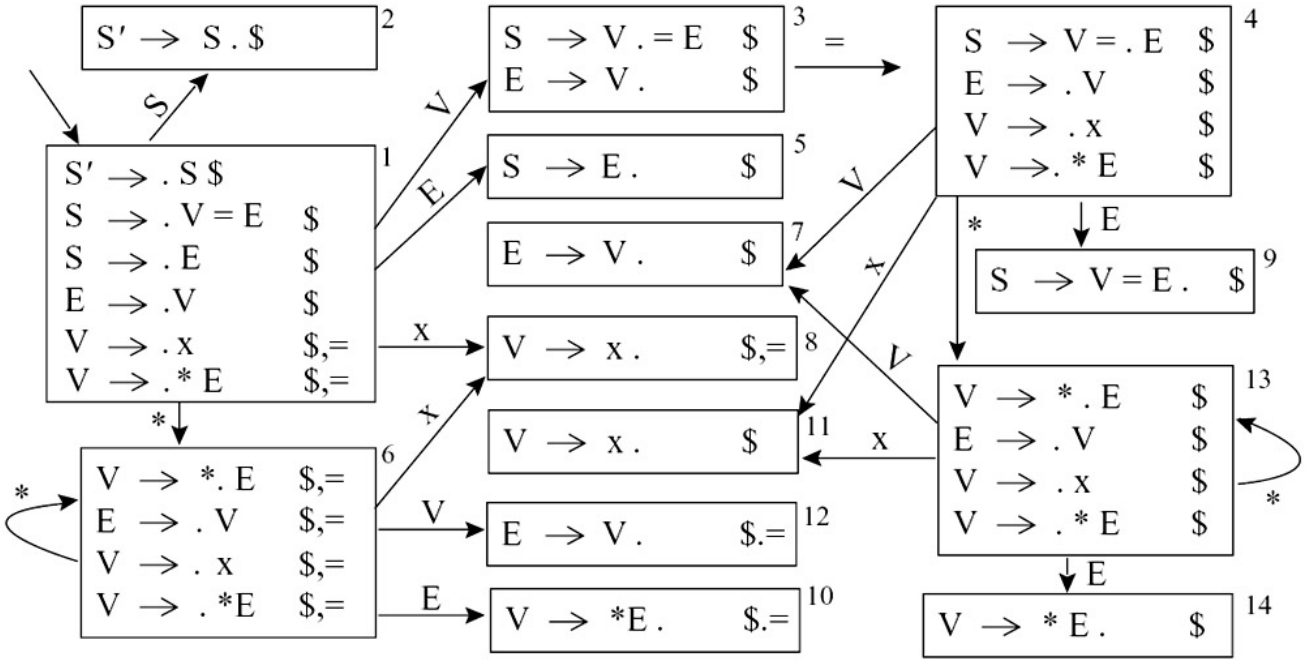


	x	*	=	$	S	E	V
1	s8	s6			g2	g5	g3
2				a			
3			s4	r3			
4	s11	s13				g9	g7
5				r2			
6	s8	s6				g10	g12
7				r3			
8			r4	r4			
9				r1			
10			r5	r5			
11				r4			
12							
13	s11	s13				g14	g7
14							

LR(1)

- $S' \rightarrow S\ \$$
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

LR(1)

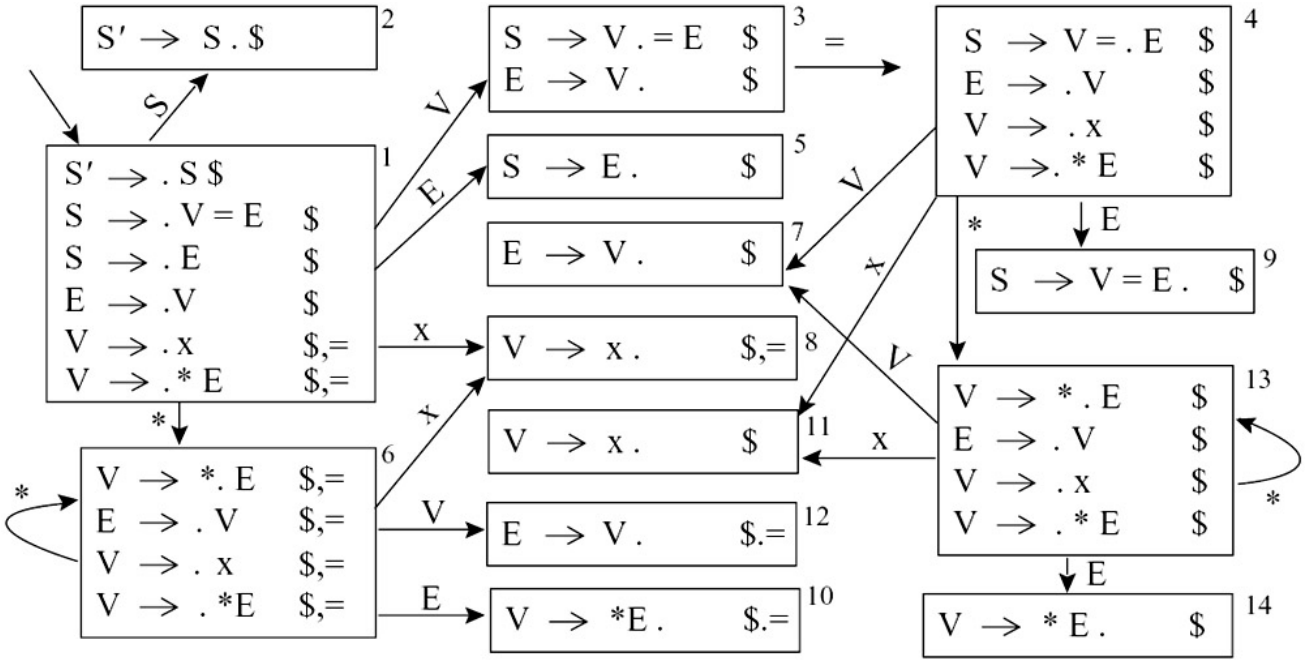


- $S' \rightarrow S\ \$$
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

	x	*	=	$	S	E	V
1	s8	s6			g2	g5	g3
2				a			
3			s4	r3			
4	s11	s13				g9	g7
5				r2			
6	s8	s6				g10	g12
7				r3			
8			r4	r4			
9				r1			
10			r5	r5			
11				r4			
12			r3	r3			
13	s11	s13				g14	g7
14							

LR(1)

LR(1)



	x	*	=	$	S	E	V
1	s8	s6			g2	g5	g3
2				a			
3			s4	r3			
4	s11	s13				g9	g7
5				r2			
6	s8	s6				g10	g12
7				r3			
8			r4	r4			
9				r1			
10			r5	r5			
11				r4			
12			r3	r3			
13	s11	s13				g14	g7
14				r5			

LR(1)

- $S' \rightarrow S\ \$$
1. $S \rightarrow V = E$
2. $S \rightarrow E$
3. $E \rightarrow V$
4. $V \rightarrow x$
5. $V \rightarrow *E$

LALR(1)

O tamanho das tabelas LR(1) pode ser muito grande.

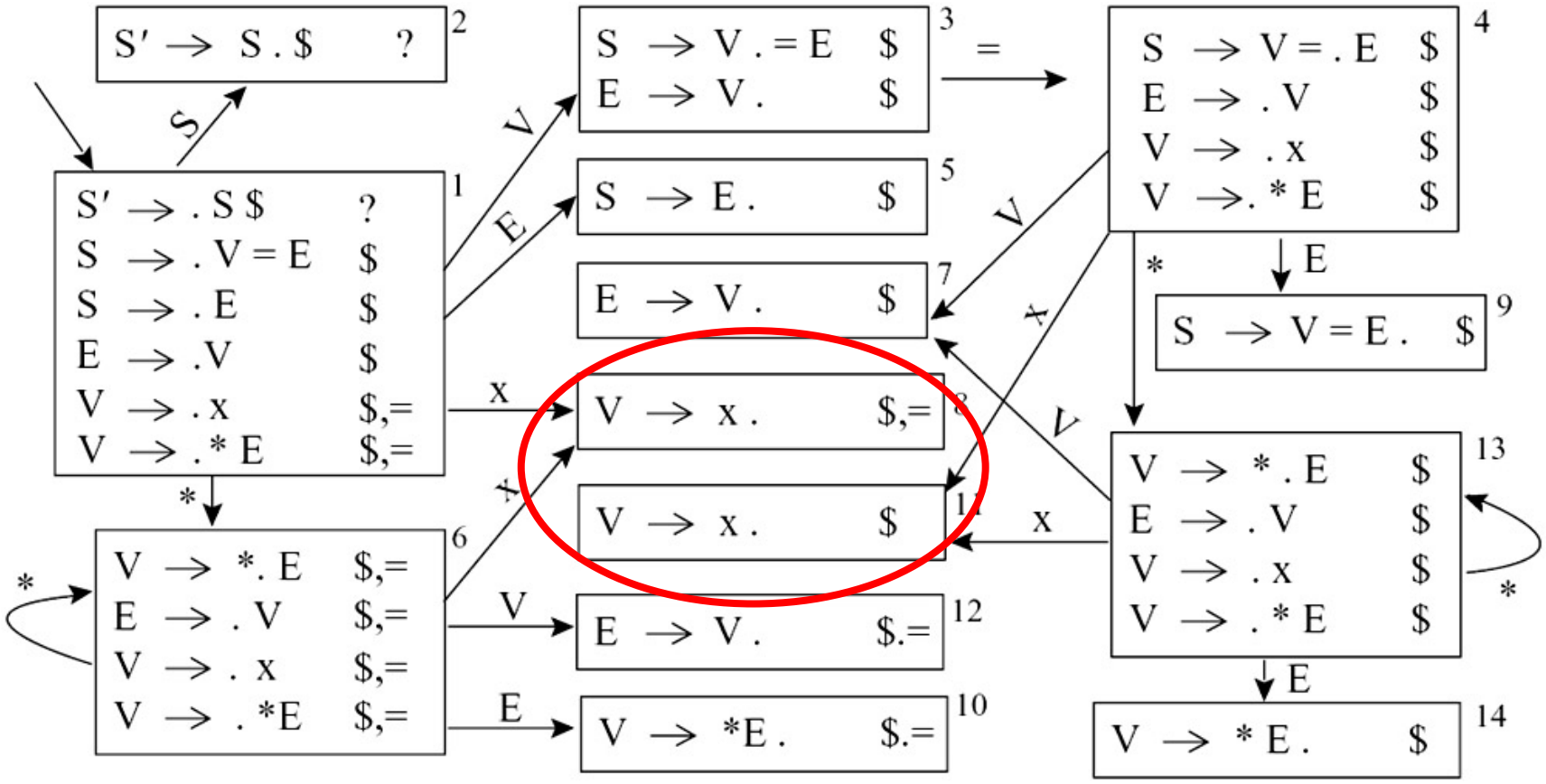
É possível reduzir unindo estados do DFA.

Junte os estados que possuam os itens idênticos, exceto pelo lookahead.

Look-**A**head **L**eft-to-right parsing, **R**ightmost-derivation, **1**-symbol lookahead

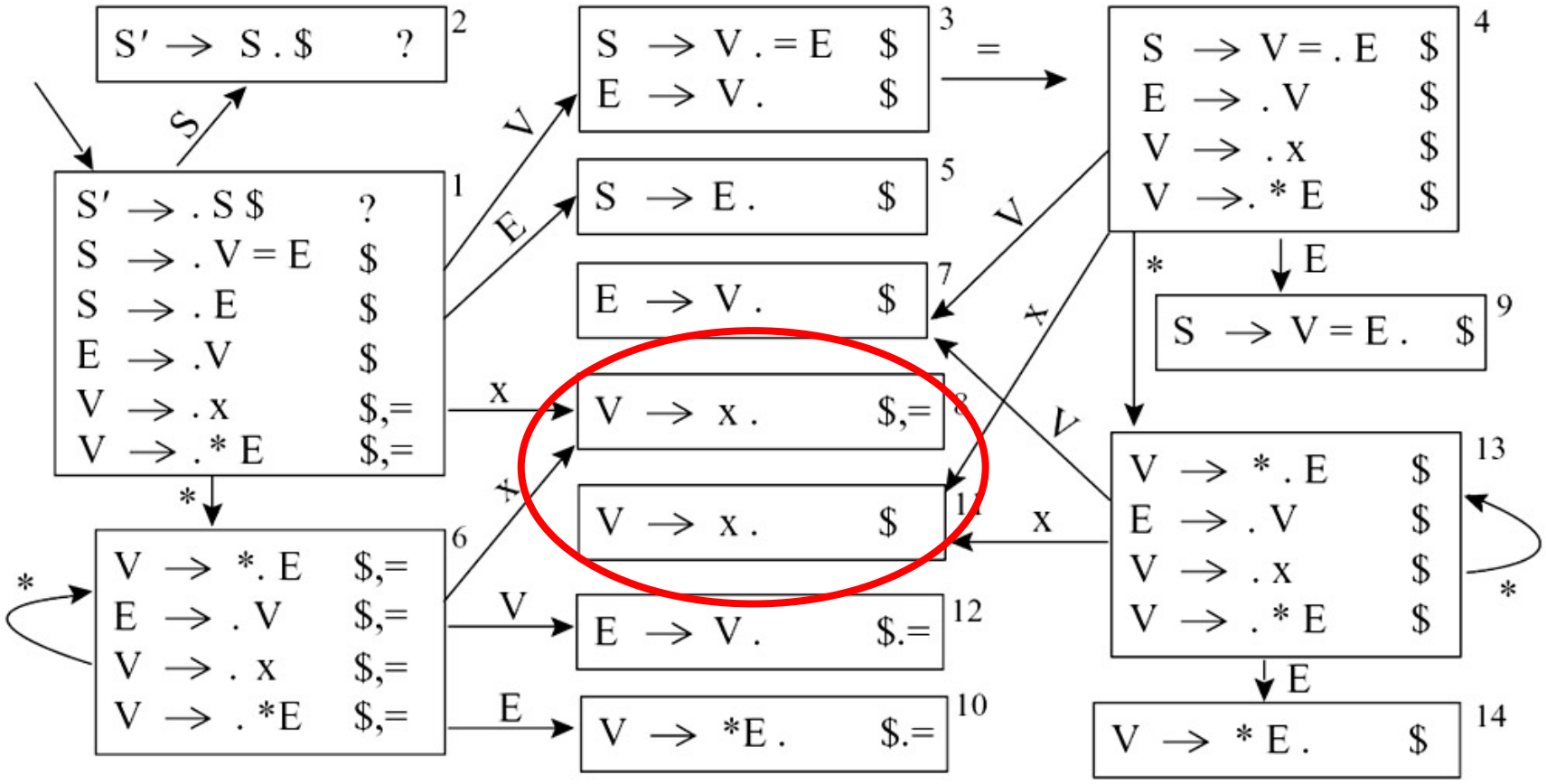
Voltando ao exemplo anterior...

LALR(1)

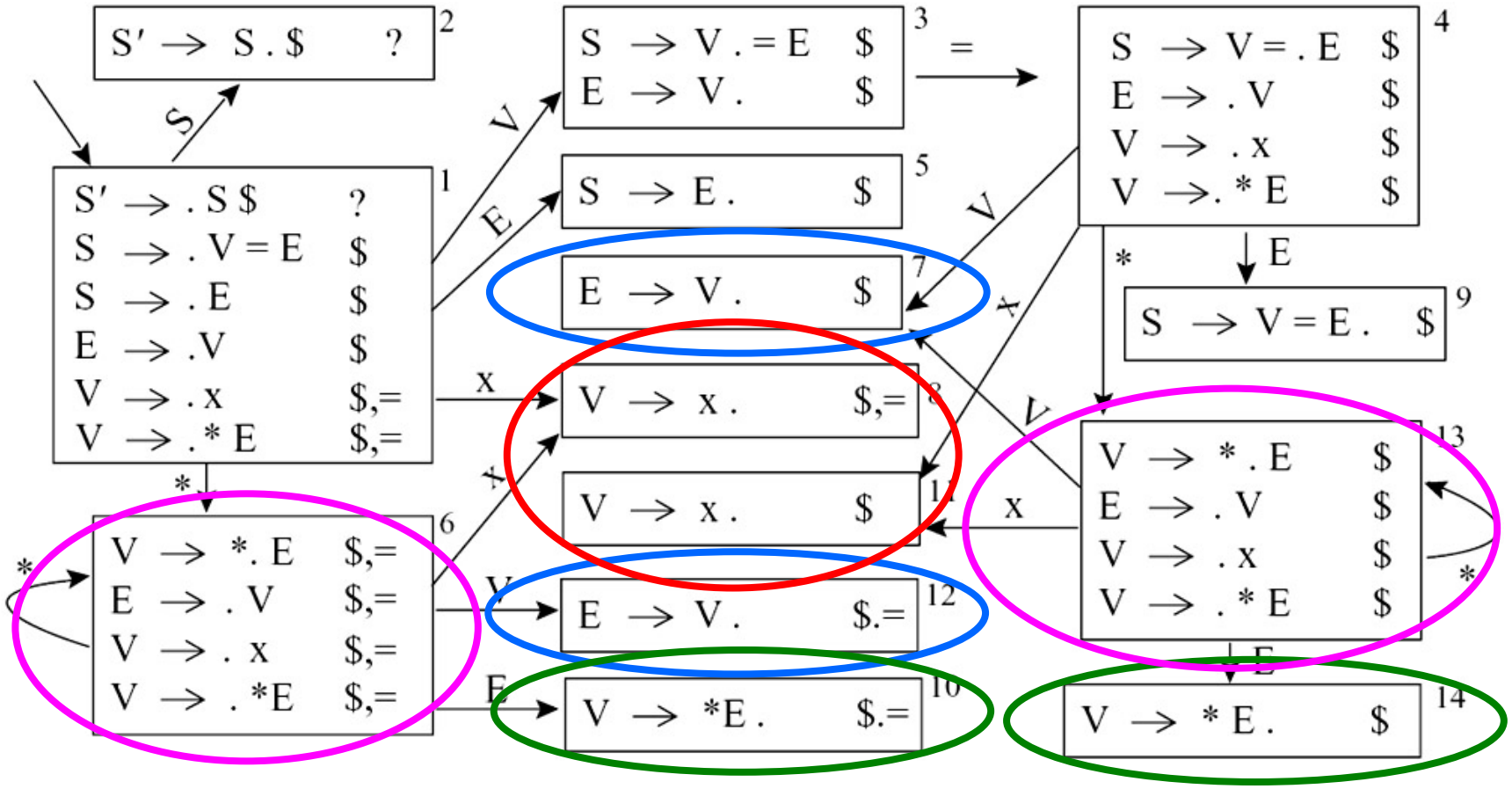

S′ → S . $? 2
S → V . = E $
E → V . $ 3
=
S → V = . E $
E → . V $
V → . x $
V → . * E $ 4
S′ → . S $?
S → . V = E $
S → . E $
E → . V $
V → . x $,=
V → . * E $,= 1
S → E . $ 5
E → V . $ 7
V → x . $,= 8
V → x . $ 11
S → V = E . $ 9
V → * . E $
E → . V $
V → . x $
V → . * E $ 13
V → * . E $,=
E → . V $,=
V → . x $,=
V → . *E $,= 6
E → V . $.= 12
V → *E . $.= 10
V → * E . $ 14
S
V
E
x
*
V
E
x
*
V
x
V
E
x
*
V
E
x
*

LALR(1)

Mais algum???



LALR(1)


S′ → S . $?
2
S
S′ → . S $?
S → . V = E $
S → . E $
E → .V $
V → . x $,=
V → . * E $,=
1
V
E
x
*
V → *. E $,=
E → . V $,=
V → . x $,=
V → . *E $,=
6
S → V . = E $
E → V . $
3
=
S → E . $
5
E → V . $
7
V → x . $,=
8
V → x . $
11
E → V . $.=
12
V → *E . $.=
10
S → V = . E $
E → . V $
V → . x $
V → . * E $
4
E
S → V = E . $
9
V → * . E $
E → . V $
V → . x $
V → . * E $
13
V → * E . $
14

LALR(1)

	x	*	=	$	*S*	*E*	*V*
1	s8	s6			g2	g5	g3
2				a			
3			s4	r3			
4	s11	s13				g9	g7
5				r2			
6	s8	s6				g10	g12
7				r3			
8			r4	r4			
9				r1			
10			r5	r5			
11				r4			
12			r3	r3			
13	s11	s13				g14	g7
14				r5			

(a) LR(1)

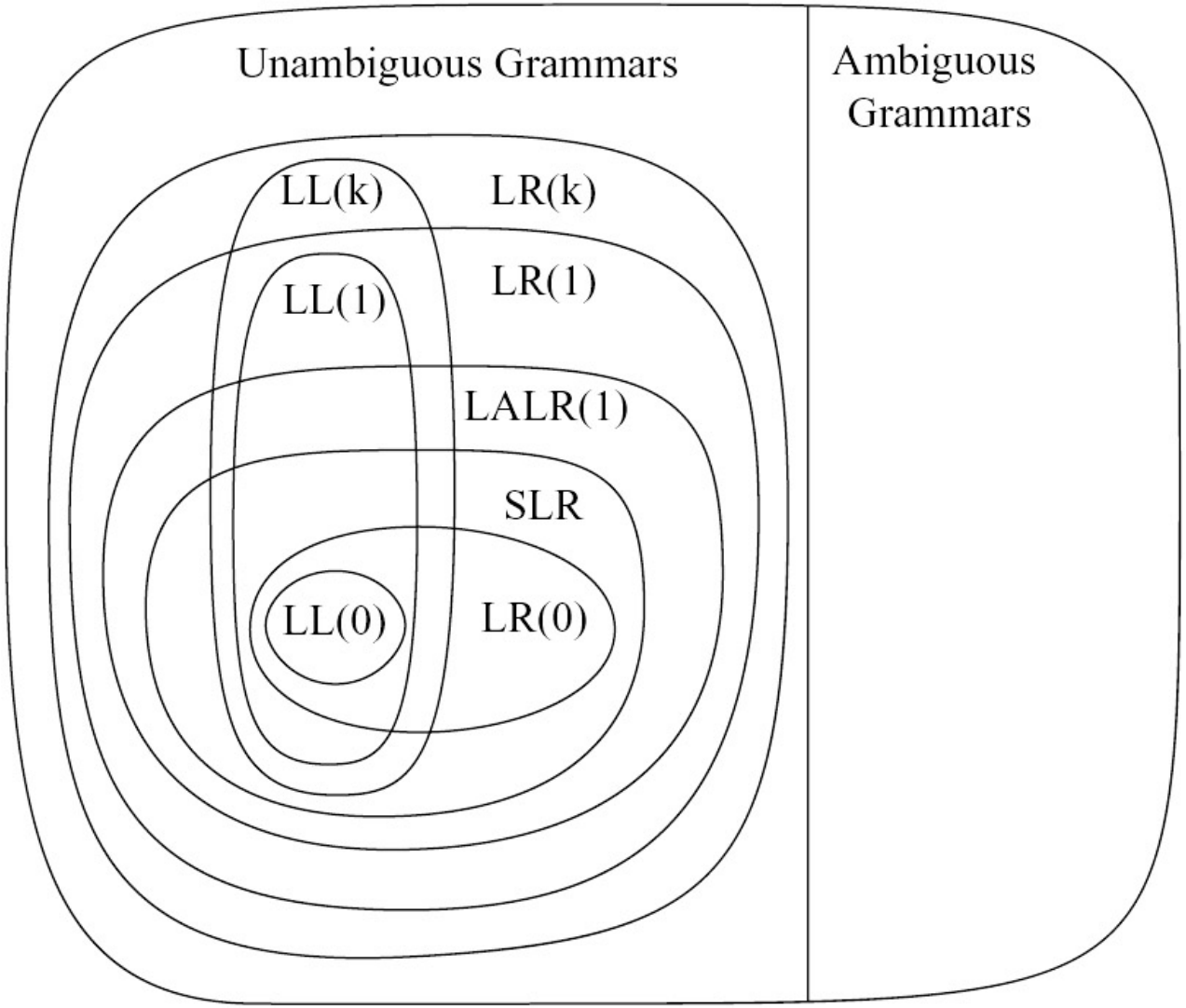
	x	*	=	$	*S*	*E*	*V*
1	s8	s6			g2	g5	g3
2				a			
3			s4	r3			
4	s8	s6				g9	g7
5				r2			
6	s8	s6				g10	g7
7			r3	r3			
8			r4	r4			
9				r1			
10			r5	r5			

(b) LALR(1)

LALR(1)

- Pode gerar uma tabela com conflitos, onde a LR(1) não possuía.
- Na prática, o efeito de redução no uso de memória é bastante desejável.
- A maioria das linguagens de programação é LALR(1).
- É o tipo mais usado em geradores automáticos de *parser*.

Hierarquia das Gramáticas



Lista de Exercícios

Lista 13

- Exercícios teóricos