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CSEN 1003 Compiler, Spring Term 2019
Practice Assignment 7
Discussion: 27.03.18 - 02.04.18

Exercise 7-1
LR(0) Automaton

Is it possible that the following items constitute an item set in an LR(0) automaton? Justify your answer.

$$\begin{array}{lcl} A & \rightarrow & \text{P.Q} \\ P & \rightarrow & .\mathtt{e} \\ Q & \rightarrow & .\mathtt{e} \end{array}$$

Solution:

The item set must be complete: so the answer is NO: $P \rightarrow .\mathtt{e}$ should not be part of it as we entered this set on a shift on P.

(Note that we can add the item $Q \rightarrow .P$ to create a complete valid item set, but this was not the question!). Whether or not an item set makes the grammar LR(0) or not does not define the validity of an item set.

Exercise 7-2
LR(0) Item sets

Which of the following pairs of terms can co-exist in an LR(0) item set:

a) $\begin{array}{lcl} A & \rightarrow & P.Q \\ B & \rightarrow & QP. \end{array}$

Solution:

Yes. Both correspond to a shift on P, but to co-exist we need to show that the items are related. So we could have the previous state as $B \rightarrow Q.P$ with the additional item $P \rightarrow .A$ and $A \rightarrow .PQ$ Now a shift on P gives the items above as co-existing items.

b) $\begin{array}{lcl} A & \rightarrow & P.Q \\ B & \rightarrow & PQ. \end{array}$

Solution:

No, because one corresponds to a shift on P, while the second item corresponds to a shift on Q. We cannot connect these items.

c) $\begin{array}{lcl} A & \rightarrow & P.Q \\ B & \rightarrow & P.Q \end{array}$

[0]Exercises are due to Dr. Carmen Gervet and Pearson textbook

Solution:

Yes with $P \to B$ for instance as extra production (thus in the previous state we have $A \to .PQ$, $P \to .B$ and $B \to .PQ$). A shift on P yields the items.

d) $$\begin{array}{lcl} A & \to & P.Q \\ A & \to & .Q \end{array}$$

Solution:

Yes, if $Q \to$ A is part of the grammar.

Exercise 7-3

LR(0) Automaton and SLR Parsing

Consider the following grammar:

$$\begin{array}{lcl} S & \to & X\texttt{a} \\ X & \to & \texttt{a} \mid \texttt{a}X\texttt{b} \end{array}$$

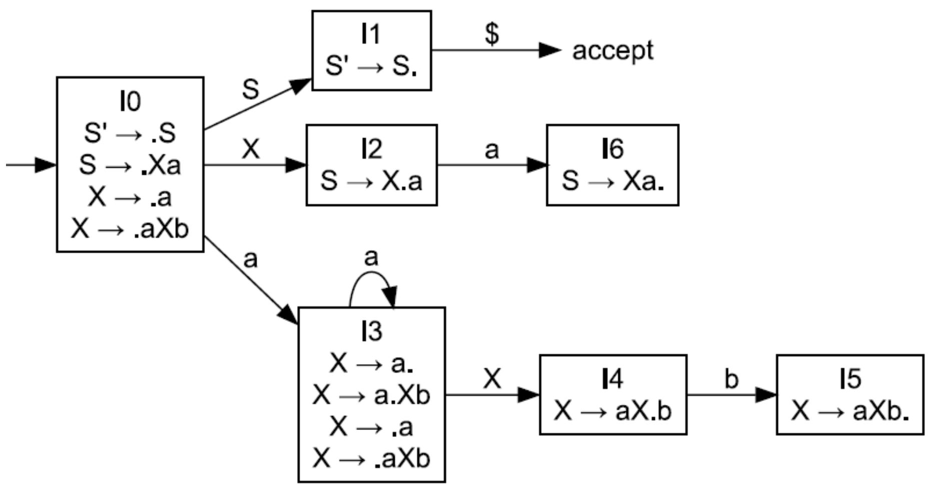
a) Compute the LR(0) item sets and construct the DFA of the augmented grammar.

Solution:

Augmented grammar:

$$\begin{array}{lcl} S' & \to & S \\ S & \to & X\texttt{a} \\ X & \to & \texttt{a} \mid \texttt{a}X\texttt{b} \end{array}$$

DFA:



b) Construct the SLR parsing table.

Solution:

Rule numbering:

1. $S \to X\texttt{a}$
2. $X \to \texttt{a}$
3. $X \to \texttt{a}X\texttt{b}$

Parsing table:

State	Action			GOTO	
	a	b	\$	S	X
0	s3			1	2
1			acc		
2	s6				
3	s3,r2	r2			4
4		s5			
5	r3	r3			
6			r1		

Note: The table above shows that the grammar is *not* SLR(1) since there is a shift/reduce conflict in state I_3. However, in this case it is safe to always resolve the conflict in favor of shifting.

c) Use the parsing table to simulate SLR parsing on the string: `aaba`

Solution:

Stack	Input	Action
0	`aaba`\$	shift
0 3	`aba`\$	shift
0 3 3	`ba`\$	reduce $X \to$ `a`
0 3 4	`ba`\$	shift
0 3 4 5	`a`\$	reduce $X \to \mathtt{a}X\mathtt{b}$
0 2	`a`\$	shift
0 2 6	\$	reduce $S \to X\mathtt{a}$
0 1	\$	accept

Exercise 7-4

LR(0) Automaton and SLR Parsing

Consider the following grammar:

$$
\begin{aligned}
S &\to \mathtt{a}S\mathtt{c} \mid T\mathtt{d} \\
T &\to T\mathtt{b} \mid \mathtt{b}
\end{aligned}
$$

a) Compute the LR(0) item sets and construct the DFA of the augmented grammar.

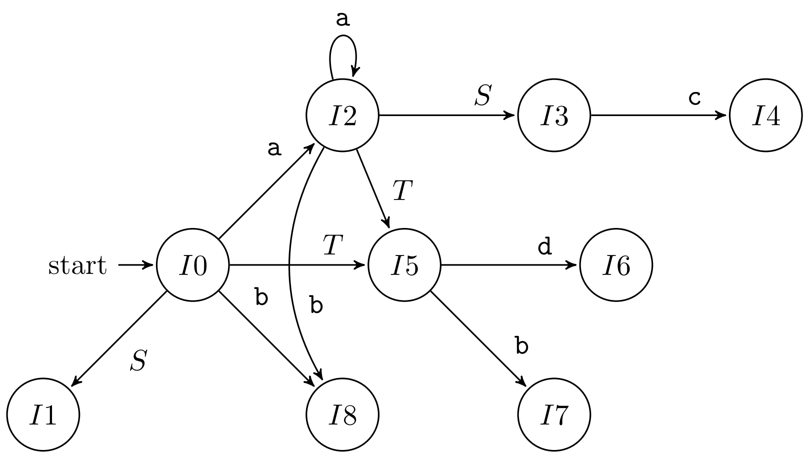
Solution:

Augmented Grammar:

$$
\begin{aligned}
S' &\to S \\
S &\to \mathtt{a}S\mathtt{c} \mid T\mathtt{d} \\
T &\to T\mathtt{b} \mid \mathtt{b}
\end{aligned}
$$

LR(0) Item sets:

I_0: $S' \to \cdot S$ $S \to \cdot \mathtt{a}S\mathtt{c}$ $S \to \cdot T\mathtt{d}$ $T \to \cdot T\mathtt{b}$ $T \to \cdot \mathtt{b}$	I_1: $S' \to S\cdot$	I_2: $S \to \mathtt{a} \cdot S\mathtt{c}$ $S \to \cdot \mathtt{a}S\mathtt{c}$ $S \to \cdot T\mathtt{d}$ $T \to \cdot T\mathtt{b}$ $T \to \cdot \mathtt{b}$
I_3: $S \to \mathtt{a}S \cdot \mathtt{c}$	I_4: $S \to \mathtt{a}S\mathtt{c}\cdot$	I_5: $S \to T \cdot \mathtt{d}$ $T \to T \cdot \mathtt{b}$
I_6: $S \to T\mathtt{d}\cdot$	I_7: $T \to T\mathtt{b}\cdot$	I_8: $T \to \mathtt{b}\cdot$



b) Construct the SLR parsing table.

Solution:

Rule numbering:

1. $S \to \mathtt{a}S\mathtt{c}$
2. $S \to T\mathtt{d}$
3. $T \to T\mathtt{b}$
4. $T \to \mathtt{b}$

Parsing table:

State	Action					GOTO	
	a	b	c	d	$	S	X
0	s2	s8				1	5
1					acc		
2	s2	s8				3	5
3			s4				
4			r1		r1		
5		s7		s6			
6			r2		r2		
7		r3		r3			
8		r4		r4			

c) Is this grammar SLR ? Justify your answer.

Solution:

The table above shows that the grammar is SLR since there is no conflicts.

d) Use the parsing table to simulate SLR parsing on the string: `aabdcc`

Solution:

Stack	Input	Action
0	`aabdcc`$	shift
0 2	`abdcc`$	shift
0 2 2	`bdcc`$	shift
0 2 2 8	`dcc`$	reduce $T \to \texttt{b}$
0 2 2 5	`dcc`$	shift
0 2 2 5 6	`cc`$	reduce $S \to T\texttt{b}$
0 2 2 3	`cc`$	shift
0 2 2 3 4	`c`$	reduce $S \to \texttt{a}S\texttt{c}$
0 2 3	`c`$	shift
0 2 3 4	$	reduce $S \to \texttt{a}S\texttt{c}$
0 2 1	$	accept

Exercise 7-5

Consider the following grammar:

$$\begin{array}{lcl} S & \to & T\,\texttt{,}\,S \mid \varepsilon \\ T & \to & \texttt{int 0} \end{array}$$

a) Compute the LR(0) item sets and construct the DFA of the augmented grammar.

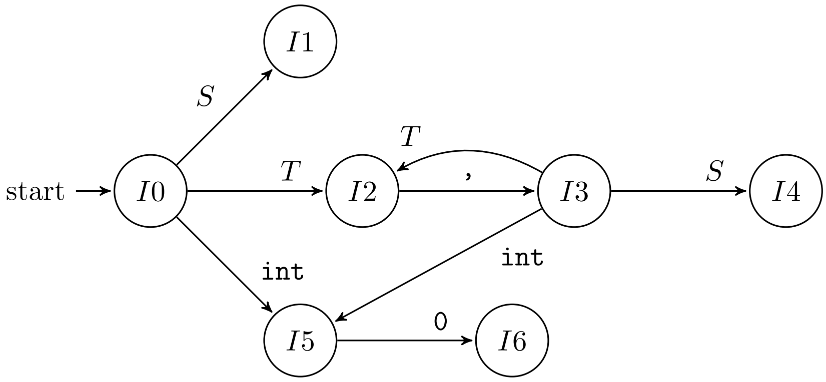
Solution:

Augmented Grammar:

$$\begin{array}{lcl} S' & \to & S \\ S & \to & T\,\texttt{,}\,S \mid \varepsilon \\ T & \to & \texttt{int 0} \end{array}$$

LR(0) Item sets:

I_0: $S' \to \cdot S$ $S \to \cdot T\,\texttt{,}\,S$ $S \to \cdot$ $T \to \cdot\texttt{int 0}$	I_1: $S' \to S\cdot$	I_2: $S \to T \cdot \texttt{,}\,S$
I_3: $S \to T\,\texttt{,} \cdot S$ $S \to \cdot T\,\texttt{,}\,S$ $S \to \cdot$ $T \to \cdot\texttt{int 0}$	I_4: $S \to T\,\texttt{,}\,S\cdot$	I_5: $T \to \texttt{int} \cdot \texttt{0}$



b) Construct the SLR parsing table.

Solution:

Rule numbering:

1. $S \;\rightarrow\; T\,\texttt{,}\,S$
2. $S \;\rightarrow\; \varepsilon$
3. $T \;\rightarrow\;$ `int 0`

Parsing table:

	Action				GOTO	
State	`int`	`0`	`,`	\$	S	X
0	s5			r2	1	2
1				acc		
2			s3			
3	s5			r2	4	2
4				r1		
5		s6				
6			r3			

c) Is this grammar SLR ? Justify your answer.

Solution:

The table above shows that the grammar is SLR since there are no conflicts.

d) Use the parsing table to simulate SLR parsing on the string: `int 0 , int 0`

Solution:

Stack	Input	Action
0	`int 0 , int 0`\$	shift
0 5	`0 , int 0`\$	shift
0 5 6	`, int 0`\$	reduce $T \rightarrow$ `int 0`
0 2	`, int 0`\$	shift
0 2 3	`int 0`\$	shift
0 2 3 5	`0`\$	shift
0 2 3 5 6	\$	Error