CSEN 1003: Compilers

Tutorial 7 - Simple LR Parsing

Today's Plan

1. LR Parsing

2. SLR Parsing

3. Recap

LR Parsing

- LR(k) Parsers are deterministic shift-reduce bottom up parsers.

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  - Left to right input scanning.
  - Reverse of a Right-most derivation.
  - k symbols of lookahed.
- LR grammars are grammars for which deterministic LR parsers can be constructed.

Conflicts in Shift-Reduce Parsers

Example

Consider the following grammar:

$$
\begin{array}{lcl}
E & \rightarrow & E + T \mid E - T \mid T \\
T & \rightarrow & T * F \mid T \, / \, F \mid F \\
F & \rightarrow & \textbf{num} \mid \textbf{id}
\end{array}
$$

and the string: **id + num * id**.

	Stack	Input	Action
1	\$	**id - num * id \$**	Shift
2	\$**id**	**- num * id \$**	Reduce $F \rightarrow$ **id**
..	..	..	..
..	..	..	..
13	\$$E$-$T$	\$	Reduce $E \rightarrow E$-T

LR(0) Items and LR(0) DFA

- An LR(0) item is a production rule with a dot somewhere on the RHS.
    - $A \rightarrow \alpha.\beta$ indicates the state of the parser attempting to parse the input using the rule $A \rightarrow \alpha\beta$ where α is already parsed, and the parser is expecting to parse β next (example: $E \rightarrow E.+T$).
    - Whenever, $A \rightarrow \alpha\beta.$, it might be suitable to reduce $\alpha\beta$ to A (example: $E \rightarrow E + T.$).

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  - Whenever, $A \rightarrow \alpha\beta.$, it might be suitable to reduce $\alpha\beta$ to A (example: $E \rightarrow E + T.$).
- The LR(0) DFA keeps track of the state of the parser regarding what we saw so far and what we need to do next.

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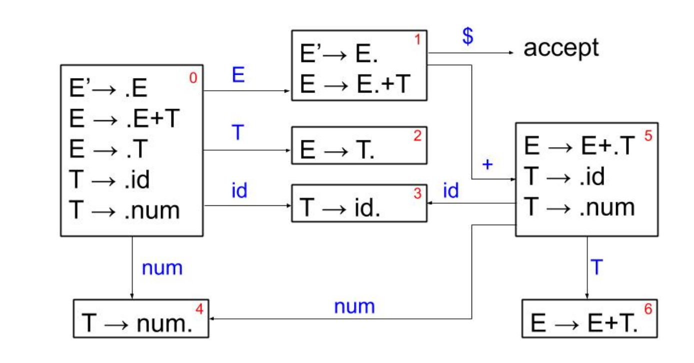
Step 1: LR(0) DFA Construction

Example

$$\begin{array}{lcl} E & \to & (a)\ E + T \mid (b)\, T \\ T & \to & (c)\ \textbf{num} \mid (d)\ \textbf{id} \end{array}$$



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  3. If $A \neq S'$ and $A \to \alpha. \in q$, $ACTION(q, a) = reduce\ A \to \alpha$ where $a \in Follow(A)$.

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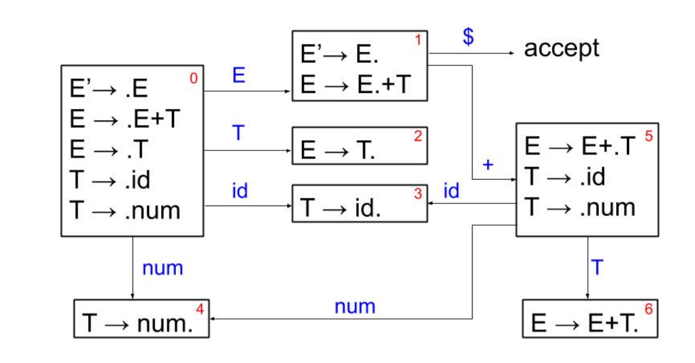
  3. If $A \neq S'$ and $A \to \alpha. \in q$, $ACTION(q, a) = reduce\ A \to \alpha$ where $a \in Follow(A)$.
  4. If $S' \to S. \in q$, $ACTION(q, \$) = accept$.
- If conflicts arise while filling the table, then the grammar is not SLR.

LR(0) Automaton

Example

$$\begin{array}{lcl} E & \rightarrow & (a)\ E + T \mid (b)\,T \\ T & \rightarrow & (c)\ \textbf{num} \mid (d)\ \textbf{id} \end{array}$$



SLR Parsing Table Example

Example

$$
\begin{array}{lcl}
E & \rightarrow & (a)\ E + T \mid (b)\,T \\
T & \rightarrow & (c)\ \textbf{num} \mid (d)\ \textbf{id}
\end{array}
$$

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

State	Action				GOTO	
	+	id	num	$	E	T
0		s3	s4		1	2
1	s5			acc		
2	rb			rb		
3	rc			rc		
4	rd			rd		
5		s3	s4			6
6	ra			ra		

Step 3: The LR Parsing Algorithm

1. Push the start state of the LR(0) automaton to the stack.
2. Loop (S is the top the stack, a is the next input symbol):
   - a. If $ACTION[S, a] = \mathit{shift}\ i$, push i to the stack.
   - b. If $ACTION[S, a] = \mathit{reduce}\ A \to \alpha$, pop $|\alpha| = r$ states off the stack and push $GOTO(q_{n-r}, A)$.

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id + num $**	

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id** + **num** $	Shift 3

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id** + **num** $	Shift 3
2	03	**id**	+ **num** $	

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id + num $**	Shift 3
2	03	**id**	**+ num $**	Reduce $T \to id$

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id** + **num** $	Shift 3
2	03	**id**	+ **num** $	Reduce $T \rightarrow id$
3	02	T	+ **num** $	

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id** + **num** $	Shift 3
2	03	**id**	+ **num** $	Reduce $T \rightarrow id$
3	02	T	+ **num** $	Reduce $E \rightarrow T$
4	01	E	+ **num** $	

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id** + **num** $	Shift 3
2	03	**id**	+ **num** $	Reduce $T \rightarrow id$
3	02	T	+ **num** $	Reduce $E \rightarrow T$
4	01	E	+ **num** $	Shift 5

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id** + **num** $	Shift 3
2	03	**id**	+ **num** $	Reduce $T \rightarrow id$
3	02	T	+ **num** $	Reduce $E \rightarrow T$
4	01	E	+ **num** $	Shift 5
5	015	E+	**num**$	

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id** + **num** $	Shift 3
2	03	**id**	+ **num** $	Reduce $T \rightarrow id$
3	02	T	+ **num** $	Reduce $E \rightarrow T$
4	01	E	+ **num** $	Shift 5
5	015	E+	**num**$	Shift 4
6	0154	E+**num**	$	

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id + num $**	Shift 3
2	03	**id**	**+ num $**	Reduce $T \rightarrow id$
3	02	T	**+ num $**	Reduce $E \rightarrow T$
4	01	E	**+ num $**	Shift 5
5	015	E+	**num$**	Shift 4
6	0154	E+**num**	**$**	Reduce $T \rightarrow num$

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id** + **num** $	Shift 3
2	03	**id**	+ **num** $	Reduce $T \rightarrow id$
3	02	T	+ **num** $	Reduce $E \rightarrow T$
4	01	E	+ **num** $	Shift 5
5	015	E+	**num**$	Shift 4
6	0154	E+**num**	$	Reduce $T \rightarrow num$
7	0156	E+T	$	

SLR Parsing Example

Example

	Stack	Symbols	Input	Action
1	0		**id + num $**	Shift 3
2	03	**id**	**+ num $**	Reduce $T \rightarrow id$
3	02	T	**+ num $**	Reduce $E \rightarrow T$
4	01	E	**+ num $**	Shift 5
5	015	E+	**num$**	Shift 4
6	0154	E+**num**	**$**	Reduce $T \rightarrow num$
7	0156	E+T	**$**	Reduce $E \rightarrow E + T$
8	01	E	**$**	

SLR Parsing Example

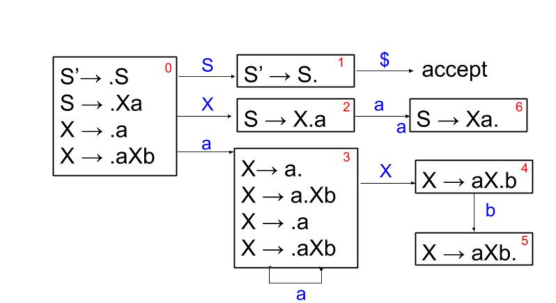
Example

	Stack	Symbols	Input	Action
1	0		**id** + **num** $	Shift 3
2	03	**id**	+ **num** $	Reduce $T \to id$
3	02	T	+ **num** $	Reduce $E \to T$
4	01	E	+ **num** $	Shift 5
5	015	E+	**num**$	Shift 4
6	0154	E+**num**	$	Reduce $T \to num$
7	0156	E+T	$	Reduce $E \to E + T$
8	01	E	$	accept

Conflicts Example - Exercise 7-3

Example

$$
\begin{array}{lcl}
S & \rightarrow & X\mathtt{a} \\
X & \rightarrow & \mathtt{a} \mid \mathtt{a}X\mathtt{b}
\end{array}
$$



State	a	b	$	S	X
3	s3,r$X \rightarrow a$	r$X \rightarrow a$			4

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Covered Topics

1. LR Parsing.
2. The LR(0) Automaton and SLR Parsing.

Next Session: LR(1) and LALR Parsing!