CS31003: Compilers: Shift-Reduce Parsing

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Grammar

$$
\begin{array}{lrcl}
1: & E & \rightarrow & E + T \\
2: & E & \rightarrow & T \\
3: & T & \rightarrow & T * F \\
4: & T & \rightarrow & F \\
5: & F & \rightarrow & (E) \\
6: & F & \rightarrow & \textbf{id}
\end{array}
$$

Parse Table

State	Action						GO TO		
	id	+	*	(	)	$	E	T	F
0	s5			s4			1	2	3
1		s6				acc			
2		r2	s7		r2	r2			
3		r4	r4		r4	r4			
4	s5			s4			8	2	3
5		r6	r6		r6	r6			
6	s5			s4				9	3
7	s5			s4					10
8		s6			s11				
9		r1	s7		r1	r1			
10		r3	r3		r3	r3			
11		r5	r5		r5	r5			

Derivation of **id * id + id**

$$
\begin{aligned}
E\ \$ &\Rightarrow \underline{E + T}\ \$ \\
&\Rightarrow E + \underline{F}\ \$ \\
&\Rightarrow E + \underline{\mathbf{id}}\ \$ \\
&\Rightarrow \underline{T} + \mathbf{id}\ \$ \\
&\Rightarrow \underline{T * F} + \mathbf{id}\ \$ \\
&\Rightarrow T * \underline{\mathbf{id}} + \mathbf{id}\ \$ \\
&\Rightarrow \underline{F} * \mathbf{id} + \mathbf{id}\ \$ \\
&\Rightarrow \underline{\mathbf{id}} * \mathbf{id} + \mathbf{id}\ \$
\end{aligned}
$$

Parsing **id * id + id**

Step	Stack	Symbols	Input	Action
(1)	0		**id * id + id $**	shift
(2)	0 5	**id**	* **id + id $**	reduce by $F \rightarrow$ **id**
(3)	0 3	F	* **id + id $**	reduce by $T \rightarrow F$
(4)	0 2	T	* **id + id $**	shift
(5)	0 2 7	T *	**id + id $**	shift
(6)	0 2 7 5	T * **id**	**+ id $**	reduce by $F \rightarrow$ **id**
(7)	0 2 7 10	$T * F$	**+ id $**	reduce by $T \rightarrow T * F$
(8)	0 2	T	**+ id $**	reduce by $E \rightarrow T$
(9)	0 1	E	**+ id $**	shift
(10)	0 1 6	$E +$	**id $**	shift
(11)	0 1 6 5	$E +$ **id**	**$**	reduce by $F \rightarrow$ **id**
(12)	0 1 6 3	$E + F$	**$**	reduce by $T \rightarrow F$
(13)	0 1 6 9	$E + T$	**$**	reduce by $E \rightarrow E + T$
(14)	0 1	E	**$**	accept

Derivation of **id + id * id**

$$
\begin{aligned}
E\ \$ &\Rightarrow \underline{E + T}\ \$ \\
&\Rightarrow E + \underline{T * F}\ \$ \\
&\Rightarrow E + T * \underline{\mathbf{id}}\ \$ \\
&\Rightarrow E + \underline{F} * \mathbf{id}\ \$ \\
&\Rightarrow E + \underline{\mathbf{id}} * \mathbf{id}\ \$ \\
&\Rightarrow \underline{T} + \mathbf{id} * \mathbf{id}\ \$ \\
&\Rightarrow \underline{F} + \mathbf{id} * \mathbf{id}\ \$ \\
&\Rightarrow \underline{\mathbf{id}} + \mathbf{id} * \mathbf{id}\ \$
\end{aligned}
$$

Parsing **id + id * id**

Step	Stack	Symbols	Input	Action
(1)	0		**id + id * id $**	shift
(2)	0 5	**id**	**+ id * id $**	reduce by $F \rightarrow$ **id**
(3)	0 3	F	**+ id * id $**	reduce by $T \rightarrow F$
(4)	0 2	T	**+ id * id $**	reduce by $E \rightarrow T$
(5)	0 1	E	**+ id * id $**	shift
(6)	0 1 6	E **+**	**id * id $**	shift
(7)	0 1 6 5	E **+ id**	*** id $**	shift
(8)	0 1 6 3	$E + F$	*** id $**	reduce by $F \rightarrow$ **id**
(9)	0 1 6 9	$E + T$	*** id $**	reduce by $T \rightarrow F$
(10)	0 1 6 9 7	$E + T$ *****	**id $**	shift
(11)	0 1 6 9 7 5	$E + T$ *** id**	**id $**	reduce by $F \rightarrow$ **id**
(12)	0 1 6 9 7 10	$E + T * F$	**id $**	reduce by $T \rightarrow T * F$
(13)	0 1 6 9	$E + T$	**id $**	reduce by $E \rightarrow E + T$
(14)	0 1	E	**id $**	accept

Derivation of **(id + id) * id**

$$
\begin{aligned}
E\ \$ &\Rightarrow \underline{T}\ \$ \\
&\Rightarrow \underline{T * F}\ \$ \\
&\Rightarrow T * \underline{\mathbf{id}}\ \$ \\
&\Rightarrow \underline{F} * \mathbf{id}\ \$ \\
&\Rightarrow \underline{(E)} * \mathbf{id}\ \$ \\
&\Rightarrow (\ \underline{E + T}\ ) * \mathbf{id}\ \$ \\
&\Rightarrow (\ E + \underline{F}\ ) * \mathbf{id}\ \$ \\
&\Rightarrow (\ E + \underline{\mathbf{id}}\ ) * \mathbf{id}\ \$ \\
&\Rightarrow (\ \underline{T} + \mathbf{id}\ ) * \mathbf{id}\ \$ \\
&\Rightarrow (\ \underline{F} + \mathbf{id}\ ) * \mathbf{id}\ \$ \\
&\Rightarrow (\ \underline{\mathbf{id}} + \mathbf{id}\ ) * \mathbf{id}\ \$
\end{aligned}
$$

Parsing (id + id) * id

Step	Stack	Symbols	Input	Action
(1)	0		**(id + id) * id $**	shift
(2)	0 4	**(**	**id + id) * id $**	shift
(3)	0 4 5	**(id**	**+ id) * id $**	reduce by $F \rightarrow$ **id**
(4)	0 4 3	**(** F	**+ id) * id $**	reduce by $T \rightarrow F$
(5)	0 4 2	**(** T	**+ id) * id $**	reduce by $E \rightarrow T$
(6)	0 4 8	**(** E	**+ id) * id $**	shift
(7)	0 4 8 6	**(** E **+**	**id) * id $**	shift
(8)	0 4 8 6 5	**(** E **+ id**	**) * id $**	reduce by $F \rightarrow$ **id**
(9)	0 4 8 6 3	**(** E **+** F	**) * id $**	reduce by $T \rightarrow F$
(10)	0 4 8 6 9	**(** E **+** T	**) * id $**	reduce by $E \rightarrow E + T$
(11)	0 4 8	**(** E	**) * id $**	shift
(12)	0 4 8 11	**(** E **)**	*** id $**	reduce by $F \rightarrow (E)$
(13)	0 3	F	*** id $**	reduce by $T \rightarrow F$
(14)	0 2	T	*** id $**	shift
(15)	0 2 7	T *****	**id $**	shift
(16)	0 2 7 5	T *** id**	**$**	reduce by $F \rightarrow$ **id**
(17)	0 2 7 10	$T * F$	**$**	reduce by $T \rightarrow T * F$
(18)	0 2	T	**$**	reduce by $E \rightarrow T$
(19)	0 1	E	**$**	accept

Simpler yet Ambiguous Grammar

$$
\begin{array}{lrcl}
1: & E & \rightarrow & E + E \\
2: & E & \rightarrow & E * E \\
3: & E & \rightarrow & (E) \\
4: & E & \rightarrow & \textbf{id}
\end{array}
$$

Ambiguous Derivation of **id * id + id**

Correct derivation: * has precedence over +

$$
\begin{aligned}
E\ \$ &\Rightarrow \underline{E + E}\ \$ \\
&\Rightarrow E + \underline{\mathbf{id}}\ \$ \\
&\Rightarrow \underline{E * E} + \mathbf{id}\ \$ \\
&\Rightarrow E * \underline{\mathbf{id}} + \mathbf{id}\ \$ \\
&\Rightarrow \underline{\mathbf{id}} * \mathbf{id} + \mathbf{id}\ \$
\end{aligned}
$$

Wrong derivation: + has precedence over *

$$
\begin{aligned}
E\ \$ &\Rightarrow \underline{E * E}\ \$ \\
&\Rightarrow E * \underline{E + E}\ \$ \\
&\Rightarrow E * E + \underline{\mathbf{id}}\ \$ \\
&\Rightarrow E * \underline{\mathbf{id}} + \mathbf{id}\ \$ \\
&\Rightarrow \underline{\mathbf{id}} * \mathbf{id} + \mathbf{id}\ \$
\end{aligned}
$$

Parse Table

State	Action						GO TO
	id	+	*	(	)	$	E
0	s3			s2			1
1		s4	s5			acc	
2	s3			s2			6
3		r4	r4		r4	r4	
4	s3			s2			7
5	s3			s2			8
6		s4	s5		s9		
7		r1	s5		r1	r1	
8		r2	r2		r2	r2	
9		r3	r3		r3	r3	

Parsing **id * id + id**

Step	Stack	Symbols	Input	Action
(1)	0		**id * id + id $**	shift
(2)	0 3	**id**	***** **id + id $**	reduce by $E \rightarrow$ **id**
(3)	0 1	E	***** **id + id $**	shift
(4)	0 1 5	E *****	**id + id $**	shift
(5)	0 1 5 3	E ***** **id**	**+ id $**	reduce by $E \rightarrow$ **id**
(6)	0 1 5 8	$E * E$	**+ id $**	reduce by $E \rightarrow E * E$
(7)	0 1	E	**+ id $**	shift
(8)	0 1 4	$E +$	**id $**	shift
(9)	0 1 4 3	$E +$ **id**	**$**	reduce by $E \rightarrow$ **id**
(10)	0 1 4 7	$E + E$	**$**	reduce by $E \rightarrow E + E$
(11)	0 1	E	**$**	accept

$$
\begin{aligned}
E\ \$ &\Rightarrow \underline{E + E}\ \$ \\
&\Rightarrow E + \underline{\textbf{id}}\ \$ \\
&\Rightarrow \underline{E * E} + \textbf{id}\ \$ \\
&\Rightarrow E * \underline{\textbf{id}} + \textbf{id}\ \$ \\
&\Rightarrow \underline{\textbf{id}} * \textbf{id} + \textbf{id}\ \$
\end{aligned}
$$