Compiler Design

Fatemeh Deldar

Isfahan University of Technology

1402-1403

Error Recovery in Predictive Parsing

- An error is detected during predictive parsing when
  1. The terminal on top of the stack does not match the next input symbol
  2. Nonterminal A is on top of the stack, a is the next input symbol, and $M[A, a]$ is error (i.e., the parsing-table entry is empty)

- **Panic Mode**
  - ***Panic-mode error recovery*** is based on the idea of skipping over symbols on the input until a token in a selected set of **synchronizing tokens** appears
  - Its effectiveness depends on the choice of synchronizing set

Error Recovery in Predictive Parsing

- **Panic Mode**
  1. Place all symbols in $FOLLOW(A)$ into the synchronizing set for nonterminal A
  2. If we add symbols in $FIRST(A)$ to the synchronizing set for nonterminal A, then it may be possible to resume parsing according to A if a symbol in $FIRST(A)$ appears in the input
  3. If a nonterminal can generate the empty string, then the production deriving ϵ can be used as a default
     - Doing so may postpone some error detection
  4. If a terminal on top of the stack cannot be matched, a simple idea is to pop the terminal

Error Recovery in Predictive Parsing

- **Panic Mode**
  5. Often, there is a hierarchical structure on constructs in a language; for example, expressions appear within statements, which appear within blocks, and so on. We can add to the synchronizing set of a lower-level construct the symbols that begin higher-level constructs. For example, we might add keywords that begin statements to the synchronizing sets for the nonterminals generating expressions

- **Example**

NON-TERMINAL	INPUT SYMBOL					
	id	+	*	(	)	$
E	$E \mapsto TE'$			$E \to TE'$	synch	synch
E'		$E \to +TE'$			$E \to \epsilon$	$E \to \epsilon$
T	$T \to FT'$	synch		$T \to FT'$	synch	synch
T'		$T' \to \epsilon$	$T' \to *FT'$		$T' \to \epsilon$	$T' \to \epsilon$
F	$F \to$ **id**	synch	synch	$F \to (E)$	synch	synch

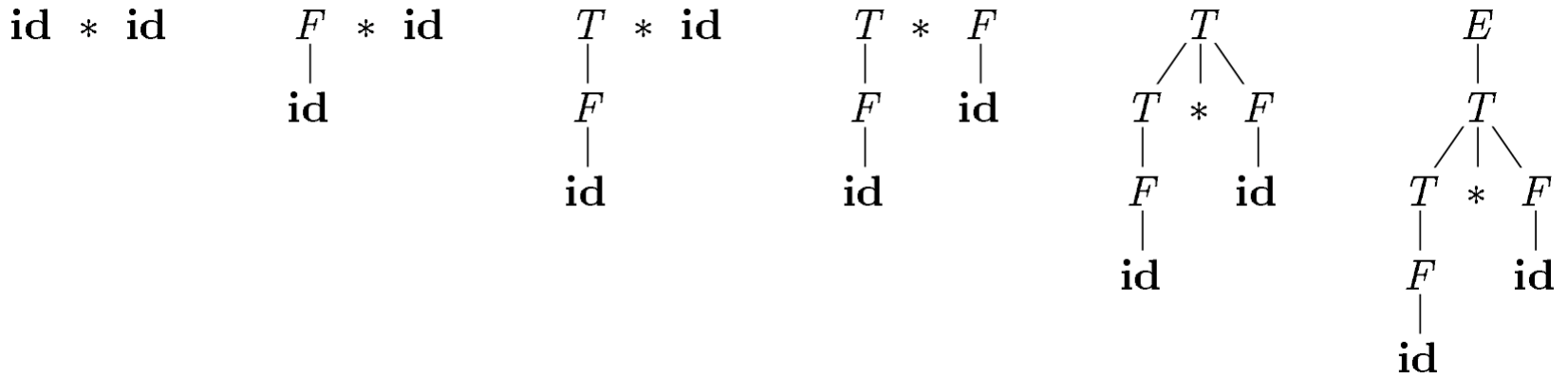
Error Recovery in Predictive Parsing

- **Example**

STACK	INPUT	REMARK
$E\ \$$	$)\ \mathbf{id} * + \mathbf{id}\ \$$	error, skip)
$E\ \$$	$\mathbf{id} * + \mathbf{id}\ \$$	**id** is in FIRST(E)
$TE'\ \$$	$\mathbf{id} * + \mathbf{id}\ \$$	
$FT'E'\ \$$	$\mathbf{id} * + \mathbf{id}\ \$$	
$\mathbf{id}\ T'E'\$$	$\mathbf{id} * + \mathbf{id}\ \$$	
$T'E'\ \$$	$* + \mathbf{id}\ \$$	
$* FT'E'\ \$$	$* + \mathbf{id}\ \$$	
$FT'E'\ \$$	$+ \mathbf{id}\ \$$	error, $M[F, +] =$ synch F has been popped
$T'E'\ \$$	$+ \mathbf{id}\ \$$	
$E'\ \$$	$+ \mathbf{id}\ \$$	
$+ TE'\ \$$	$+ \mathbf{id}\ \$$	
$TE'\ \$$	$\mathbf{id}\ \$$	
$FT'E'\ \$$	$\mathbf{id}\ \$$	
$\mathbf{id}\ T'E'\ \$$	$\mathbf{id}\ \$$	
$T'E'\ \$$	$\$$	
$E'\ \$$	$\$$	
$\$$	$\$$	

Bottom-Up Parsing

- A bottom-up parse corresponds to the construction of a parse tree for an input string beginning at the leaves (the bottom) and working up towards the root (the top)
- **Example**



Bottom-Up Parsing

- **Reductions**
  - We can think of bottom-up parsing as the process of ***reducing*** a string w to the start symbol of the grammar
  - The key decisions during bottom-up parsing are about when to reduce and about what production to apply, as the parse proceeds
  - **Example**
    - The sequence of reductions in the previous example:
      - $id * id,\ F * id,\ T * id,\ T * F,\ T,\ E$
  - A reduction is the reverse of a step in a derivation
  - The goal of bottom-up parsing is therefore to construct a derivation in reverse
  - **In previous example:** $E \Rightarrow T \Rightarrow T * F \Rightarrow T * \mathbf{id} \Rightarrow F * \mathbf{id} \Rightarrow \mathbf{id} * \mathbf{id}$
    - ***This derivation is in fact a rightmost derivation***

Bottom-Up Parsing

- **Handle Pruning**
  - Bottom-up parsing during a left-to-right scan of the input constructs a ***rightmost derivation in reverse***
  - A ***handle*** is a substring that matches the body of a production, and whose reduction represents one step along the reverse of a rightmost derivation
  - **Example**

RIGHT SENTENTIAL FORM	HANDLE	REDUCING PRODUCTION
$\mathbf{id}_1 * \mathbf{id}_2$	$\mathbf{id}_1$	$F \to \mathbf{id}$
$F * \mathbf{id}_2$	F	$T \to F$
$T * \mathbf{id}_2$	$\mathbf{id}_2$	$F \to \mathbf{id}$
$T * F$	$T * F$	$T \to T * F$
T	T	$E \to T$

Bottom-Up Parsing

- **Shift-Reduce Parsing**
  - **Shift-reduce parsing is a form of bottom-up parsing** in which a stack holds grammar symbols and an input buffer holds the rest of the string to be parsed
  - The **handle always appears at the top of the stack** just before it is identified as the handle
  - We use $ to mark the bottom of the stack and also the right end of the input
  - In bottom-up parsing, we show **the top of the stack on the right**, rather than on the left as we did for top-down parsing

Bottom-Up Parsing

- **Shift-Reduce Parsing**
  - Initially, the stack is empty, and the string *w* is on the input

STACK	INPUT
$	*w* $

  - If parser enters the following configuration announces successful completion of parsing

STACK	INPUT
$ *S*	$

Bottom-Up Parsing

- **Shift-Reduce Parsing**
  - **Example**

STACK	INPUT	ACTION
$	$\mathbf{id}_1 * \mathbf{id}_2$ $	shift
$ $\mathbf{id}_1$	$* \mathbf{id}_2$ $	reduce by $F \to \mathbf{id}$
$ F	$* \mathbf{id}_2$ $	reduce by $T \to F$
$ T	$* \mathbf{id}_2$ $	shift
$ $T *$	$\mathbf{id}_2$ $	shift
$ $T * \mathbf{id}_2$	$	reduce by $F \to \mathbf{id}$
$ $T * F$	$	reduce by $T \to T * F$
$ T	$	reduce by $E \to T$
$ E	$	accept

Bottom-Up Parsing

- **Shift-Reduce Parsing**
  - Possible actions a shift-reduce parser can make
    1. **Shift**
       - Shift the next input symbol onto the top of the stack
    2. **Reduce**
       - The right end of the string to be reduced must be at the top of the stack
       - Locate the left end of the string within the stack and decide with what nonterminal to replace the string
    3. **Accept**
       - Announce successful completion of parsing.
    4. **Error**
       - Discover a syntax error and call an error recovery routine.

Bottom-Up Parsing

- Conflicts During Shift-Reduce Parsing
  - **Shift/Reduce conflict**

stmt	→	**if** *expr* **then** *stmt*
	|	**if** *expr* **then** *stmt* **else** *stmt*
	|	**other**

STACK	INPUT
··· **if** *expr* **then** *stmt*	**else** ··· $

  - **Reduce/Reduce conflict**

(1)	*stmt*	→	**id** (*parameter_list*)
(2)	*stmt*	→	*expr* := *expr*
(3)	*parameter_list*	→	*parameter_list* , *parameter*
(4)	*parameter_list*	→	*parameter*
(5)	*parameter*	→	**id**
(6)	*expr*	→	**id** (*expr_list*)
(7)	*expr*	→	**id**
(8)	*expr_list*	→	*expr_list* , *expr*
(9)	*expr_list*	→	*expr*

STACK	INPUT
··· **id** (**id**	, **id**) ···