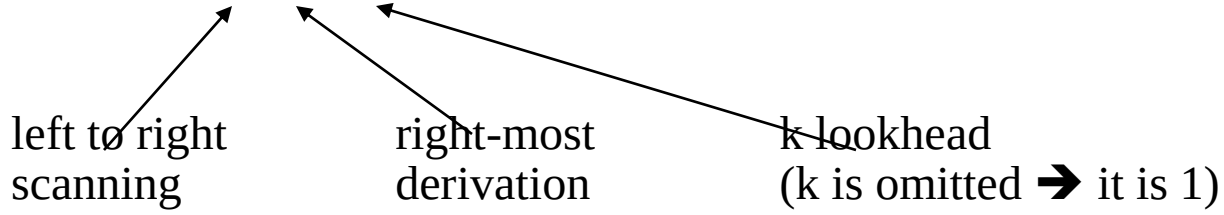
LR Parsing

LR Parsers

- The most powerful shift-reduce parsing (yet efficient) is:

LR(k) parsing.



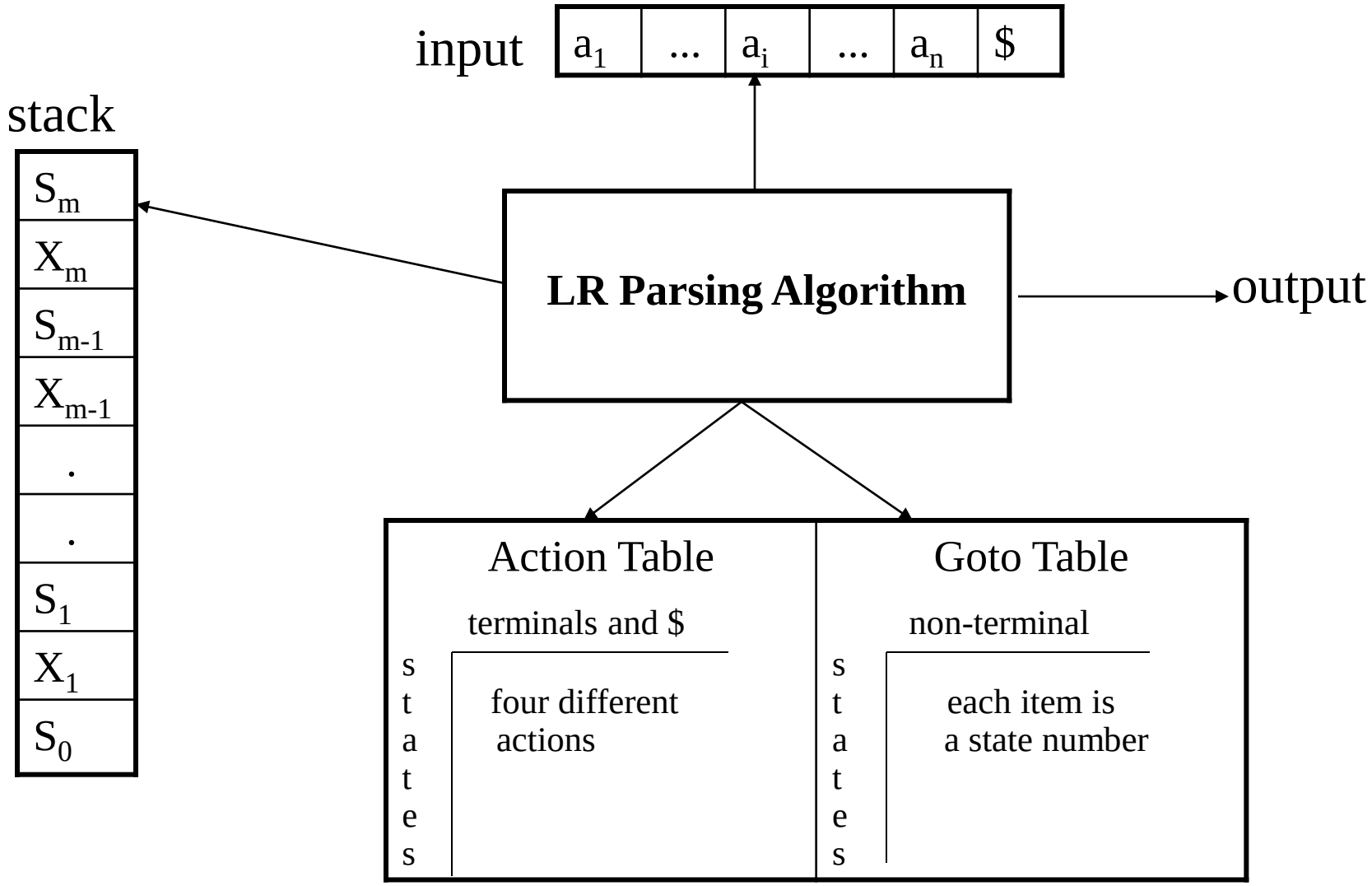
- LR parsing is attractive because:
  - LR parsing is most general non-backtracking shift-reduce parsing, yet it is still efficient.
  - The class of grammars that can be parsed using LR methods is a proper superset of the class of grammars that can be parsed with predictive parsers.

    LL(1)-Grammars $\subset$ LR(1)-Grammars
  - An LR-parser can detect a syntactic error as soon as it is possible to do so a left-to-right scan of the input.

LR Parsers

- **LR-Parsers**
  - covers wide range of grammars.
  - SLR – simple LR parser
  - LR – most general LR parser
  - LALR – intermediate LR parser (look-head LR parser)
  - SLR, LR and LALR work same (they used the same algorithm), only their parsing tables are different.

LR Parsing Algorithm



A Configuration of LR Parsing Algorithm

- A configuration of a LR parsing is:

$$(S_o X_1 S_1 \ldots X_m S_m, \; a_i a_{i+1} \ldots a_n \$)$$

- S_m and a_i decides the parser action by consulting the parsing action table. (*Initial Stack* contains just S_o)

- A configuration of a LR parsing represents the right sentential form:

$$X_1 \ldots X_m \, a_i \, a_{i+1} \ldots a_n \$$$

Actions of A LR-Parser

1. **shift s** -- shifts the next input symbol and the state **s** onto the stack

   (S_o X_1 S_1 ... X_m S_m, a_i a_{i+1} ... a_n \$) ➔ (S_o X_1 S_1 ... X_m S_m a_i s, a_{i+1} ... a_n \$)

2. **reduce A→β** (or **`rn`** where n is a production number)
   - pop 2|β| (=r) items from the stack;
   - then push **A** and **s** where **s=goto[s_{m-r},A]**

   (S_o X_1 S_1 ... X_m S_m, a_i a_{i+1} ... a_n \$) ➔ (S_o X_1 S_1 ... X_{m-r} S_{m-r} A s, a_i ... a_n \$)

   - Output is the reducing production reduce A→β

3. **Accept** – Parsing successfully completed

4. **Error** -- Parser detected an error (an empty entry in the action table)

Reduce Action

- pop $2|\beta|$ (=r) items from the stack; let us assume that $\beta = Y_1 Y_2 ... Y_r$
- then push **A** and **s** where **$s=goto[s_{m-r},A]$**

$(S_o X_1 S_1 ... X_{m-r} S_{m-r} Y_1 S_{m-r+1} ... Y_r S_m, a_i a_{i+1} ... a_n \$)$

$\rightarrow (S_o X_1 S_1 ... X_{m-r} S_{m-r} A s, a_i ... a_n \$)$

- In fact, $Y_1 Y_2 ... Y_r$ is a handle.

$X_1 ... X_{m-r} A a_i ... a_n \$ \Rightarrow X_1 ... X_m Y_1 ... Y_r a_i a_{i+1} ... a_n \$$

(SLR) Parsing Tables for Expression Grammar

1) $E \rightarrow E+T$
2) $E \rightarrow T$
3) $T \rightarrow T*F$
4) $T \rightarrow F$
5) $F \rightarrow (E)$
6) $F \rightarrow id$

	Action Table							Goto Table		
state	**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				

Actions of A (S)LR-Parser -- Example

stack	input	action	output
0	id*id+id$	shift 5	
0id5	*id+id$	reduce by F→id	F→id
0F3	*id+id$	reduce by T→F	T→F
0T2	*id+id$	shift 7	
0T2*7	id+id$	shift 5	
0T2*7id5	+id$	reduce by F→id	F→id
0T2*7F10	+id$	reduce by T→T*F	T→T*F
0T2	+id$	reduce by E→T	E→T
0E1	+id$	shift 6	
0E1+6	id$	shift 5	
0E1+6id5	$	reduce by F→id	F→id
0E1+6F3	$	reduce by T→F	T→F
0E1+6T9	$	reduce by E→E+T	E→E+T
0E1	$	accept	

Panic Mode Error Recovery in LR Parsing

- Scan down the stack until a state **s** with a goto on a particular nonterminal **A** is found. (Get rid of everything from the stack before this state s).
- Discard zero or more input symbols until a symbol **a** is found that can legitimately follow A.
  - The symbol a is simply in FOLLOW(A), but this may not work for all situations.
- The parser stacks the nonterminal **A** and the state **goto[s,A]**, and it resumes the normal parsing.
- This nonterminal A is normally is a basic programming block (there can be more than one choice for A).
  - stmt, expr, block, ...

Phrase-Level Error Recovery in LR Parsing

- Each empty entry in the action table is marked with a specific error routine.
- An error routine reflects the error that the user most likely will make in that case.
- An error routine inserts the symbols into the stack or the input (or it deletes the symbols from the stack and the input, or it can do both insertion and deletion).
  - missing operand
  - unbalanced right parenthesis

The End