

Compiler Design

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Introduction to LR Parsing

- The most prevalent type of bottom-up parser: LR(k)
 - "L" is for left-to-right scanning of the input
 - "R" is for constructing a rightmost derivation in reverse
 - k is for the number of input symbols of lookahead that are used in making parsing decisions
- LR parsers are table-driven, much like the non-recursive LL parsers

Items and the LR(0) Automaton

- An LR parser makes shift-reduce decisions by maintaining states to keep track of where we are in a parse
- **States** represent sets of **items**
- An **LR(0) item of a grammar G** is a production of G with a dot at some position of the body
- **Example:** Production $A \rightarrow XYZ$ yields the four items:

$$A \rightarrow \cdot XYZ$$

$$A \rightarrow X \cdot YZ$$

$$A \rightarrow XY \cdot Z$$

$$A \rightarrow XYZ \cdot$$

- The production $A \rightarrow \varepsilon$ generates only one item, $A \rightarrow \cdot$.

Items and the LR(0) Automaton

- **Canonical LR(0) collection** provides the basis for constructing an LR(0) automaton
- To construct the canonical LR(0) collection for a grammar, we define an augmented grammar and two functions, **CLOSURE** and **GOTO**
- *If G is a grammar with start symbol S , then the augmented grammar for G , is G with a new start symbol S_0 and production $S_0 \rightarrow S$*
- **Closure of Item Sets**
 - If I is a set of items for a grammar G , then **CLOSURE(I)** is the set of items constructed from I by the two rules:
 1. Initially, add every item in I to **CLOSURE(I)**.
 2. If $A \rightarrow \alpha \cdot B \beta$ is in **CLOSURE(I)** and $B \rightarrow \gamma$ is a production, then add the item $B \rightarrow \cdot \gamma$ to **CLOSURE(I)**, if it is not already there. Apply this rule until no more new items can be added to **CLOSURE(I)**.

Items and the LR(0) Automaton

- **Example:** Consider the augmented expression grammar:

$$\begin{array}{lcl} E' & \rightarrow & E \\ E & \rightarrow & E + T \mid T \\ T & \rightarrow & T * F \mid F \\ F & \rightarrow & (E) \mid \text{id} \end{array}$$

- If I is the set of one item $\{[E' \rightarrow \cdot E]\}$, then $\text{CLOSURE}(I)$ is:

$E' \rightarrow \cdot E$
$E \rightarrow \cdot E + T$
$E \rightarrow \cdot T$
$T \rightarrow \cdot T * F$
$T \rightarrow \cdot F$
$F \rightarrow \cdot (E)$
$F \rightarrow \cdot \text{id}$

Items and the LR(0) Automaton

- We divide all the sets of items of interest into two classes:
 - **Kernel items:** the initial item, $S' \rightarrow \cdot S$, and all items whose dots are not at the left end
 - **Non-kernel items:** all items with their dots at the left end, except for $S' \rightarrow \cdot S$

$E' \rightarrow \cdot E$	}	Kernel items
$E \rightarrow \cdot E+T$		
$E \rightarrow \cdot T$	}	Non-kernel items
$T \rightarrow \cdot T^*F$		
$T \rightarrow \cdot F$		
$F \rightarrow \cdot (E)$		
$F \rightarrow \cdot id$		

Items and the LR(0) Automaton

- **The Function GOTO**

- The GOTO function is used to define the transitions in the LR(0) automaton for a grammar

- **Example:** If I is the set of two items $\{[E' \rightarrow E.], [E \rightarrow E. + T]\}$, then $\text{GOTO}(I, +)$ contains the items

$$E \rightarrow E + \cdot T$$

$$T \rightarrow \cdot T * F$$

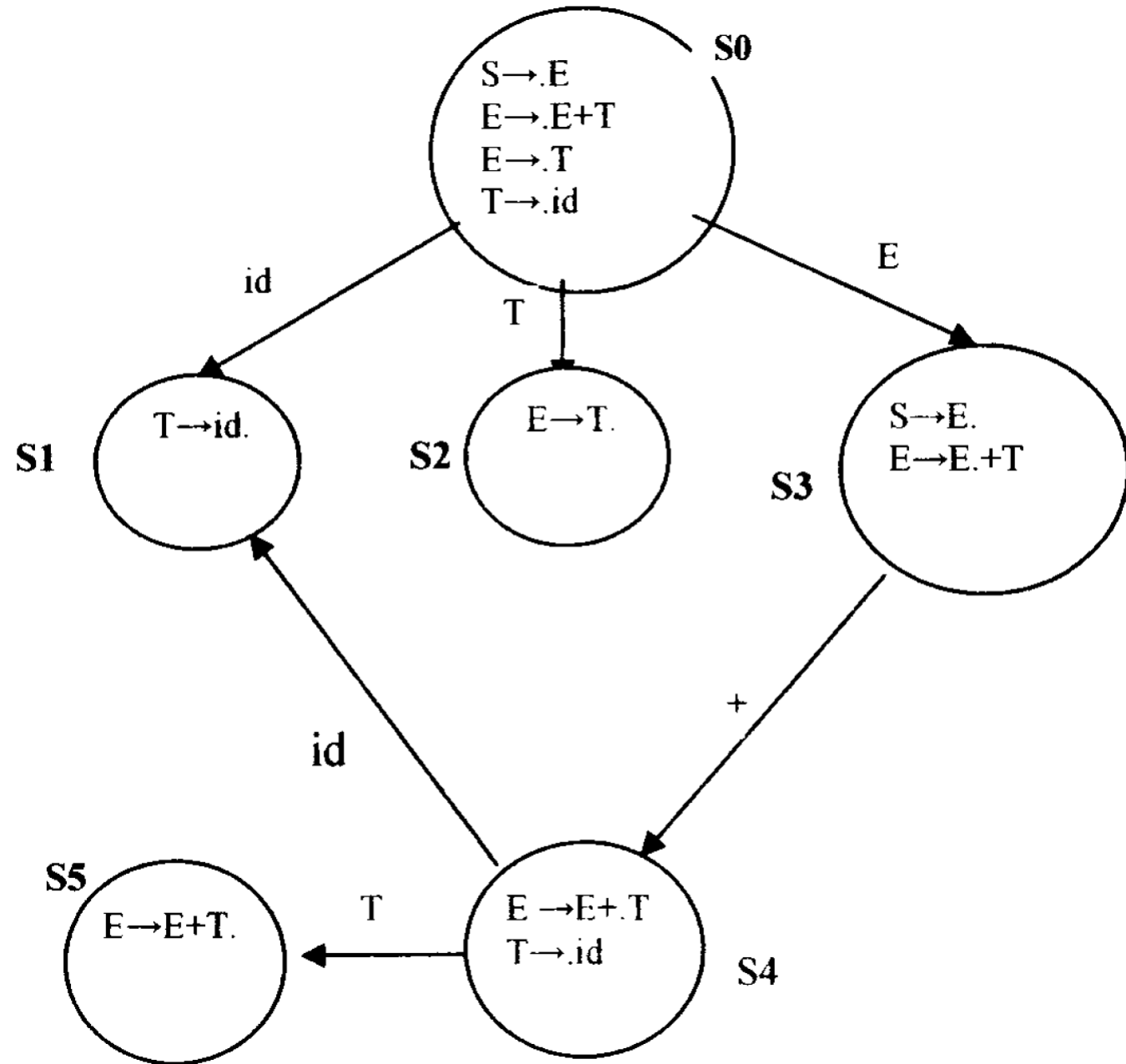
$$T \rightarrow \cdot F$$

$$F \rightarrow \cdot (E)$$

$$F \rightarrow \cdot \text{id}$$

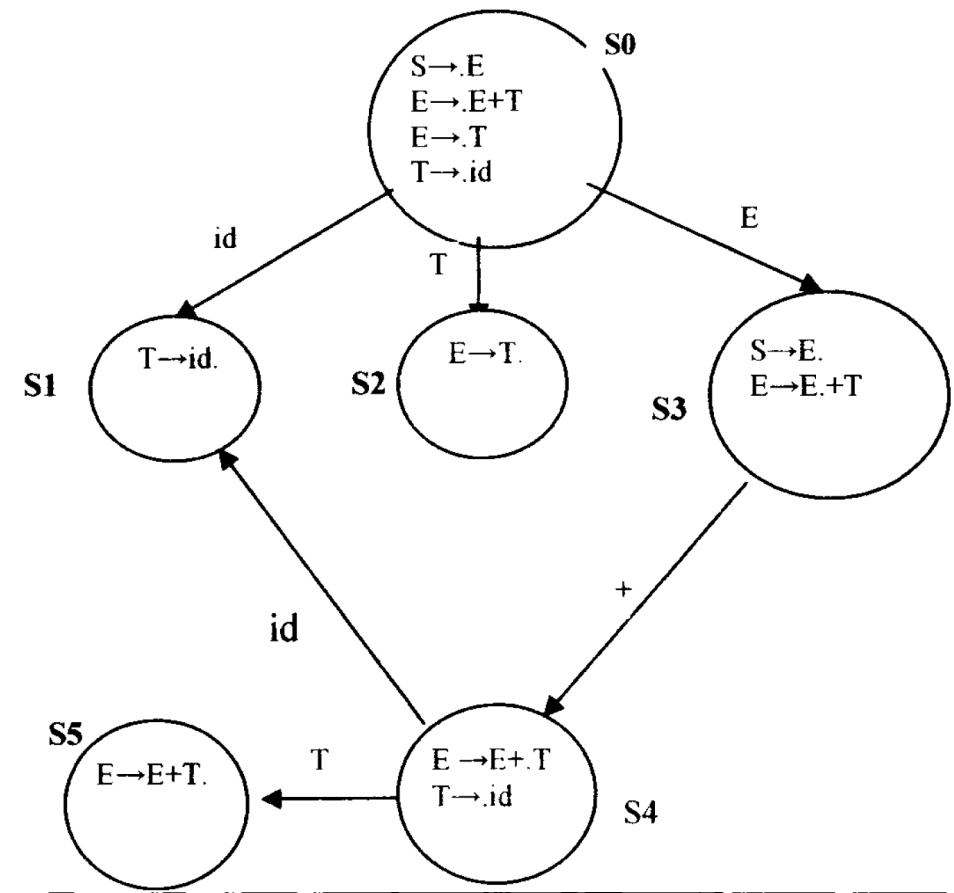
• **Example:**

- 1- $S \rightarrow E$
- 2- $E \rightarrow E+T$
- 3- $E \rightarrow T$
- 4- $T \rightarrow id$



LR(0) Parse Table

- The reduction is performed for all terminals
- If there are collisions in the LR(0) parse table cells, the grammar is not LR(0)*

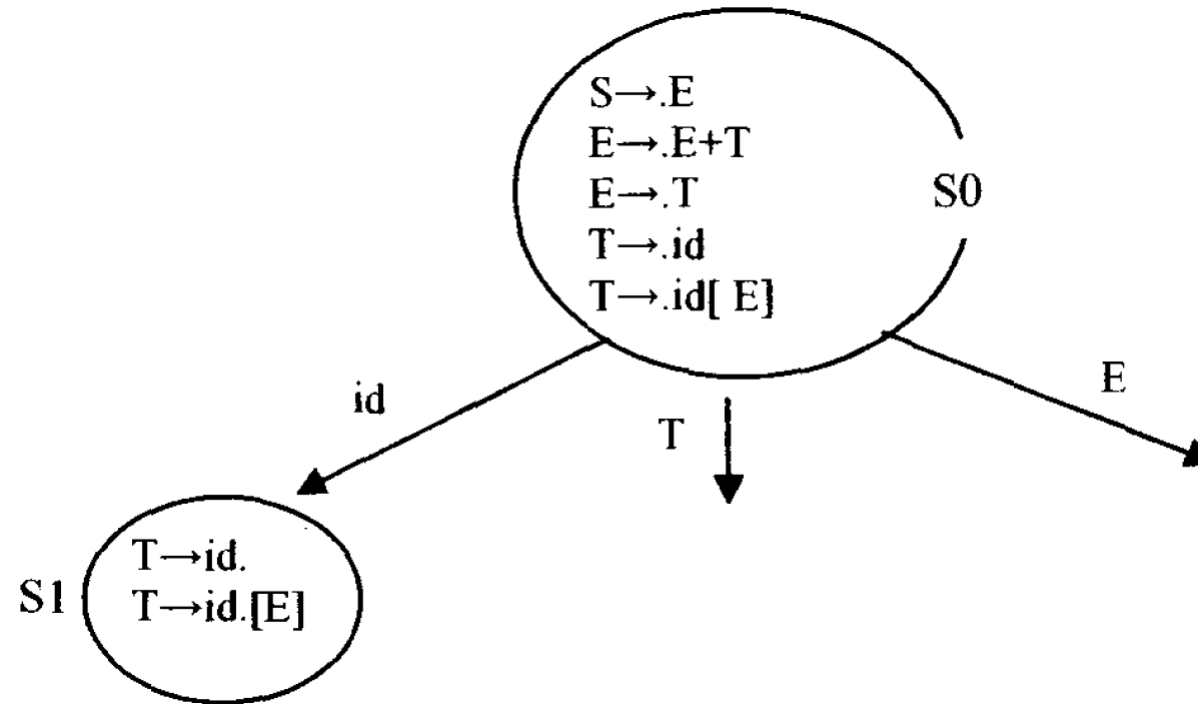


حالات	action			goto	
	id	+	\$	T	E
0	s1	error	error	2	3
1	r4	r4	r4		
2	r3	r3	r3		
3	error	s4	accept		
4	s1	error	error	5	
5	r2	r2	r2		

LR(0) Grammar

- **Example: Shift/Reduce Conflict**
 - The grammar is not LR(0)

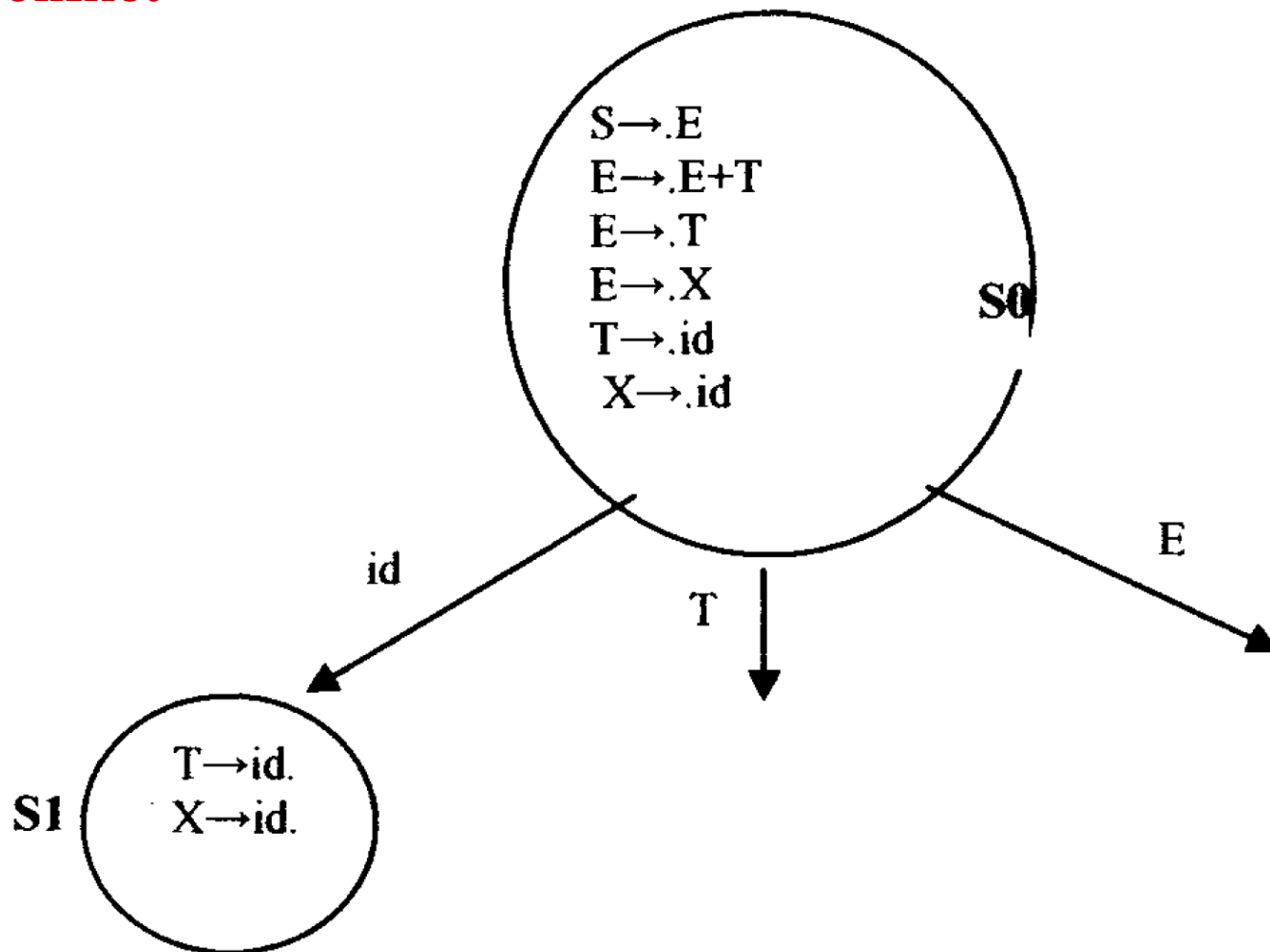
$S \rightarrow E$
 $E \rightarrow E + T$
 $E \rightarrow T$
 $T \rightarrow id$
 $T \rightarrow id [E]$



LR(0) Grammar

- **Example: Reduce/Reduce Conflict**
 - The grammar is not LR(0)

$S \rightarrow E$
 $E \rightarrow E+T$
 $E \rightarrow T$
 $E \rightarrow X$
 $T \rightarrow id$
 $X \rightarrow id$



LR(0) Grammar

- **Example: Shift/Reduce Conflict**
 - The grammar is not LR(0)

$S \rightarrow E$
 $E \rightarrow E+T$
 $E \rightarrow T$
 $T \rightarrow \epsilon$
 $T \rightarrow id$

