

## \* LALR Parser

Q  $S \rightarrow AA$

$A \rightarrow aA$

$A \rightarrow b$

construct the parsing table with LALR parser.

⇒ Step 1: Augmented grammar

$S_1 \rightarrow S$

$S \rightarrow AA$

$A \rightarrow aA$

$A \rightarrow b$

Step 2: closure

$(S_1 \rightarrow \cdot S)$

$\left\{ \begin{array}{l} S_1 \rightarrow \cdot S, \$ \\ S \rightarrow \cdot AA, \$ \\ A \rightarrow \cdot aA, a \mid b \\ A \rightarrow \cdot b, a \mid b \end{array} \right\} I_0$

goto( $I_0, S$ )  $\rightarrow \{ S \cdot, \$ \} I_1$

goto( $I_0, A$ )  $\rightarrow \left\{ \begin{array}{l} S \rightarrow A \cdot A, \$ \\ A \rightarrow aA, \$ \\ A \rightarrow b, \$ \end{array} \right\} I_2$

goto( $I_0, a$ )  $\rightarrow \left\{ \begin{array}{l} A \rightarrow a \cdot A, a \mid b \\ A \rightarrow \cdot aA, a \mid b \\ A \rightarrow \cdot b, a \mid b \end{array} \right\} I_3$

goto( $I_0, b$ )  $\rightarrow \{ A \rightarrow b \cdot, a \mid b \} I_4$

$I_1 \rightarrow \emptyset$ 

$\text{goto } (I_2, A) \rightarrow \{ S \rightarrow AA\cdot, \$ \} I_5$

$\text{goto } (I_2, a) \rightarrow \left\{ \begin{array}{l} A \rightarrow a \cdot A, \$ \\ A \rightarrow \cdot aA, \$ \\ A \rightarrow \cdot b, \$ \end{array} \right\} I_6$

$\text{goto } (I_2, b) \rightarrow \{ A \rightarrow b \cdot, \$ \} I_7$

$\text{goto } (I_3, A) \rightarrow \{ A \rightarrow aA\cdot, a|b \} I_8$

$\text{goto } (I_3, a) \rightarrow \left\{ \begin{array}{l} A \rightarrow a \cdot A, a|b \\ A \rightarrow \cdot aA, a|b \\ A \rightarrow \cdot b, a|b \end{array} \right\} I_3$

$\text{goto } (I_3, b) \rightarrow \{ A \rightarrow b \cdot, a|b \} I_4$

 $I_4 \rightarrow \emptyset$ 
 $I_5 \rightarrow \emptyset$ 

$\text{goto } (I_6, A) \rightarrow \{ A \rightarrow aA\cdot, \$ \} \rightarrow I_9$

$\text{goto } (I_6, a) \rightarrow \left\{ \begin{array}{l} A \rightarrow a \cdot A, \$ \\ A \rightarrow \cdot aA, \$ \\ A \rightarrow \cdot b, \$ \end{array} \right\} I_3$

 $I_7 \rightarrow \emptyset$ 
 $I_8 \rightarrow \emptyset$ 
 $I_9 \rightarrow \emptyset$

$C \rightarrow I_0, I_1, I_2, I_3, I_4, I_5, I_6, I_7, I_8$

### Action table

### goto-table

|       | a        | b        | \$     | S. | A  |
|-------|----------|----------|--------|----|----|
| $I_0$ | $S_3$    | $S_4$    |        |    | 2  |
| $I_1$ |          |          | Accept |    |    |
| $I_2$ | $S_6$    | $S_7$    |        |    | 5  |
| $I_3$ | $S_{36}$ | $S_{47}$ |        |    | 8g |
| $I_4$ | $R_3$    | $R_3$    |        |    |    |
| $I_5$ | $R_1$    |          |        |    |    |
| $I_6$ | $R_2$    | $R_2$    |        |    |    |
| $I_7$ |          |          |        |    |    |
| $I_8$ |          |          |        |    |    |

Final state  $I_3$   $\leftarrow$  final state

Final state  $I_3$   $\leftarrow$  final state

Final state  $I_3$   $\leftarrow$  final state

Final state

Final state

Final state

Final state

ST () f Follow

|          |  |  |
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$\rightarrow TA$

$\rightarrow +TA \mid \epsilon$

$\rightarrow FB$

$\rightarrow *FB \mid \epsilon$

$\vdash \rightarrow (E) \mid id$

$FIRST(E) \rightarrow FIRST(TA) \rightarrow ①$

$FIRST(A) \rightarrow FIRST(+TA) \cup FIRST(G)$   
 $\rightarrow \{+, \epsilon\}$

$FIRST(T) \rightarrow FB \rightarrow ②$

$FIRST(B) \rightarrow FIRST(*FB) \cup FIRST(G)$   
 $\rightarrow \{\ast, \epsilon\}$

$FIRST(F) \rightarrow FIRST[(E)] \cup FIRST(id)$   
 $\rightarrow \{[, id]\}$

$\therefore eq^* ② \Rightarrow$

$FIRST(T) \rightarrow FIRST(F)$   
 $\rightarrow \{[, id]\}$

$\therefore eq^* ① \Rightarrow$

$FIRST(E) \rightarrow FIRST(T)$   
 $\rightarrow \{[, id\}\}$

$Follow(E) \rightarrow FIRST() \cup \{\$\}$   
 $\rightarrow \{[, \$\}$

$Follow(A) \rightarrow FIRST(E)$   
 $\rightarrow \{[, \$\}$

$Follow(T) \rightarrow FIRST(A) - \{E\} \cup Follow(A)$   
 $\rightarrow \{+, [, \$\} - \{G\} \cup \{[, \$\}$   
 $\rightarrow \{+, [, \$\}$

$\text{Follow}(B) \rightarrow \text{Follow}(\tau)$   
 $\rightarrow \{+, ), \$\}$

$\text{Follow}(F) \rightarrow \text{FIRST}(B) - \{\epsilon\} \cup \text{Follow}(\tau)$   
 $\rightarrow \{\ast, \in\} - \{\in\} \cup \{+, ), \$\}$   
 $\rightarrow \{\ast, +, ), \$\}$

Consider the grammar

$$S \rightarrow ACB \mid CbB \mid Ba$$

$$A \rightarrow da \mid Bc$$

$$B \rightarrow g \mid \epsilon$$

$$C \rightarrow h \mid \epsilon$$

$$\Rightarrow \text{FIRST}(S) \rightarrow \text{FIRST}(ACB) \cup \text{FIRST}(CbB) \cup \text{FIRST}(Ba)$$

$$\text{FIRST}(A) \rightarrow \text{FIRST}(da) \cup \text{FIRST}(Bc) \rightarrow ①$$

$$\text{FIRST}(B) \rightarrow \{g, \epsilon\}$$

$$\text{FIRST}(C) \rightarrow \{h, \epsilon\}$$

$$\begin{aligned} \text{FIRST}(Bc) &\rightarrow \text{FIRST}(B) - \{g\} \cup \text{FIRST}(C) \\ &\rightarrow \{g, \epsilon\} - \{\epsilon\} \cup \{h, \epsilon\} \\ &\rightarrow \{g, h, \epsilon\} \end{aligned}$$

e.g. ②  $\Rightarrow$

$$\begin{aligned} \text{FIRST}(A) &\rightarrow \text{FIRST}(da) \cup \{g, h, \epsilon\} \\ &\rightarrow \{d, g, h, \epsilon\} \rightarrow ③ \end{aligned}$$

$$\begin{aligned} \text{FIRST}(ACB) &\rightarrow \text{FIRST}(A) \cup \text{FIRST}(CbB) \\ &\rightarrow \{d, g, h, \epsilon\} \cup \text{FIRST}(CbB) \rightarrow ③ \end{aligned}$$

$$\begin{aligned} \text{FIRST}(CbB) &\rightarrow \text{FIRST}(C) - \{\epsilon\} \cup \text{FIRST}(B) \\ &\rightarrow \{h, \epsilon\} - \{\epsilon\} \cup \{g, \epsilon\} \\ &\rightarrow \{h, g, \epsilon\} \end{aligned}$$

$$\therefore \text{e.g. } ③ \Rightarrow \{d, gh, \epsilon\}$$

$$\begin{aligned}\text{FIRST}(cbb) &\rightarrow \text{FIRST}(c) - \{\epsilon\} \cup \text{FIRST}(bb) \\ &\rightarrow \{h, \epsilon\} - \{\epsilon\} \cup \{b\} \\ &\rightarrow \{h, b\}\end{aligned}$$

$$\begin{aligned}\text{FIRST}(Ba) &\rightarrow \text{FIRST}(B) - \{\epsilon\} \cup \text{FIRST}(a) \\ &\rightarrow \{g, \epsilon\} - \{\epsilon\} \cup \{a\} \\ &\rightarrow \{g, a\}\end{aligned}$$

$\therefore \text{op}^n \textcircled{1} \Rightarrow$

$$\begin{aligned}\text{FIRST}(s) &\rightarrow \{d, g, h, \epsilon\} \cup \{b, h\} \cup \{g, a\} \\ &\rightarrow \{a, b, d, g, h, \epsilon\}\end{aligned}$$

Q

Consider the following grammar

$$S \rightarrow ABC$$

$$A \rightarrow a | \epsilon$$

$$B \rightarrow \gamma | \epsilon$$

$$C \rightarrow b | \epsilon$$

$$\Rightarrow \text{FIRST}(S) \rightarrow \text{FIRST}(ABC) \rightarrow \textcircled{1}$$

$$\text{FIRST}(A) \rightarrow \{a, \epsilon\}$$

$$\text{FIRST}(B) \rightarrow \{\gamma, \epsilon\}$$

$$\text{FIRST}(C) \rightarrow \{b, \epsilon\}$$

$$\text{FIRST}(ABC) \rightarrow \text{FIRST}(A) - \{\epsilon\} \cup \text{FIRST}(BC) \rightarrow \textcircled{2}$$

$$\text{FIRST}(BC) \rightarrow \text{FIRST}(B) - \{\epsilon\} \cup \text{FIRST}(C)$$

$$\rightarrow \{\gamma, \epsilon\} - \{\epsilon\} \cup \{b, \epsilon\}$$

$$\rightarrow \{\gamma, b, \epsilon\}$$

## LL(1)

$\therefore \text{ep}^n \Rightarrow$

$$\text{FIRST}(s) \rightarrow \{a, \epsilon\} - \{\epsilon\} \cup \{x, b, c\} \\ \rightarrow \{a, x, b, c\}$$

\* Check whether the following grammar is LL(1) or not :-

$$S \rightarrow ABC$$

$$A \rightarrow a \mid \epsilon$$

$$B \rightarrow x \mid \epsilon$$

$$C \rightarrow b \mid \epsilon$$

$$\Rightarrow \text{Follow}(S) \rightarrow \{\$\}$$

$$\text{Follow}(A) \rightarrow \text{FIRST}(Bc)$$

$$\rightarrow \{x, b, \epsilon\}$$

$$\text{Follow}(B) \rightarrow \text{FIRST}(Cc) - \{\epsilon\} \cup \text{Follow}(s)$$

$$\rightarrow \{b, \epsilon, \$\}$$

$$\text{Follow}(C) \rightarrow \text{FIRST}(\epsilon) - \{\epsilon\} \cup \text{Follow}(s)$$

$$\rightarrow \{b, \epsilon\} - \{\epsilon\} \cup \{\$\}$$

$$\rightarrow \{b, \$\}$$

|   | a                   | b                        | x                        | \$                       |
|---|---------------------|--------------------------|--------------------------|--------------------------|
| S | $s \rightarrow ABC$ | $s \rightarrow ABC$      | $s \rightarrow ABC$      | $s \rightarrow ABC$      |
| A | $A \rightarrow a$   | $A \rightarrow \epsilon$ | $A \rightarrow \epsilon$ | $A \rightarrow \epsilon$ |
| B |                     | $B \rightarrow \epsilon$ | $B \rightarrow x$        | $B \rightarrow \epsilon$ |
| C |                     | $c \rightarrow b$        |                          | $c \rightarrow \epsilon$ |

$\because$  The grammar does not contain multiple entries  $\therefore$  The grammar is LL(1)

(a)

$$S \rightarrow AaAb \mid BbBa$$

$$A \rightarrow G$$

$$B \rightarrow E$$

$$\Rightarrow \text{FIRST}(S) \rightarrow \text{FIRST}(AaAb) \cup \text{FIRST}(BbBa) \rightarrow (1)$$

$$\text{FIRST}(A) \rightarrow \{G\}$$

$$\text{FIRST}(B) \rightarrow \{E\}$$

$$\text{FIRST}(AaAb) \rightarrow \text{FIRST}(A) - \{E\} \cup \text{FIRST}(aAb)$$

$$\rightarrow \{G\} - \{E\} \cup \{a\}$$

$$\rightarrow \{a\}$$

$$\text{FIRST}(BbBa) \rightarrow \text{FIRST}(B) - \{G\} \cup \text{FIRST}(bBa)$$

$$\rightarrow \{E\} - \{G\} \cup \{b\}$$

$$\rightarrow \{b\}$$

$$\therefore \text{FIRST}(S) \rightarrow \{a\} \cup \{b\}$$

$$\rightarrow \{a, b\}$$

$$\text{Follow}(S) \rightarrow \{\$\}$$

$$\text{Follow}\{A\} \rightarrow \text{FIRST}\{aAb\}$$

$$\rightarrow \{a\}$$

$$\text{Follow}\{A\} \rightarrow \text{FIRST}(b)$$

$$\rightarrow \{b\}$$

$$\text{Follow}(B) \rightarrow \text{FIRST}(bBa)$$

$$\rightarrow \{b\}$$

$$\text{Follow}(B) \rightarrow \text{FIRST}(a)$$

$$\rightarrow \{a\}$$

|   | a                           | b                           | \$ |
|---|-----------------------------|-----------------------------|----|
| S | $S \rightarrow AaAb   BBBa$ | $S \rightarrow Aabb   BbBa$ |    |
| A | $A \rightarrow \epsilon$    | $A \rightarrow \epsilon$    |    |
| B | $B \rightarrow \epsilon$    | $B \rightarrow \epsilon$    |    |

Q L(L(1)) or not

$$F \rightarrow XYZa$$

$$X \rightarrow x | \epsilon$$

$$Y \rightarrow y | \epsilon$$

$$Z \rightarrow z | \epsilon$$

$$\Rightarrow \text{FIRST}(F) \rightarrow \text{FIRST}(XYZa) \rightarrow \textcircled{1}$$

$$\text{FIRST}(X) \rightarrow \{x, \epsilon\}$$

$$\text{FIRST}(Y) \rightarrow \{y, \epsilon\}$$

$$\text{FIRST}(Z) \rightarrow \{z, \epsilon\}$$

$$\text{FIRST}(XYZa) \rightarrow \text{FIRST}(X) - \{\epsilon\} \cup \text{FIRST}(YZa) \rightarrow \textcircled{11}$$

$$\text{FIRST}(YZa) \rightarrow \text{FIRST}(Y) - \{\epsilon\} \cup \text{FIRST}(Za) \rightarrow \textcircled{10}$$

$$\begin{aligned} \text{FIRST}(Za) &\rightarrow \text{FIRST}(Z) - \{\epsilon\} \cup \text{FIRST}(a) \\ &\rightarrow \{z, \epsilon\} - \{\epsilon\} \cup \{a\} \end{aligned}$$

$$\therefore \text{FIRST}(YZa) \rightarrow \{z, a\}$$

$$\begin{aligned} \therefore \text{eq } \textcircled{11} &\Rightarrow \{x, \epsilon\} - \{\epsilon\} \cup \{z, a\} \\ &= \{x, z, a\} \end{aligned}$$

$$\begin{aligned} \therefore \text{eq } \textcircled{10} &\Rightarrow \{x, \epsilon\} - \{\epsilon\} \cup \{y, z, a\} \\ &\Rightarrow \{x, y, z, a\} \end{aligned}$$

$$\therefore \text{FIRST}(F) = \{x, y, z, a\}$$

Follow (F)  $\rightarrow \{\$\}$

Follow (X)  $\rightarrow \text{FIRST}(YZa)$   
 $\rightarrow \{y, z, a\}$

Follow (Y)  $\rightarrow \text{FIRST}(za)$   
 $\rightarrow \{z, a\}$

Follow (Z)  $\rightarrow \text{FIRST}(a)$   
 $\rightarrow \{a\}$

|   | a                        | x                        | y                        | z                        | \$ |
|---|--------------------------|--------------------------|--------------------------|--------------------------|----|
| F | $F \rightarrow XY2a$     | $F \rightarrow XY2a$     | $F \rightarrow XY2a$     | $F \rightarrow XY2a$     |    |
| X | $X \rightarrow \epsilon$ | $X \rightarrow x$        | $X \rightarrow \epsilon$ | $X \rightarrow \epsilon$ |    |
| Y | $Y \rightarrow \epsilon$ |                          | $Y \rightarrow y$        | $Y \rightarrow \epsilon$ |    |
| Z | $Z \rightarrow a$        | $Z \rightarrow \epsilon$ |                          | $Z \rightarrow z$        |    |

$\because$  The grammar does not contain multiple value  $\therefore$  It is LL(1) parsed.

Q.  $S \rightarrow aAB \mid bA \mid C$

A  $\rightarrow aAb \mid \epsilon$

B  $\rightarrow bB \mid c$

$\Rightarrow \text{FIRST}(S) \rightarrow \text{FIRST}(aAB) \cup \text{FIRST}(bA) \cup \text{FIRST}(\epsilon)$

$\rightarrow \{a\} \cup \{b\} \cup \{\epsilon\}$

$\rightarrow \{a, b, \epsilon\}$

$\text{FIRST}(A) \rightarrow \text{FIRST}\{aAb\} \cup \text{FIRST}(\epsilon)$

$\rightarrow \{a, \epsilon\}$

$\text{FIRST}(B) \rightarrow \text{FIRST}(bB) \cup \text{FIRST}(c)$

$\rightarrow \{b, c\}$

$\text{Follow}(S) \rightarrow \{\$\}$

$\text{Follow}(A) \rightarrow \text{FIRST}(B) \cup \text{Follow}(A) \rightarrow \text{FIRST}(b)$

$\rightarrow \{b\}$

$\text{Follow}(B) \rightarrow \text{Follow}(S) \cup \text{Follow}(B)$

$\rightarrow \{\$\}$

$a \quad b \quad c \quad \$$

$S \rightarrow \underline{\quad}$

$S \rightarrow \underline{\quad}$

$S \rightarrow \underline{\quad}$

$A \rightarrow QAb$

$A \rightarrow qE$

$A \rightarrow E$

$A \rightarrow E$

$B \rightarrow qBB$

$B \rightarrow bB$

$B \rightarrow \underline{B}$

$B \rightarrow qEE$

$(q \rightarrow q_1, q_2, q_3, q_4, q_5, q_6, q_7, q_8, q_9, q_{10}, q_{11}, q_{12}, q_{13}, q_{14}, q_{15})$

$(q_1 \rightarrow q_2, q_3, q_4, q_5, q_6, q_7, q_8, q_9, q_{10}, q_{11}, q_{12}, q_{13}, q_{14}, q_{15})$

$(q_2 \rightarrow q_3, q_4, q_5, q_6, q_7, q_8, q_9, q_{10}, q_{11}, q_{12}, q_{13}, q_{14}, q_{15})$

$(q_3 \rightarrow q_4, q_5, q_6, q_7, q_8, q_9, q_{10}, q_{11}, q_{12}, q_{13}, q_{14}, q_{15})$

$(q_4 \rightarrow q_5, q_6, q_7, q_8, q_9, q_{10}, q_{11}, q_{12}, q_{13}, q_{14}, q_{15})$

$(q_5 \rightarrow q_6, q_7, q_8, q_9, q_{10}, q_{11}, q_{12}, q_{13}, q_{14}, q_{15})$

$(q_6 \rightarrow q_7, q_8, q_9, q_{10}, q_{11}, q_{12}, q_{13}, q_{14}, q_{15})$

$(q_7 \rightarrow q_8, q_9, q_{10}, q_{11}, q_{12}, q_{13}, q_{14}, q_{15})$

$(q_8 \rightarrow q_9, q_{10}, q_{11}, q_{12}, q_{13}, q_{14}, q_{15})$

$(q_9 \rightarrow q_{10}, q_{11}, q_{12}, q_{13}, q_{14}, q_{15})$

$(q_{10} \rightarrow q_{11}, q_{12}, q_{13}, q_{14}, q_{15})$

$(q_{11} \rightarrow q_{12}, q_{13}, q_{14}, q_{15})$

$(q_{12} \rightarrow q_{13}, q_{14}, q_{15})$

$(q_{13} \rightarrow q_{14}, q_{15})$

$(q_{14} \rightarrow q_{15})$

$(q_{15} \rightarrow q_{15})$



$\text{FIRST}(E) \rightarrow \Sigma \cup S^*$

$\text{FIRST}(T) \rightarrow \text{FIRST}(PS) \rightarrow \textcircled{1}$

$\text{FIRST}(S) \rightarrow \text{FIRST}(OP) \cup \text{FIRST}(E) \rightarrow \textcircled{2}$

$\text{FIRST}(O) \rightarrow \{+, *\}$

$\text{FIRST}(P) \rightarrow \{a, b, c\}$

$\therefore \text{eq} \textcircled{1} \Rightarrow \text{FIRST}(T) \rightarrow \text{FIRST}(P)$   
 $\rightarrow \{a, b, c\}$

$\text{FIRST}(S) \rightarrow \text{FIRST}(O) \cup \text{FIRST}(E)$   
 $\rightarrow \{+, *\} \cup \{\epsilon\}$   
 $\rightarrow \{+, *, \epsilon\}$

$\text{Follow}(E) \rightarrow \{\$\}$

$\text{Follow}(T) \rightarrow \text{Follow}(E)$   
 $\rightarrow \{\$\}$

$\text{Follow}(S) \rightarrow \text{Follow}(T)$   
 $\rightarrow \{\$\}$

$\text{Follow}(O) \rightarrow \text{FIRST}(P)$   
 $\rightarrow \{a, b, c\}$

$\text{Follow}(P) \rightarrow \text{Follow}(S) \setminus \text{FIRST}(S)$   
 $\rightarrow \{+, *, \epsilon\}$   
 $\rightarrow \text{FIRST}(S) - \{\epsilon\} \cup \text{Follow}(S)$   
 $\rightarrow \{+, *, \epsilon\} - \{\epsilon\} \cup \{\$\}$   
 $\rightarrow \{+, *, \$\}$

$$\textcircled{a} \quad S \rightarrow iE + SS' \mid a$$

$$S' \rightarrow eS \mid \epsilon$$

$$E \rightarrow b$$

$$\Rightarrow \text{FIRST}(S) \rightarrow \text{FIRST}(iE + SS') \cup \text{FIRST}(a)$$

$$\rightarrow \{i, a\}$$

$$\text{FIRST}(S') \rightarrow \{\epsilon, E\}$$

$$\text{FIRST}(E) \rightarrow \{b\}$$

$$\text{Follow}(S) \rightarrow \text{FIRST}(S') - \{E\} \cup \text{Follow}(S)$$

$$\rightarrow \{e, \epsilon\} - \{E\} \cup \{\$\}$$

$$\rightarrow \{e, \$\}$$

$$\text{Follow}(S') \rightarrow \text{Follow}(S)$$

$$\rightarrow \{\$\}$$

$$\text{Follow}(E) \rightarrow \text{FIRST}(+SS')$$

$$\rightarrow \{+\}$$

$$+ \quad a \quad s \quad b \quad . \quad \epsilon \quad i \quad ; \quad \$$$

|    |                    |                          |
|----|--------------------|--------------------------|
| S  | $s \rightarrow a$  | $s \rightarrow iE + SS'$ |
| S' | $s \rightarrow eS$ | $s \rightarrow \epsilon$ |
| E  | $E \rightarrow b$  |                          |

Get parsing table for the grammar

$$S \rightarrow a I J h$$

$$I \rightarrow I b s e \mid c$$

$$J \rightarrow K L K_r \mid \epsilon$$

$$K \rightarrow d \mid \epsilon$$

$$L \rightarrow p \mid \epsilon$$

$$I \rightarrow I b s e \mid c$$

$$\therefore I \rightarrow I(bse) \mid c$$

$$I' \rightarrow b s e I' \mid \epsilon$$

$$\therefore A' \rightarrow K A' \mid \epsilon$$

$$I \rightarrow C I'$$

$$A \rightarrow P A'$$

Thus, after eliminating left recursion from grammar it becomes

$$S \rightarrow a I J h$$

$$I' \rightarrow b s e I' \mid \epsilon$$

$$I \rightarrow C I'$$

$$J \rightarrow K L K_r \mid \epsilon$$

$$K \rightarrow d \mid \epsilon$$

$$L \rightarrow p \mid \epsilon$$

$$\therefore \text{FIRST}(S) \rightarrow \{a\}$$

$$\text{FIRST}(I') \rightarrow \{b, G\}$$

$$\text{FIRST}(I) \rightarrow \{c\}$$

$$\text{FIRST}(J) \rightarrow \text{FIRST}(KLK_r) \cup \text{FIRST}(G) \rightarrow ①$$

$$\text{FIRST}(K) \rightarrow \{d, \epsilon\}$$

$$\text{FIRST}(L) \rightarrow \{p, \epsilon\}$$

$$\text{FIRST}(KL) \rightarrow \text{FIRST}(K) - \{G\} \cup \text{FIRST}(L) \rightarrow ②$$

$$\text{FIRST}(KL) \rightarrow \text{FIRST}(L) - \{G\} \cup \text{FIRST}(K_r) \rightarrow ③$$

$$\text{FIRST}(K_r) \rightarrow \text{FIRST}(k) - \{G\} \cup \text{FIRST}(r)$$

$$\rightarrow \{d, \epsilon\} - \{G\} \cup \{r\}$$

$$\rightarrow \{d, a\}$$

$$\therefore \text{eq } ③ \Rightarrow \{P, E\} - \{E\} \cup \{d, r\} \\ \Rightarrow \{P, d, r\}$$

$$\therefore \text{eq } ② \Rightarrow \{d, G\} - \{G\} \cup \{P, d, r\} \\ \Rightarrow \{P, d, r\}$$

$$\therefore \text{FIRST}(S) \Rightarrow \{P, d, r\} \cup \{G\} \\ \Rightarrow \{P, d, r, G\}$$

$$\text{Follow}(S) \Rightarrow \text{FIRST}(eI^1) \cup \text{Follow}(S) \\ \Rightarrow \{e, \$\}$$

$$\text{Follow}(S) \Rightarrow \text{FIRST}(Jh) - \{E\} \cup \text{Follow}(h) \\ \Rightarrow \{P, d, r, h\}$$

$$\text{Follow}(I^1) \Rightarrow \text{Follow}(I) - \{G\} \cup \text{Follow}(S) \\ \Rightarrow \{P, d, r, h, e\} - \{G\} \cup \{\$\} \\ \Rightarrow \{P, d, r, h, e\}$$

$$\text{Follow}(S) \Rightarrow \text{FIRST}(h) \\ \Rightarrow \{h\}$$

~~$$\text{Follow}(k) \Rightarrow \text{FIRST}(r) - \{G\} \cup \text{Follow}(S) \\ \Rightarrow \{r\} - \{\$\} \\ \Rightarrow \{r, \$\}$$~~

~~$$\text{Follow}(l) \Rightarrow \text{FIRST}(kr) - \{E\} \cup \text{Follow}(S)$$~~

$$\text{Follow}(k) \Rightarrow \text{FIRST}(kr)$$

$$\text{Follow}(k) \Rightarrow \text{FIRST}(r) \\ \Rightarrow \{r\}$$

$$\text{Follow}(l) \Rightarrow \text{FIRST}(kr) \\ \Rightarrow \{P, d, r\}$$

|    | a                 | b                 | c                  | d                 | e                  | p                 | q                  | r                 | s                  | h | \$ |
|----|-------------------|-------------------|--------------------|-------------------|--------------------|-------------------|--------------------|-------------------|--------------------|---|----|
| S  | $S \rightarrow a$ |                   |                    |                   |                    |                   |                    |                   |                    |   |    |
| I  |                   | $I \rightarrow b$ |                    |                   | $I \rightarrow c$  |                   | $I \rightarrow d$  |                   | $I \rightarrow e$  |   |    |
| I' |                   |                   | $I' \rightarrow b$ |                   | $I' \rightarrow c$ |                   | $I' \rightarrow d$ |                   | $I' \rightarrow e$ |   |    |
| J  |                   |                   |                    | $J \rightarrow e$ |                    |                   |                    |                   | $J \rightarrow f$  |   |    |
| K  |                   |                   |                    | $k \rightarrow e$ |                    |                   |                    |                   | $k \rightarrow f$  |   |    |
| L  |                   |                   |                    | $k \rightarrow d$ |                    |                   |                    |                   | $k \rightarrow g$  |   |    |
|    |                   |                   |                    | $b \rightarrow c$ |                    |                   |                    |                   | $b \rightarrow d$  |   |    |
|    |                   |                   |                    |                   | $b \rightarrow e$  |                   |                    |                   | $b \rightarrow f$  |   |    |
|    |                   |                   |                    |                   |                    | $p \rightarrow q$ |                    |                   | $p \rightarrow r$  |   |    |
|    |                   |                   |                    |                   |                    |                   | $q \rightarrow r$  |                   | $q \rightarrow s$  |   |    |
|    |                   |                   |                    |                   |                    |                   |                    | $r \rightarrow s$ |                    |   |    |

" The grammar contain multiple value :  
 If it not LL(1) parser

$$S \rightarrow I L U E T | a$$

$$L \rightarrow L S | \epsilon$$

$$E \rightarrow b$$

$$T \rightarrow d L e | \epsilon$$

⇒ FIRST eliminate the left recursion.

$$\therefore L' \rightarrow S L' | \epsilon \quad \because EL' = L' \quad \dots$$

$$L \rightarrow E L' - \{ L, L' \} \quad \therefore L \rightarrow L' \dots$$

$$(L \rightarrow E L') \cup L' \rightarrow S L' | \epsilon$$

$$L \rightarrow S L' | \epsilon$$

The grammar after recursion is,

$$S \rightarrow I L U E T | a$$

Lexical

$$L' \rightarrow S L^* | \epsilon$$

$$E \rightarrow b$$

$$T \rightarrow d L e | \epsilon$$

LR(0)

Q Get LR(0) parsing table for the grammar and show whether the grammar is LR(0) or not.

$$S \rightarrow \underline{ySy} \mid OSO \mid \underline{yO}$$

⇒ Step 1: Augmented grammar

$$S' \rightarrow S$$

$$1) \quad S \rightarrow \underline{ySy} \rightarrow \textcircled{1}$$

$$2) \quad S \rightarrow OSO \rightarrow \textcircled{2}$$

$$3) \quad S \rightarrow \underline{yO} \rightarrow \textcircled{3}$$

R<sub>1</sub>R<sub>2</sub>

Step 2: Closure ..

$$S' \rightarrow .S$$

$$S \rightarrow \underline{yS} \underline{yS}.$$

$$S \rightarrow .OSO \quad OSO$$

$$S \rightarrow .yO$$

n) states

A → d.

T<sub>0</sub>T<sub>1</sub>T<sub>2</sub>T<sub>3</sub>

$$\text{goto } (I_0, S) \rightarrow \{ S' \rightarrow S. \} - I_1$$

$$\text{goto } (I_0, y) \rightarrow \{ S \rightarrow y.S. \} - I_2$$

$$\text{goto } (I_0, O) \rightarrow \{ S \rightarrow y.O. \} - I_3$$

$$\text{goto } (I_1) \rightarrow \emptyset$$

$$\text{goto } (I_2, S) \rightarrow \emptyset$$

$$\text{goto } (I_2, y) \rightarrow \{ S \rightarrow y.S. \} - I_4$$

$$\text{goto } (I_2, O) \rightarrow \{ S \rightarrow y.O. \} - I_4$$

$$\text{goto } (I_2, S) \rightarrow \{ S \rightarrow y.S. \} - I_5$$

$$\text{goto } (I_3, S) \rightarrow \{ S \rightarrow OS.O. \} - I_6$$

$$\text{goto } (I_5, y) \rightarrow \{ S \rightarrow y.S. \} - I_7$$

$\text{goto}(I_6, 0) \rightarrow \{ s \rightarrow 0S0. \} - I_8$

Action Table

| t     | 1     | 0     | s     | \$     |
|-------|-------|-------|-------|--------|
| $I_0$ | $s_2$ | $s_3$ |       |        |
| $I_1$ |       |       |       | ACCEPT |
| $I_2$ |       | $s_4$ | $s_5$ |        |
| $I_3$ | c     |       | $s_6$ |        |
| $I_4$ |       |       |       | $R_3$  |
| $I_5$ | $s_7$ |       |       |        |
| $I_6$ |       | $s_8$ |       |        |
| $I_7$ |       |       |       | $R_1$  |
| $I_8$ |       |       |       | $R_2$  |

goto Table

| t | 1 | 0 | s   | \$ |
|---|---|---|-----|----|
|   |   |   | $s$ | I  |

$\text{follow}(s) \rightarrow .\mathbb{F}$

## LR(1)

Consider the grammar,

$$S \rightarrow AaAb \mid BbBa$$

$$A \rightarrow E$$

$$B \rightarrow E$$

solve by LR(1) parser

→ step 1 : Augumented grammar

$$S^* \rightarrow S \quad \{ \text{initial} \}$$

$$S \rightarrow AaAb$$

$$S \rightarrow BbBa$$

$$A \rightarrow E$$

$$B \rightarrow E$$

step 2 : closure ( $S_i \rightarrow \cdot S$ )

$$S_1^* \rightarrow \cdot S, \$ \quad \left. \begin{array}{l} \text{Follow of } S_1 \\ \text{Follow of } S \end{array} \right\}$$

$$S \rightarrow \cdot AaAb, \$ \quad \left. \begin{array}{l} \text{Follow of } S \\ \text{Follow of } S \end{array} \right\}$$

$$S \rightarrow \cdot BbBa, \$ \quad \left. \begin{array}{l} \text{Follow of } S \\ \text{Follow of } S \end{array} \right\}$$

$$A \rightarrow \cdot , a \quad \left. \begin{array}{l} \text{Follow of } S \\ \text{Follow of } A \end{array} \right\}$$

$$B \rightarrow \cdot , b \quad \left. \begin{array}{l} \text{Follow of } S \\ \text{Follow of } B \end{array} \right\}$$

step 3 :

$$\text{goto } (I_0, S) \rightarrow \{ S_1 \rightarrow S \cdot, \$ \} \quad I_1$$

$$\text{goto } (I_0, A) \rightarrow \{ S \rightarrow A \cdot aAb, \$ \} \quad I_2$$

$$\text{goto } (I_0, B) \rightarrow \{ S \rightarrow B \cdot bBa, \$ \} \quad I_3$$

$$\text{goto } (I_0, a) \rightarrow \{ \phi \}$$

$$\text{goto } (I_0, b) \rightarrow \phi$$

$$I_1 \rightarrow \phi$$

$$\text{goto } (I_2, a) \rightarrow \{ S \rightarrow Aa \cdot Ab, \$ \} \quad I_4$$

$$A \rightarrow \cdot , b$$

$\text{goto } (I_3, b) \rightarrow \left\{ S \rightarrow Bb \cdot Ba, \$ \right\} I_5$

$B \rightarrow \cdot, a$

$\text{goto } (I_1, A) \rightarrow \left\{ S \cdot AaA \cdot b, \$ \right\} I_6$

$\text{goto } (I_5, B) \rightarrow \left\{ S \rightarrow BbB \cdot ab \right\} I_7$

$\text{goto } (I_6, b) \rightarrow \left\{ S \rightarrow AaAb \cdot \right\} I_8$

$\text{goto } (I_7, a) \rightarrow \left\{ S \rightarrow BbBa \cdot \right\} I_9$

$I_8 \Rightarrow \phi$

$I_9 \Rightarrow \phi$

$C \rightarrow \{ I_0, I_1, I_2, I_3, I_4, I_5, I_6, I_7, I_8, I_9 \}$

Action Table

a    b    ·    \$

goto Table

|       |       |       |
|-------|-------|-------|
| S     | A     | B     |
| $s_1$ | $s_2$ | $s_3$ |

$I_0$

Accept

$I_1$

$I_2 \quad s_4$

$I_3$

$s_5$

$I_4$

6

$I_5$

$I_6$

$I_7$

$I_8$

$I_9$