

CS & IT Engineering

Compiler Design

Lexical Analysis and Syntax Analysis

Lecture: 10



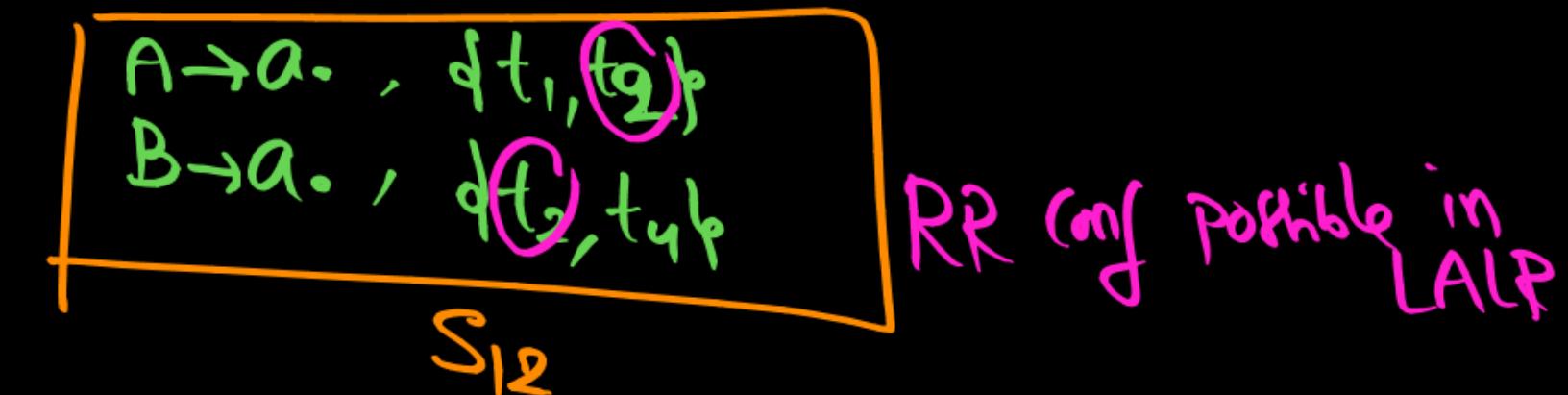
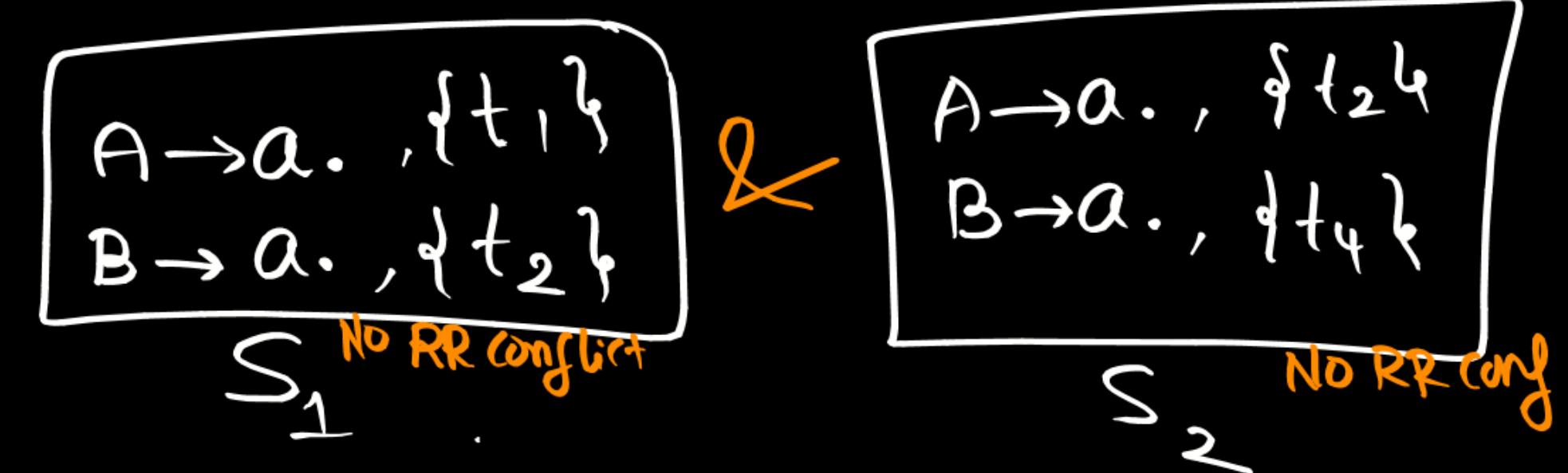
Deva sir

Topics to be covered:

- Table construction for LR(0) / SLR / CLR / LALR
- * * * → Relations
- Parsing Algo
- GATE PYQs

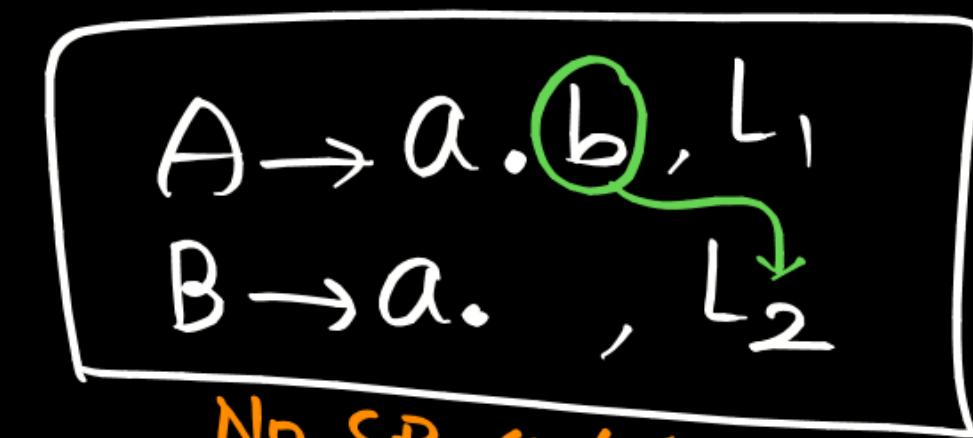
CLR VS LALR

I) If CFG is CLR(1) and after merging states of CLR to make LALR then RR conflict possible in LALR.

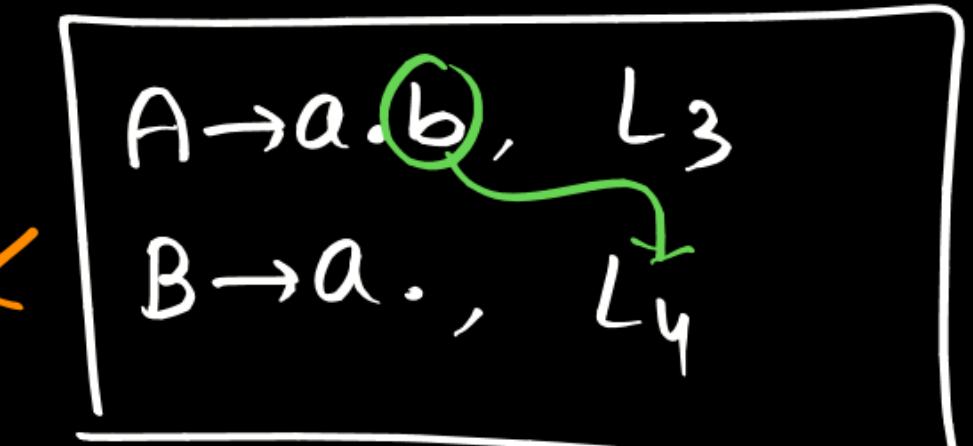


CLR VS LALR

II) If CFG is CLR(1) and after merging States of CLR to make LALR then SR conflict never possible (Impossible) in LALR.



No SR Conf in CLR
 $b \notin L_2$

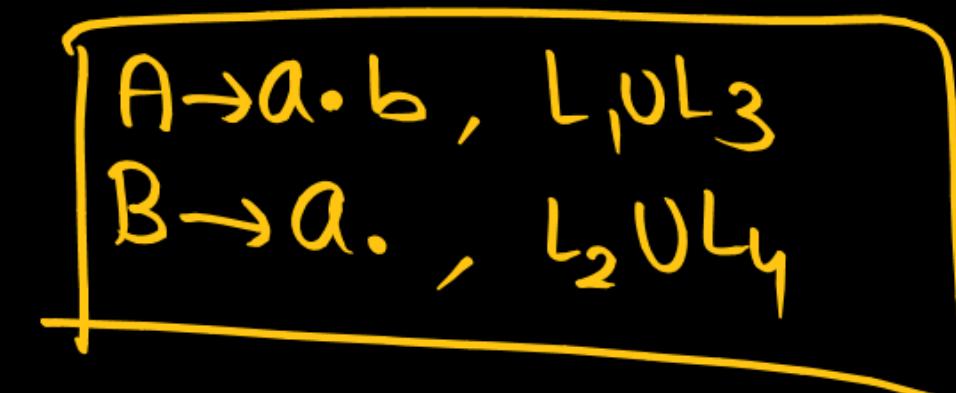


No SR Conf in CLR
 $b \notin L_4$

$b \notin L_2$ and $b \notin L_4$

||

$b \notin L_2 \cup L_4$



No SR Conf in LALR

Note:

Today, many compilers built based on LALR.



If any SR conflict occurs, then

it performs Shift action and
proceeds for further parsing.

{ LALR is ^{more} popular parser
CLR is more powerful parser

Table Construction:

LL(1) Table

Entries

I) Production (Rule)

II) Blank

LR Table

Entries

I) Shift Entry

II) Goto Entry
(State)

III) Reduced Entry

IV) Acceptance Entry

V) Blank Entry

Shift, Reduce, Accept
ACTION Table

GOTO
Table

Goto entry

Size of Table :

LL(1) Table

$$\begin{aligned} &= |V| * (|T| + 1) \\ &= \text{No. of Non-terminals} * (\text{No. of terminals} + 1) \end{aligned}$$

LR Tables

No. of Rows * No. of columns

ACTION Table:

No. of states * (No. of terminals + 1)

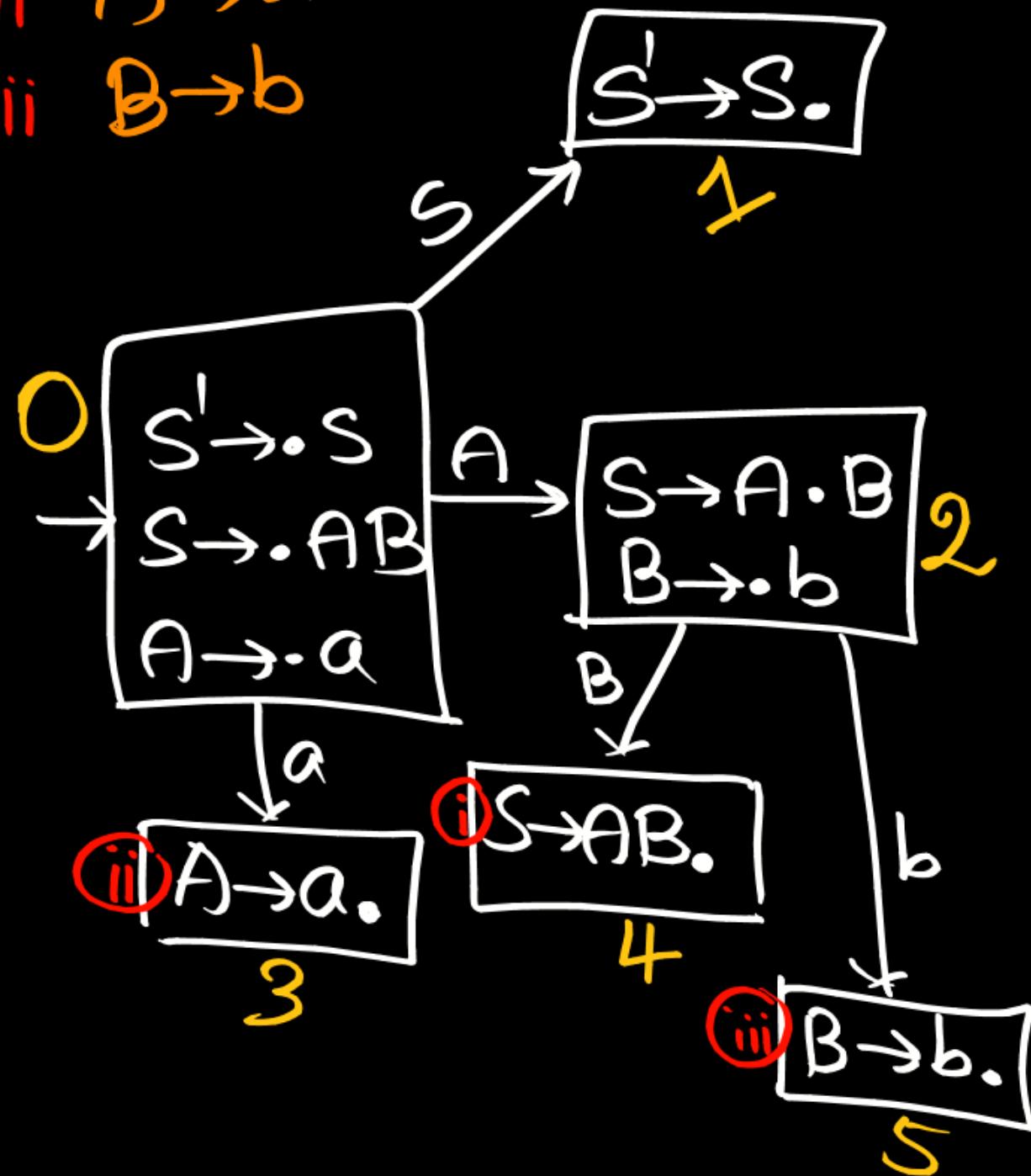
GOTO Table:

No. of states * (No. of non-terminals)

LR(0) Table Construction:

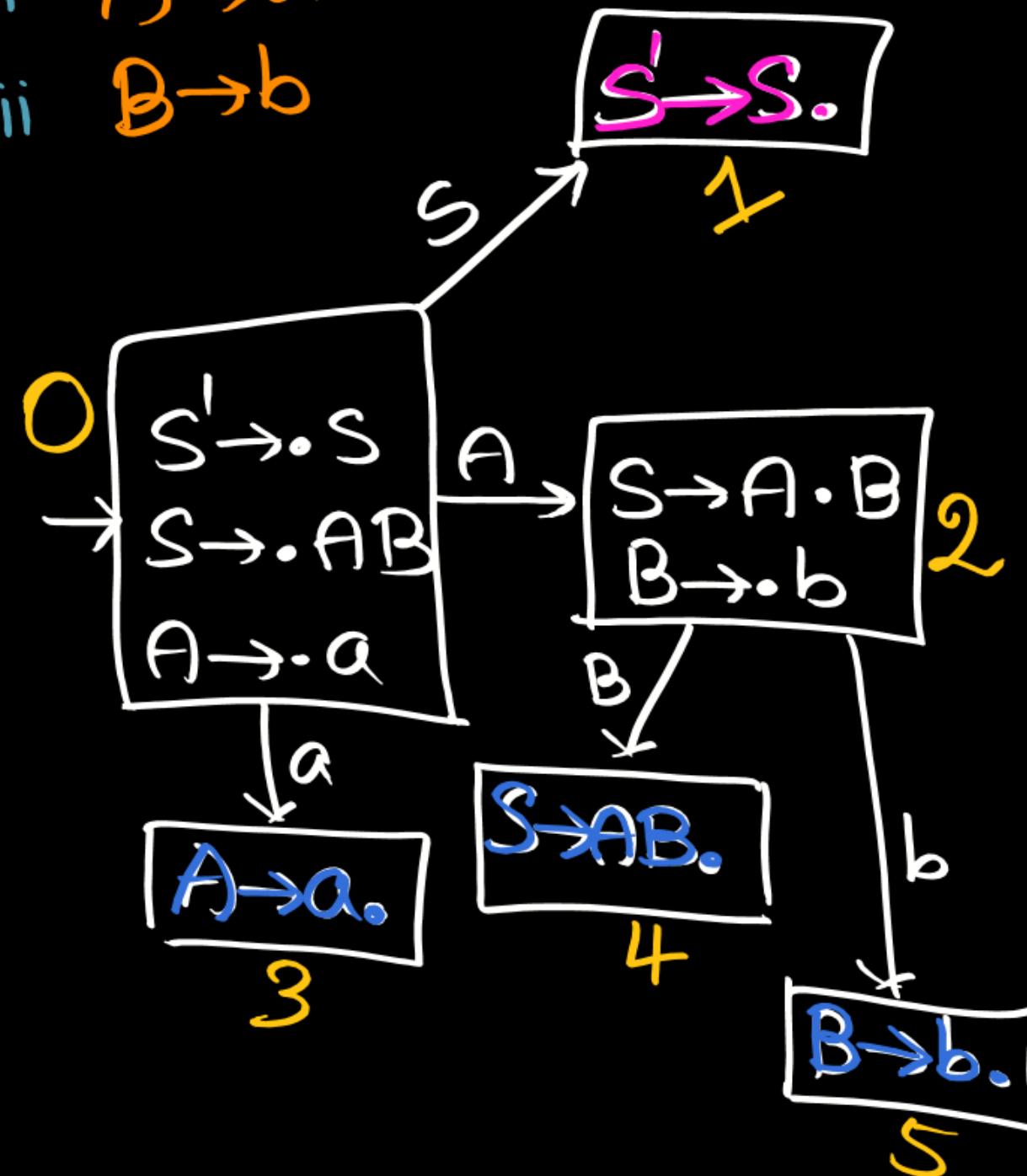
- I) Shift Entry
- II) Goto Entry
- III) Reduced Entry
- IV) ACCEPT Entry

- i $S \rightarrow AB$
- ii $A \rightarrow a$
- iii $B \rightarrow b$



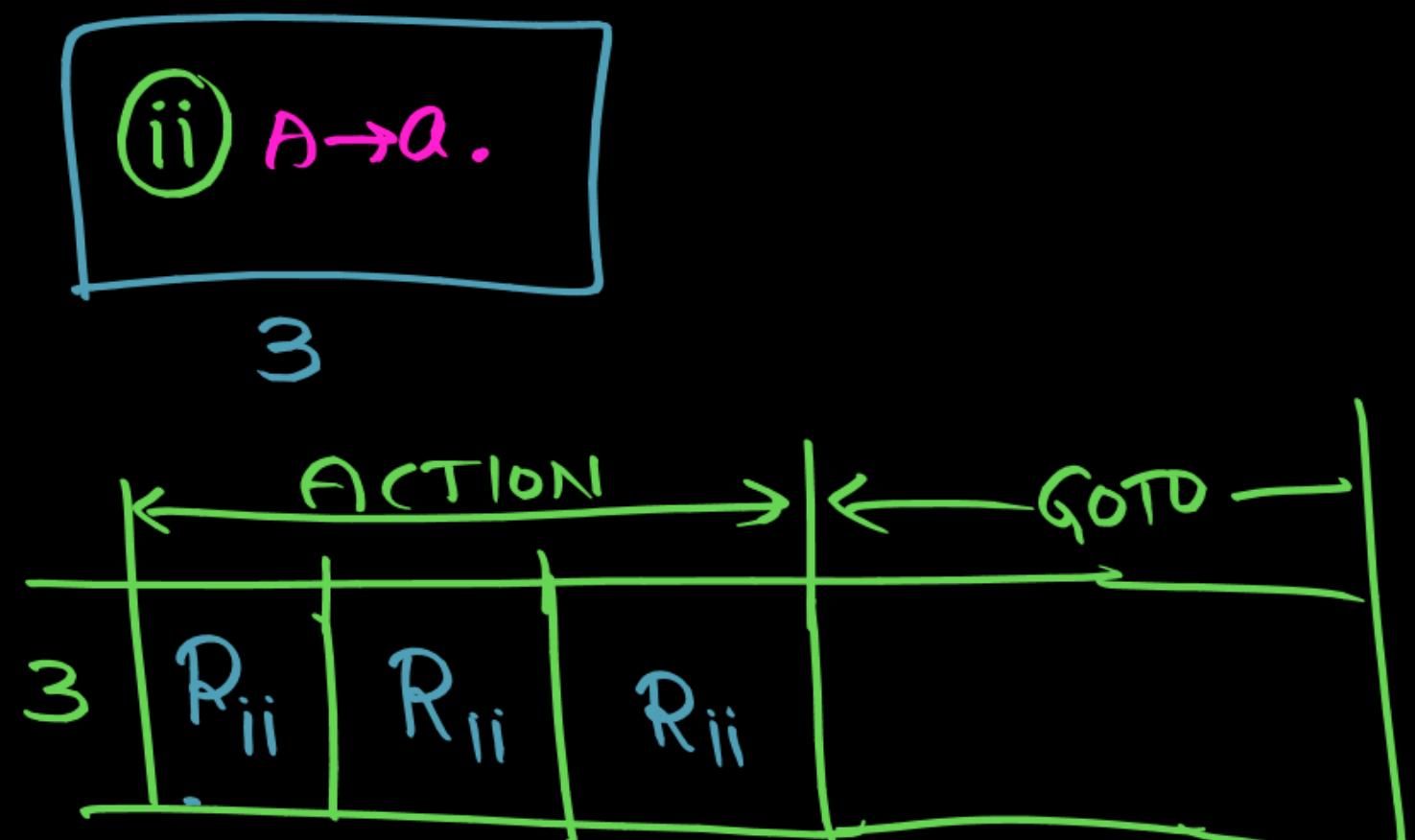
| LR(0) | ACTION | | | GOTO | | |
|-------|-----------|-----------|-----------|---------------|---|---|
| | a | b | \$ | S | A | B |
| 0 | S_3 | | | 1 | 2 | |
| 1 | | | | | | |
| 2 | | | | ACCEPT | | |
| 3 | R_{ii} | R_{ii} | R_{ii} | | | |
| 4 | R_i | R_i | R_i | | | |
| 5 | R_{iii} | R_{iii} | R_{iii} | | | |

- i $S \rightarrow AB$
- ii $A \rightarrow a$
- iii $B \rightarrow b$

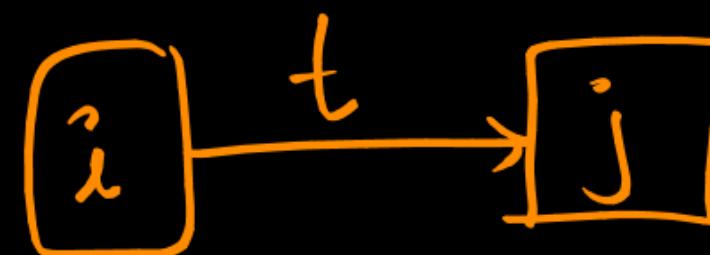


Reduced Entry for LR(0) :

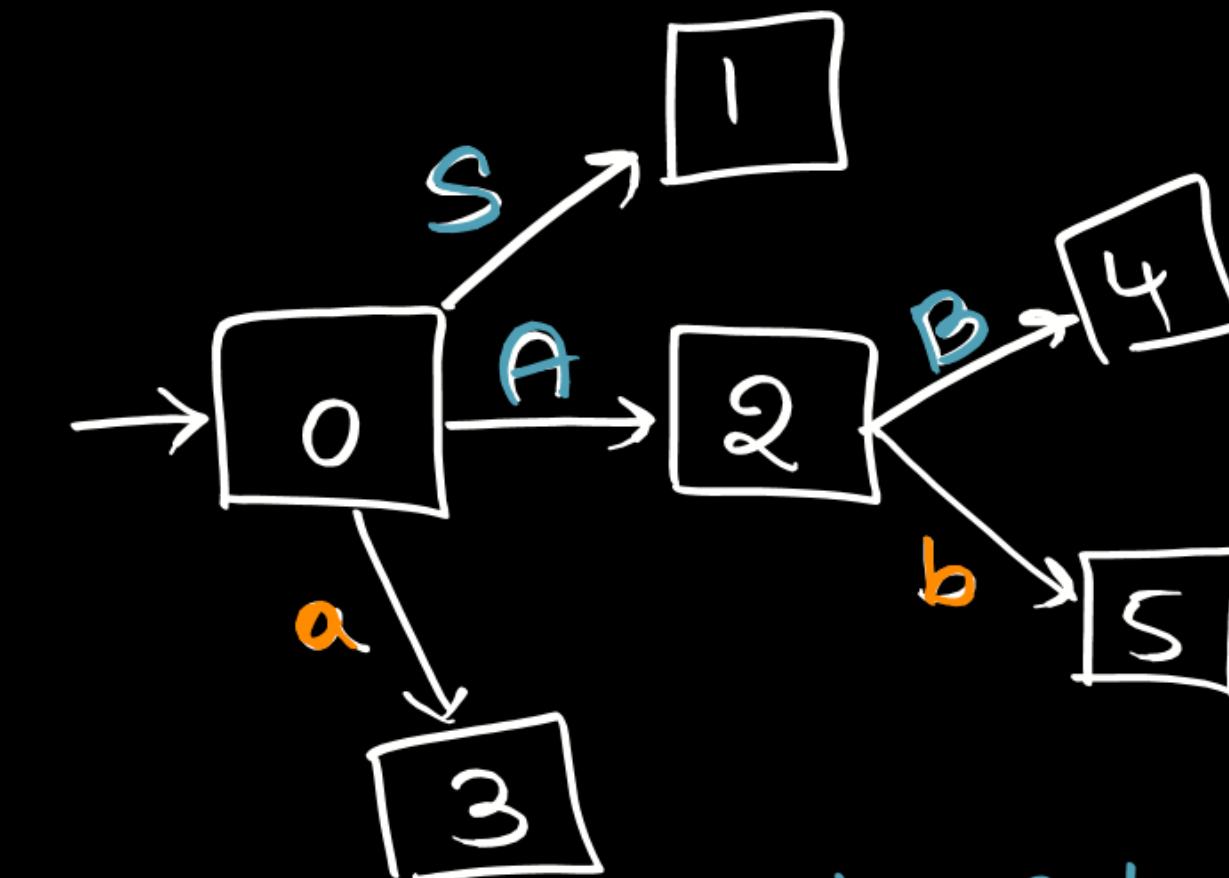
↳ We should look at every reduced item



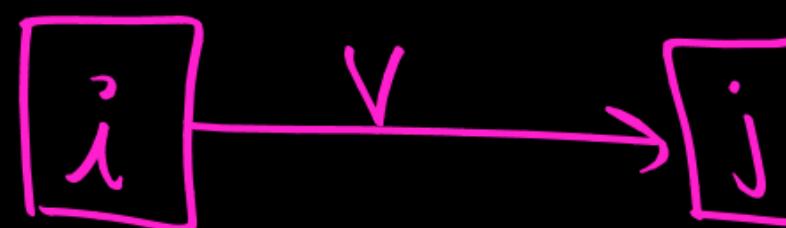
Shift Entry:



$$\frac{t}{i \uparrow S_j}$$



State (Goto) Entry:



$$\frac{v}{i \uparrow j}$$

| | S | A | B |
|---|---|---|---|
| 0 | 1 | 2 | |
| 2 | | | 4 |

Acceptance Entry:

$S' \rightarrow S.$

i

$\frac{\$}{\text{ACCEPT}}$

Note:

- I) No. of Shift entries = No. of terminal transitions in DFA
- II) No. of State entries = No. of non-terminal transitions in DFA
(goto)

LR(0) Table & SLR(1) Table

Shift entries are same

goto entries are same

only Reduced entries may differ

Note:

- I) No.of Shift entries in LR(0) = No.of shift entries in SLR(1)
- II) " goto " " = " goto " "
- III) No.of Reduced entries in LR(0) \geq No.of reduced entries in SLR(1)

Reduced Entry in SLR(1):

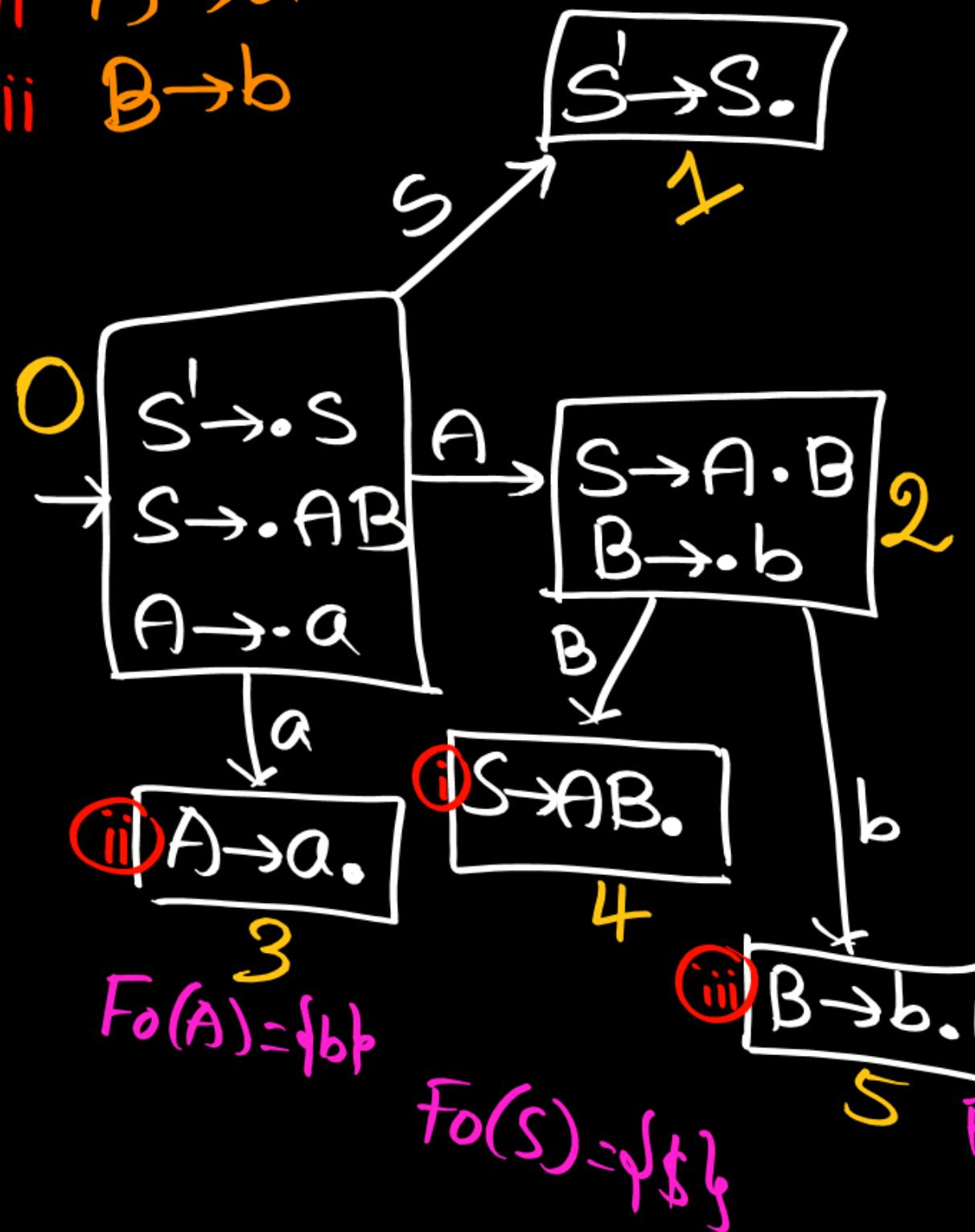
K $X \rightarrow \alpha.$

i

Follow(X) = {t₁, t₂}

| | | |
|---|----------------|----------------|
| i | t ₁ | t ₂ |
| | R _k | R _k |

- i $S \rightarrow AB$
- ii $A \rightarrow a$
- iii $B \rightarrow b$

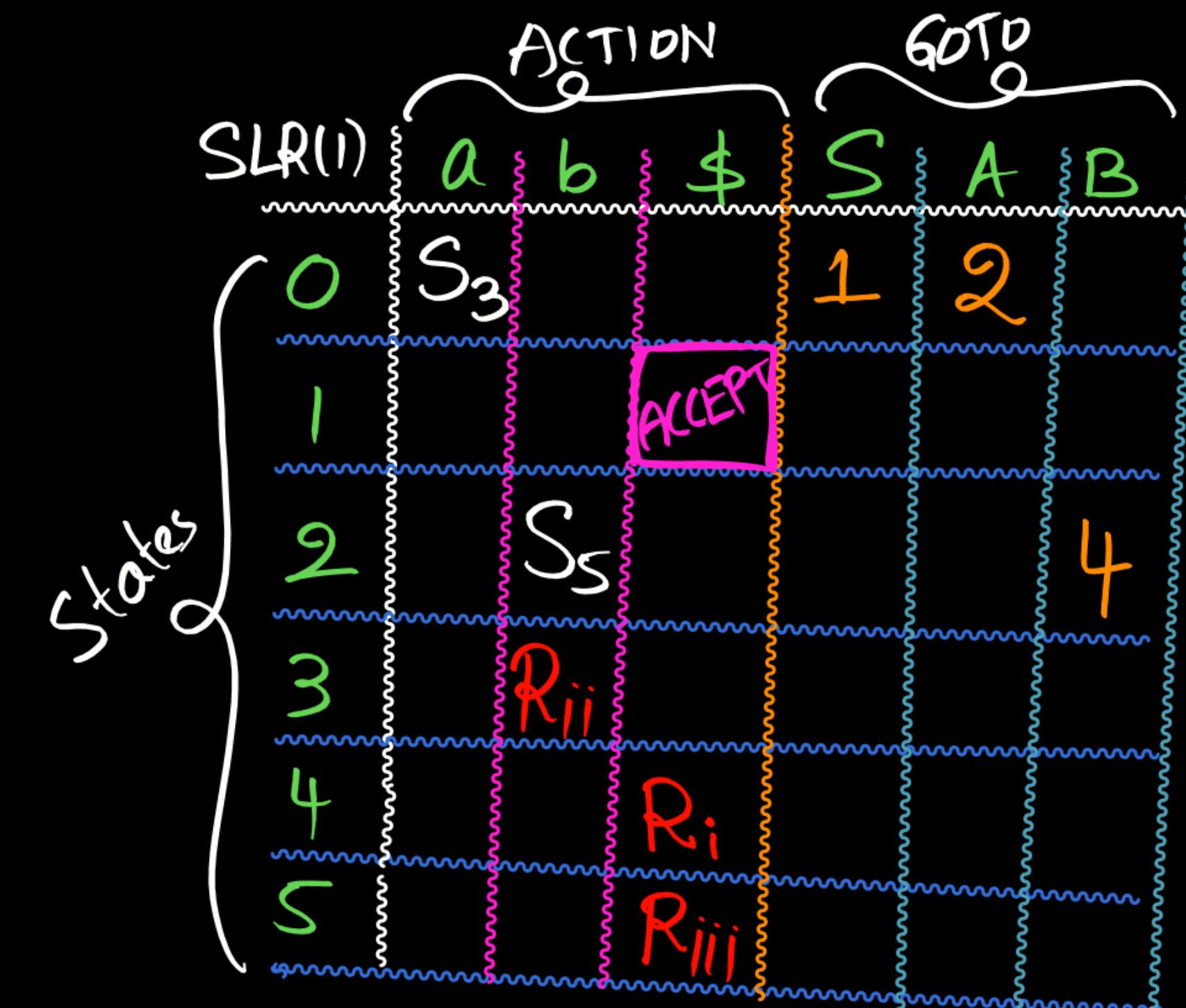


$$F_0(A) = \{b\}$$

$$F_0(S) = \{\$\}$$

$$5$$

$$F_0(B) = \{\$\}$$



CLR and LALR Reduced Entries

↳ Look at every reduced item

Production K $\rightarrow \alpha, \{t_1, t_3\}$

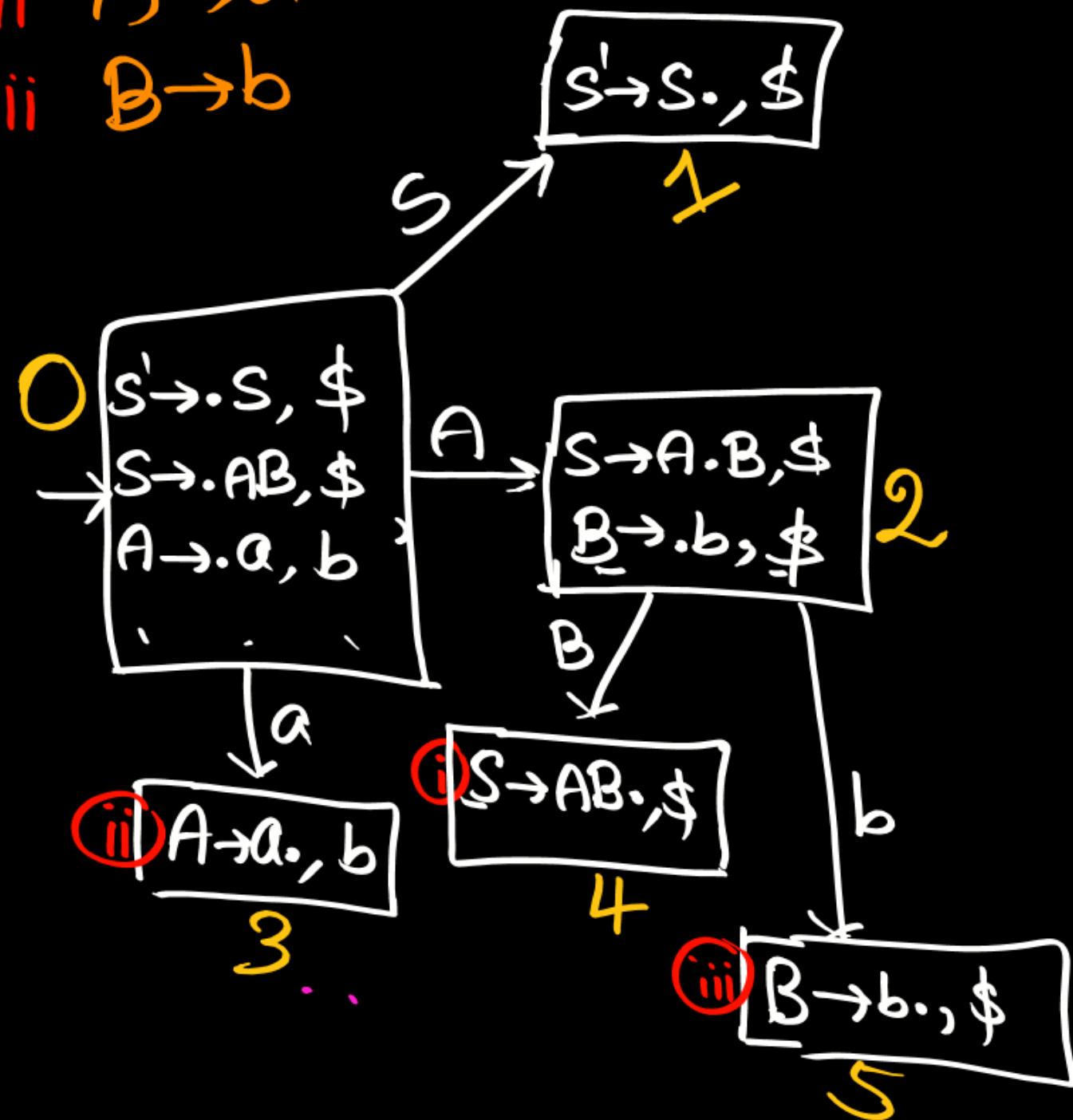
:

S-state i

| | | |
|-----|-------|-------|
| | t_1 | t_3 |
| i | R_K | R_K |

CLR and LALR Table:

- i $S \rightarrow AB$
- ii $A \rightarrow a$
- iii $B \rightarrow b$



States

Items

Action and CLR(1)

GO TO

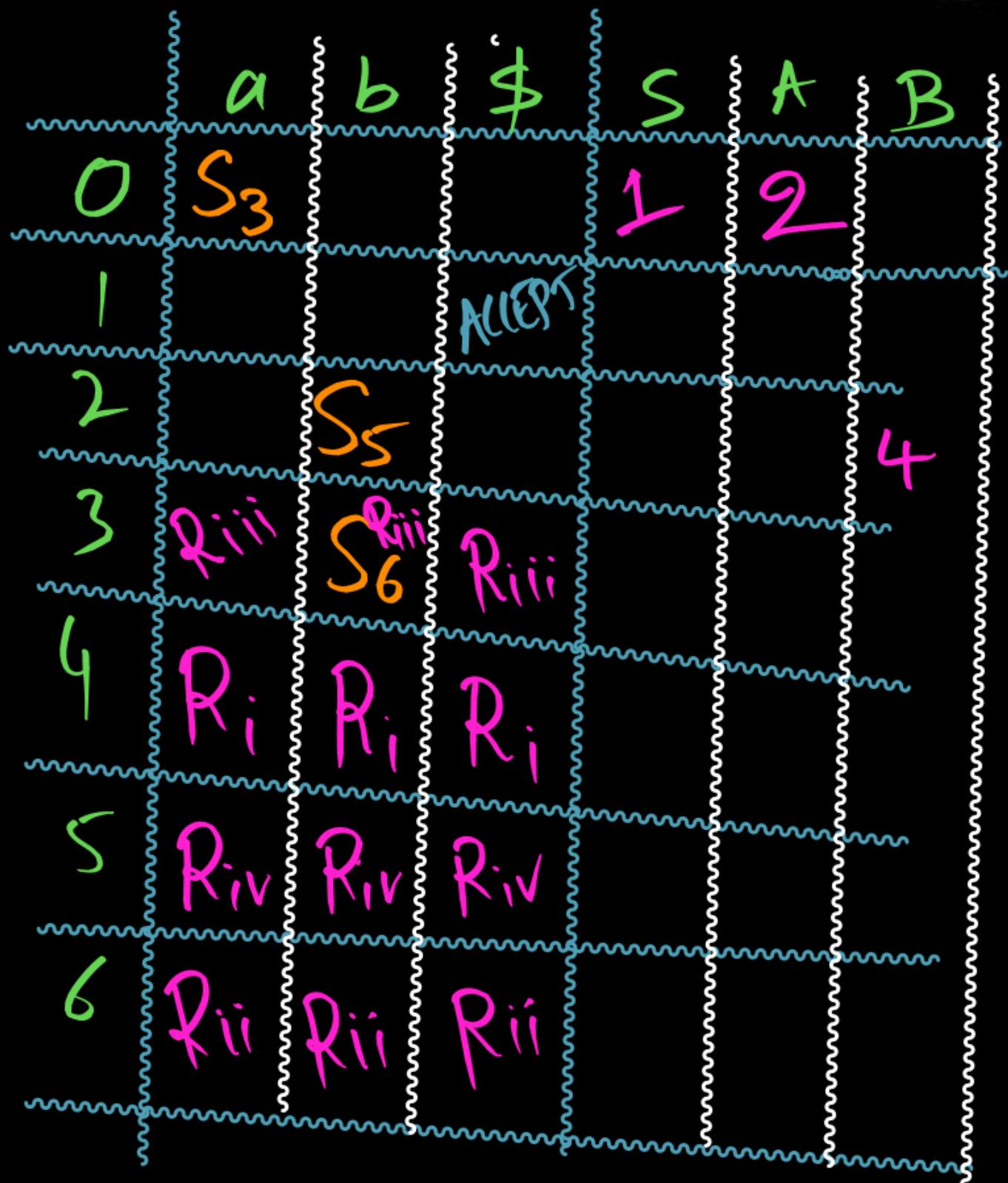
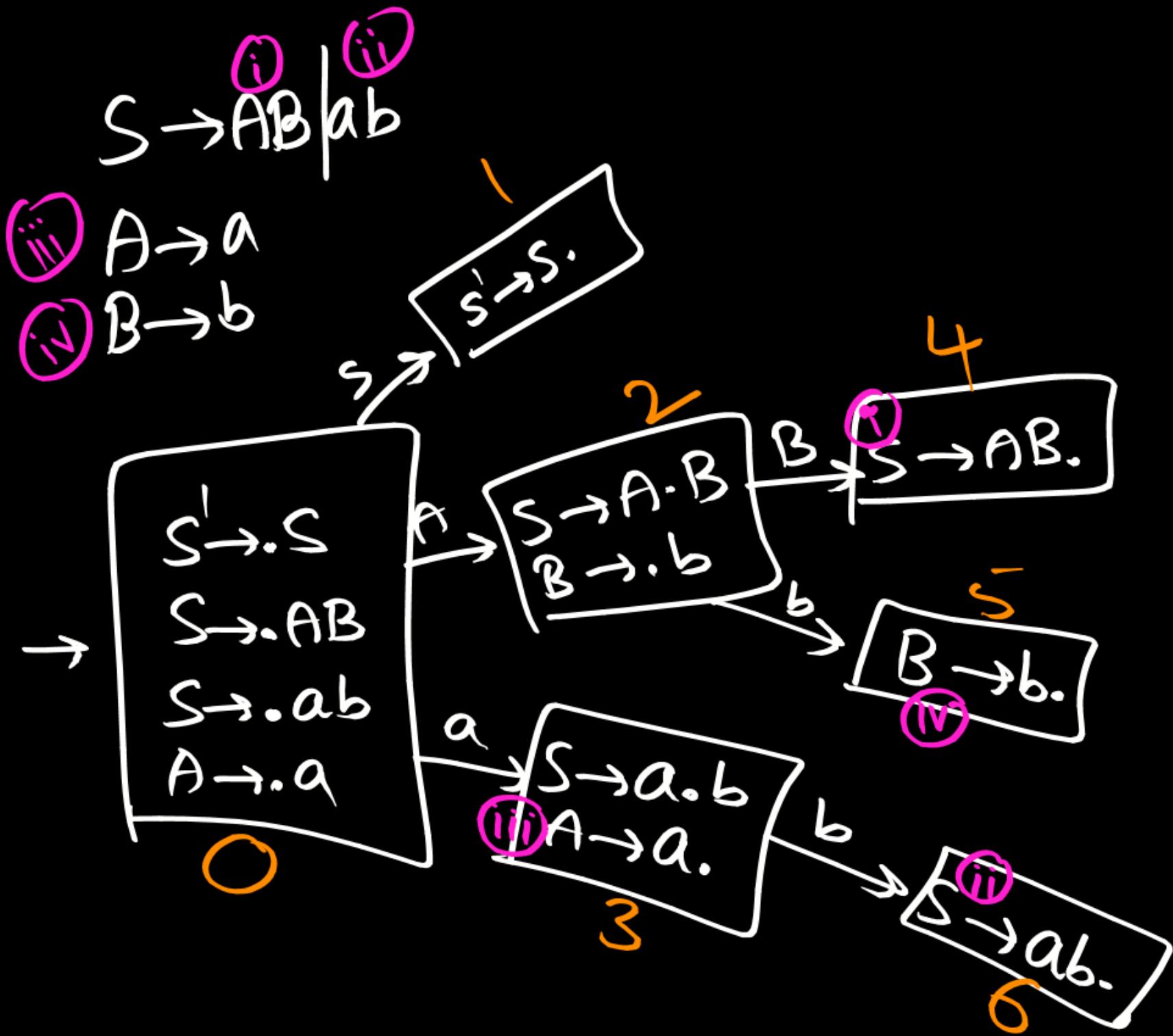
| | a | b | \$ | S | A | B |
|---|-------|---|----|-----------|---|---|
| 0 | S_3 | | | 1 | 2 | |
| 1 | | | | | | |
| 2 | | | | S_5 | | |
| 3 | | | | R_{ii} | | |
| 4 | | | | R_i | | |
| 5 | | | | R_{iii} | | |

LR(0) Table | SLR(1) | LALR | CLR

- I) Shift entries in LR(0), SLR, and LALR are always same
- II) Goto " " , " , " , " , "
- III) Reduced entries may differ

Note :

- I) Shift entries (LR(0)) = Shift entries (SLR) = Shift entries (LALR) \leq Shift entries in CLR(1)
- II) Goto entries in LR(0) = Goto entries in SLR = Goto entries in LALR \leq Goto entries in CLR
- III) Reduced entries in LR(0) \geq Reduced entries in SLR $>$ Reduced entries in LALR ? Reduced entries in CLR



Shift Entry : Look at terminal transition in DFA

Goto Entry : Look " nonterminal " "

Reduced Entry : Look at Reduced Item

Accept Entry : Look at $S \rightarrow S.$

Blank Entry

Relations :

I) Parsers :

$$\text{Less powerful} \quad LR(0) < SLR < LALR < CLR \quad \text{More powerful}$$

$$LL(i) < LR(i)$$

Relations:

II) Grammars:



Relations:

III) classes

L_1 = set of LR(0) CFGs

L_2 = " " SLR "

L_3 = " LALR "

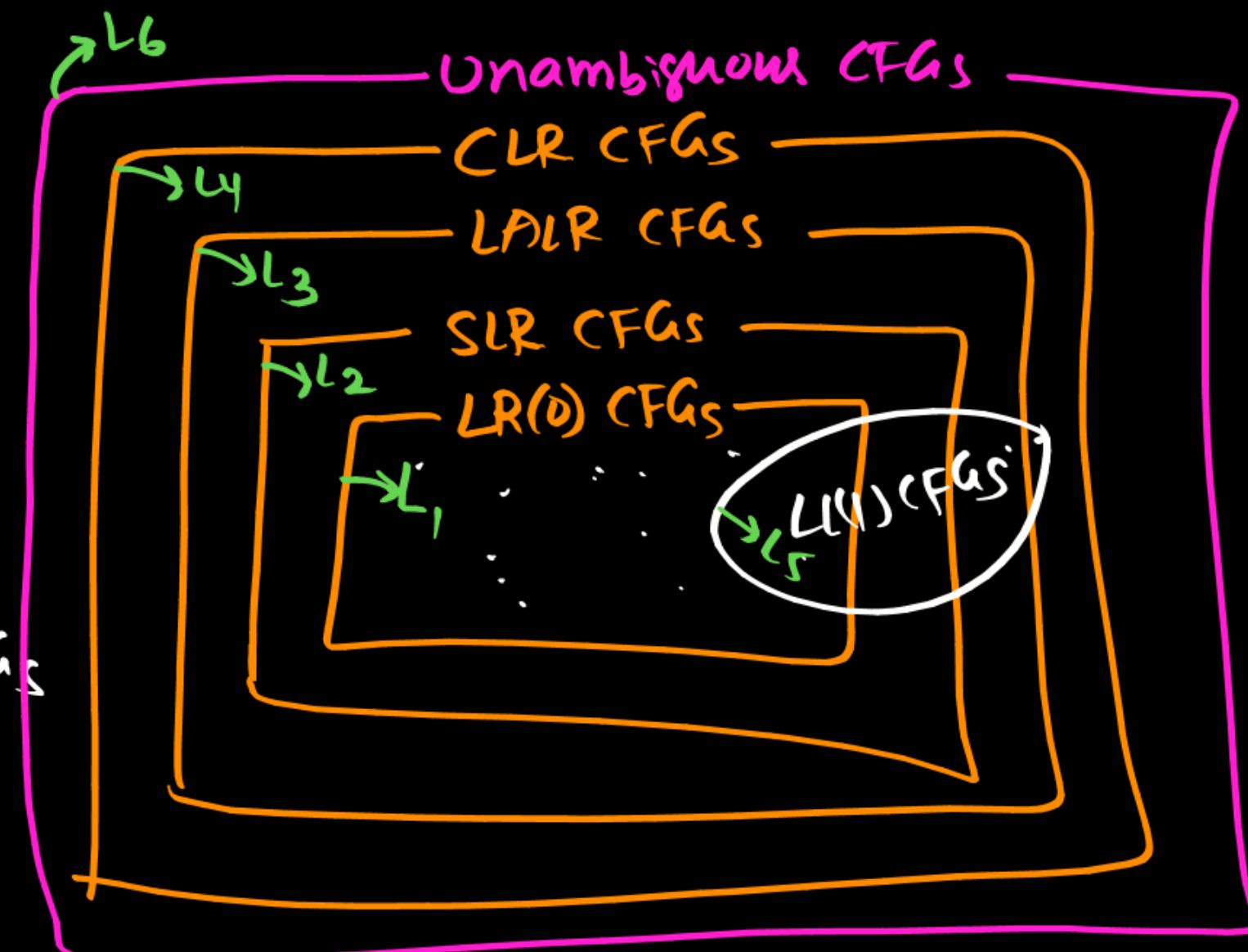
L_4 = " CLR "

L_5 = " LL(1) "

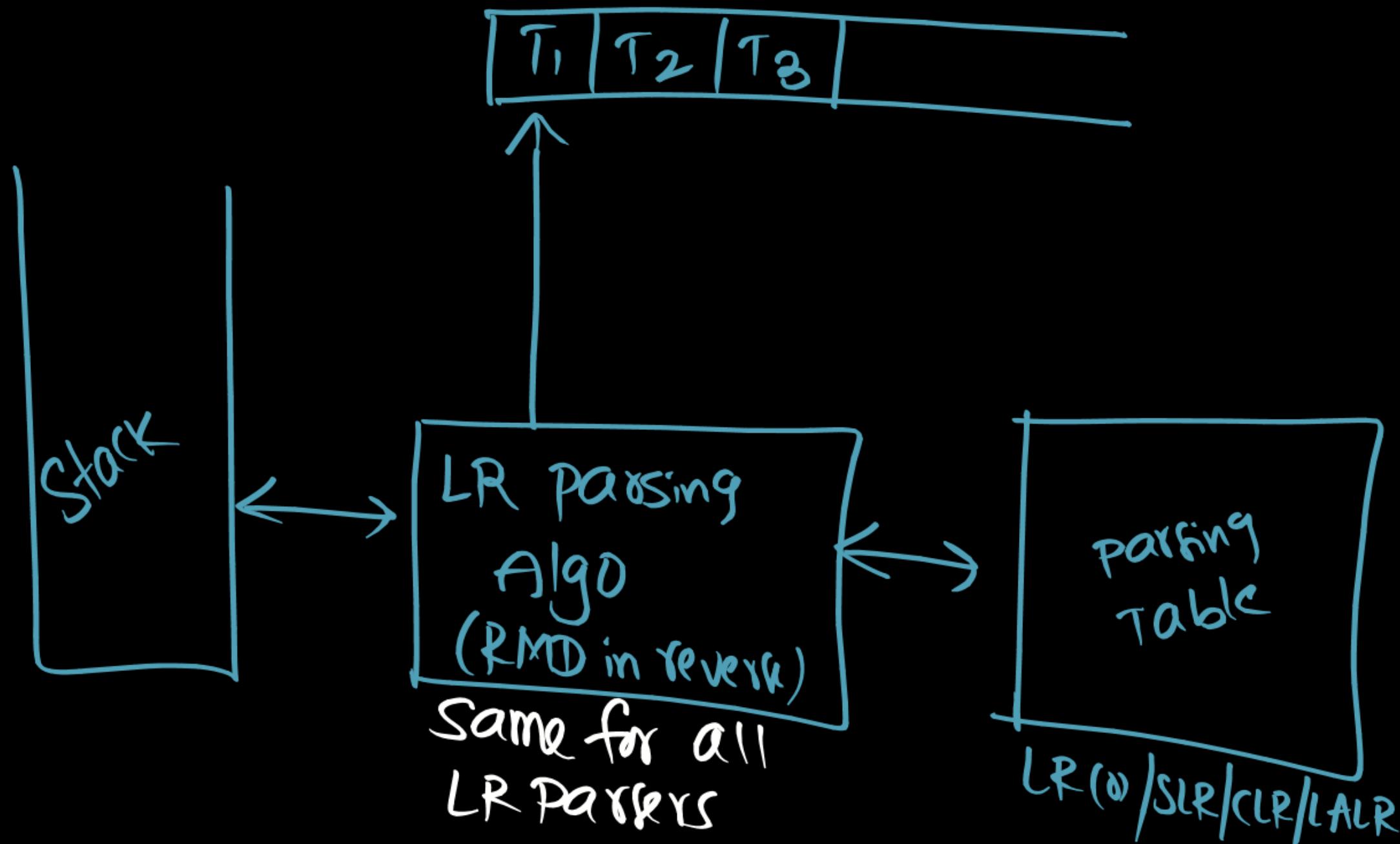
L_6 = " Unambiguous CFGs

$$\text{I)} \quad L_1 \subset L_2 \subset L_3 \subset L_4 \subset L_6$$

$$\text{II)} \quad L_5 \subset L_4 \subset L_6$$



LR Parsers



LR Parsing Algorithm: Input: ab

P
W

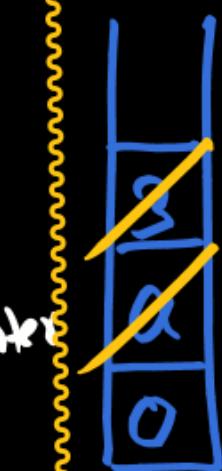
Step 1:



$$M[0,a] : S_3$$

- I) PUSH A & Inc pointer
- II) PUSH 3

Step 2: b\$



$$M[3,b] : R_{ii}$$

- I) 2*|a| POP
- II) PUSH LHS
- III) Push M[0,A]

Step 3:



$$M[2,b] : S_5$$

- i) PUSH b
- ii) PUSH 5

ACTION

| M | a | b | \$ | S | A | B |
|---|-------|---|----|---------------|-----------|---|
| 0 | S_3 | | | 1 | 2 | |
| 1 | | | | ACCEPT | | |
| 2 | | | | S_5 | | |
| 3 | | | | | R_{ii} | |
| 4 | | | | | R_i | |
| 5 | | | | | R_{iii} | |

Step 4:



$$M[5,$] : R_{iii}$$

- I) POP 2*|b|
- II) PUSH LHS
- III) PUSH $M[2,B]$

Step 5:



$$M[4,$] : S \rightarrow AB$$

- I) POP 2*|AB|
- II) PUSH S
- III) PUSH $M[0,S]$

Step 6:



$$M(1,$) : \text{Accept}$$

i) $S \rightarrow AB$

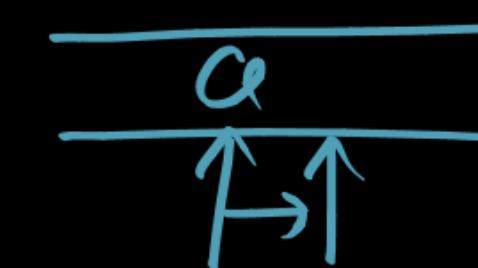
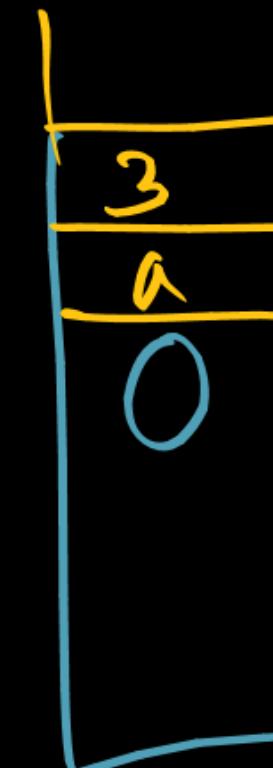
ii) $A \rightarrow a$

iii) $B \rightarrow b$

Shift Action:

$\frac{a}{0} \mid s_3$

Shift Entry



- I) PUSH ^{input} a onto stack &
INC pointer
- II) PUSH next state number
(3)

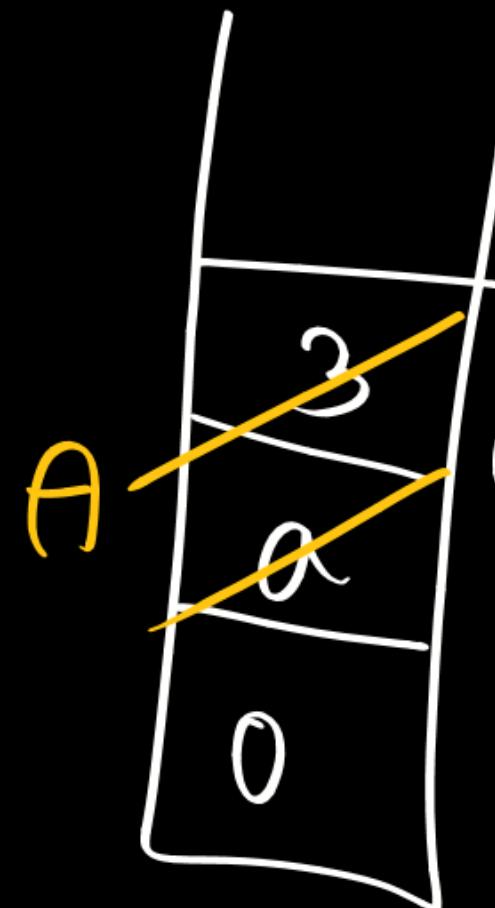
Reduced ACTION:

$M[3, b] : R_{ii}$

$A \rightarrow a$

- I) Pop $2 * |RHS|$
- II) PUSH LHS

Goto entry III) PUSH $M[\text{below tos}, \text{tos}]$
 (below tos) (LHS)



$M[3, b] : A \rightarrow a$

- I) $= 2 * |a|$
 $= 2 \text{ symbols pop}$

II) PUSH A

III) $M[0, A]$ push
 goto entry



$$\cdot ab \xrightarrow{\text{shift}} a \cdot b$$

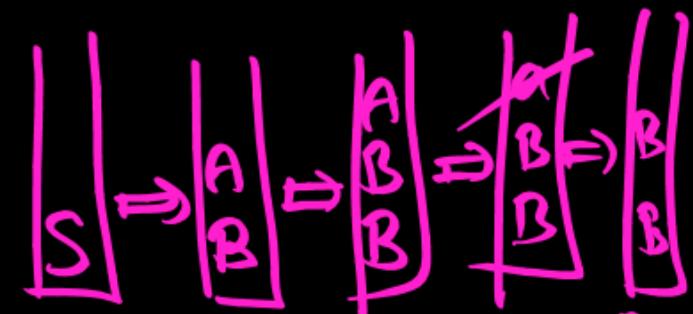
$\uparrow \text{Reduced}$

$$a \cdot b \xrightarrow{\text{shift}} ab.$$

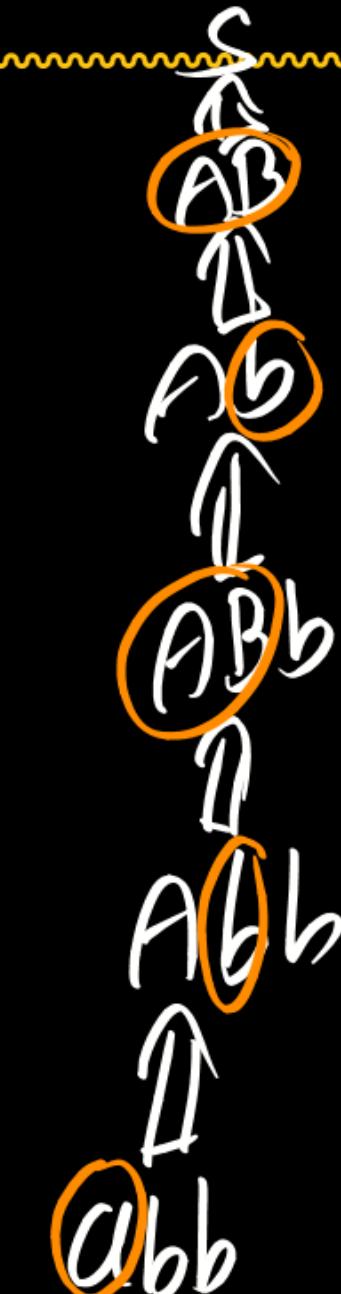
S.
↓ Reduced $S \rightarrow AB$

AB.
↓ Reduced $B \rightarrow b$

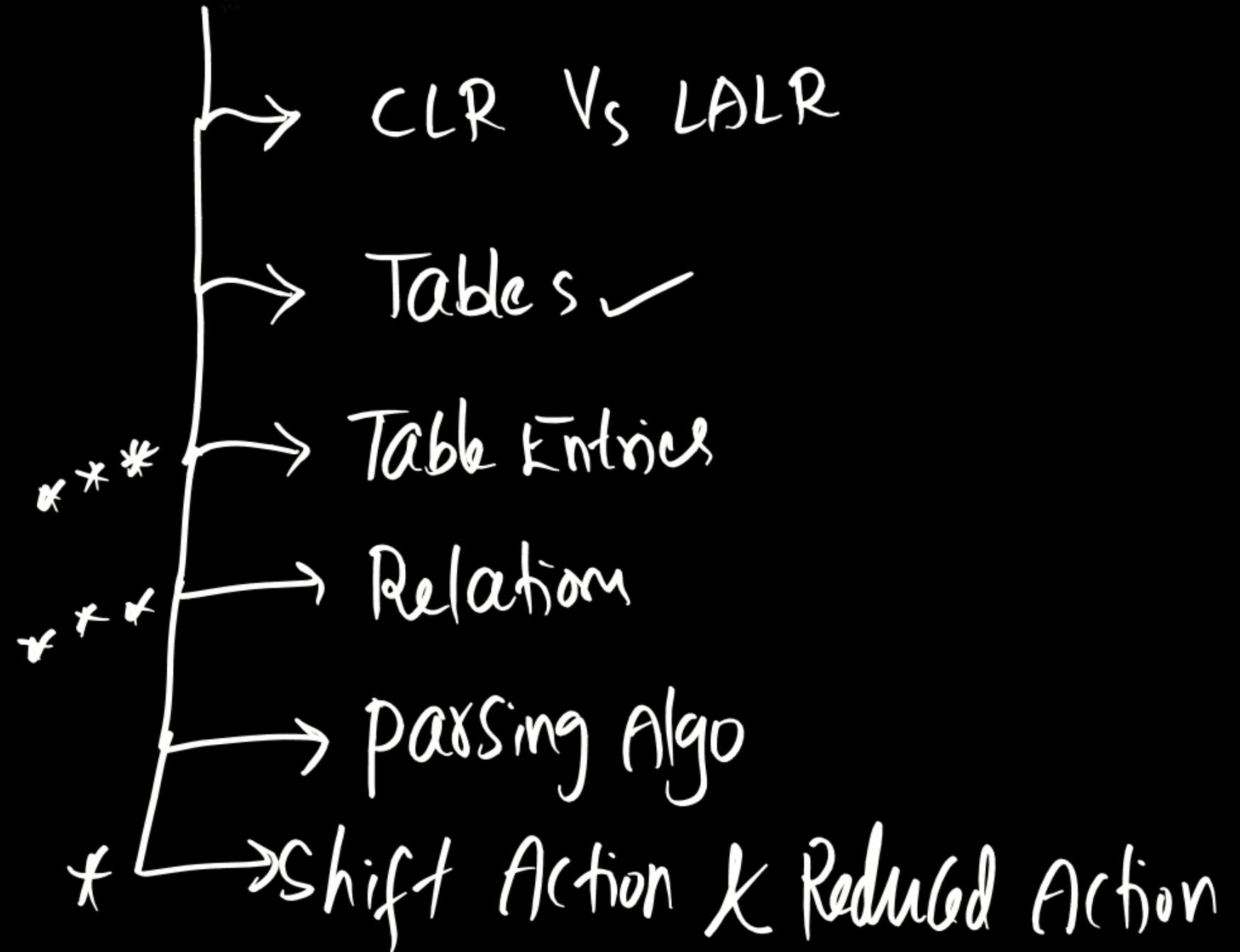


$S \rightarrow AB$ $A \rightarrow AB | a$ $B \rightarrow b$  $w = abb$

LMD: SAABB

RMD: ~~SBABA~~ $\xrightarrow{\text{Reverse of RMD}}$ ABABS

Summary



Thank you
PW
Soldiers

