CS & IT ENGINEERING

Compiler Design

Lexical Analysis & Syntax Analysis

Lecture No. 09

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TOPICS TO BE COVERED

01 LR(0) DFA

02 LR(0) CFG ?

03 SLR(1) CFG ?

04

05

↳ CLR & LALR

LR(0) Item

$\Downarrow$

LR(0) parser

SLR(1) parser

$X \to \alpha . \beta$

LR(1) Item

LALR parser

CLR Parser

$X \to \underbrace{\alpha . \beta}_{\text{core}} , \underbrace{t_1 | t_2}_{\text{look-a-head}}$

How to compute look-a-heads of LR(1) Item?

$$X \rightarrow \alpha . \boxed{Y} \overset{S}{} \beta \,,\, \overset{\$}{\gamma}$$

we know

(Y)

After Y

$\boxed{\beta\gamma}$

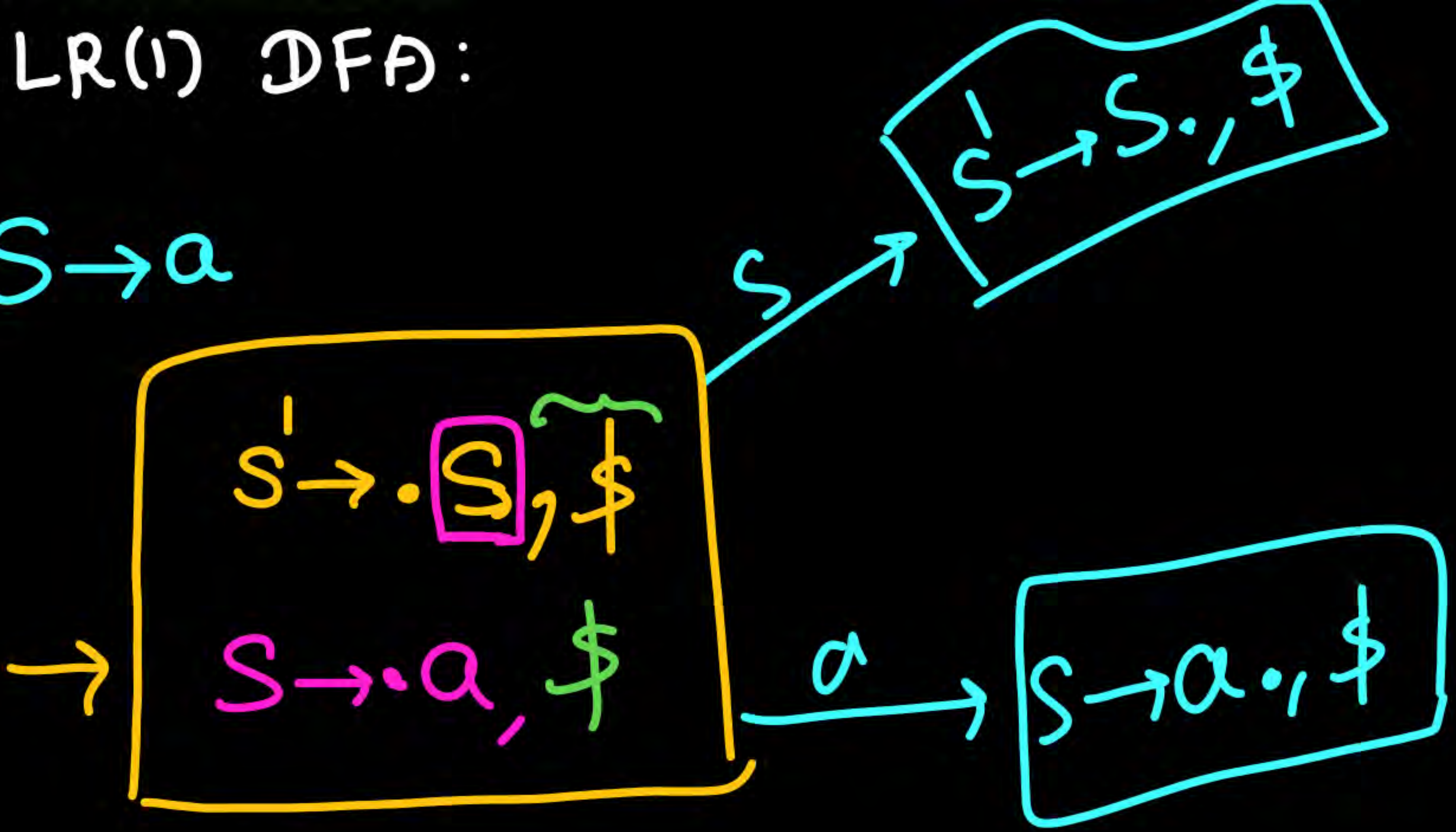
$$Y \rightarrow .RHS \;,\; \text{First}(\beta\gamma)$$

$\epsilon\,\$$

How to compute?

CLR(1) DFA:

① $S \rightarrow a$

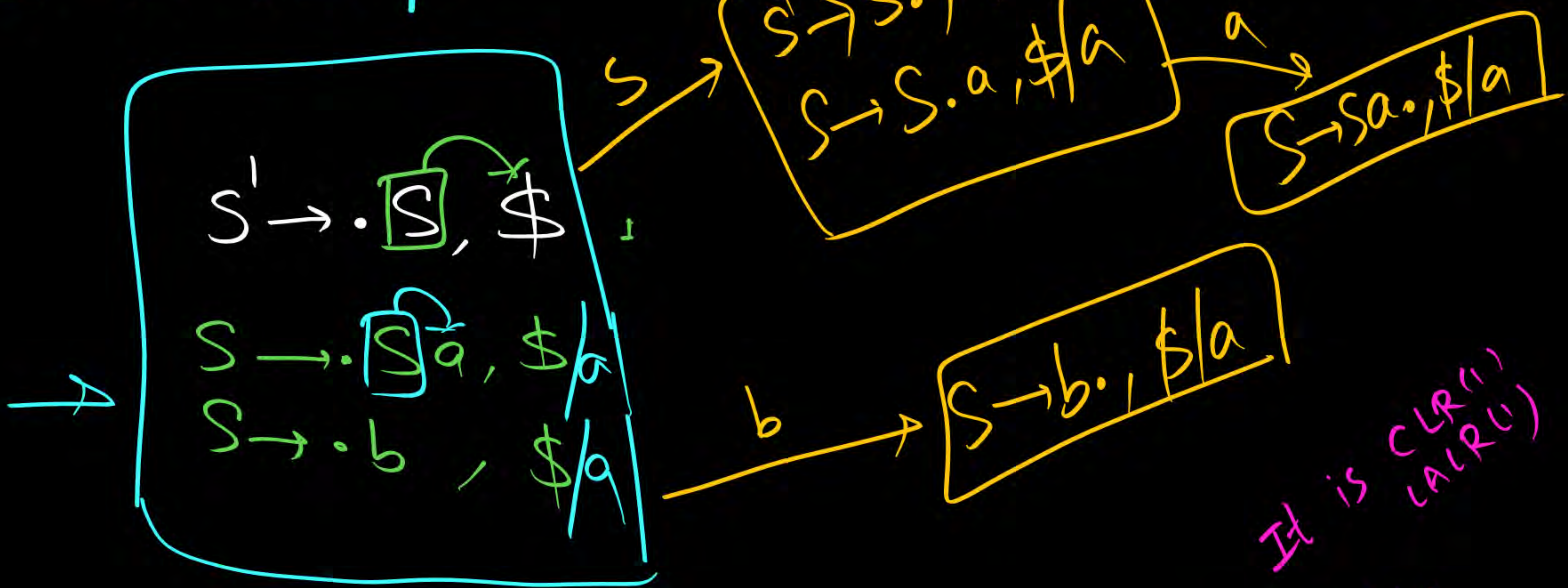


given CFG is CLR

given CFG is LR(0)
SLR(1)
LALR(1)
CLR(1)

This DFA for both CLR & LALR

② $S \to Sa \mid b$



It is CLR(1)
LALR(1)

It is LR(0)
SLR(1)
LALR(1)
CLR(1)

③ $S \to Sa \mid Sb \mid c$

$S' \to \bullet \boxed{S}, \$$
$S \to \bullet \boxed{S}a, \$|a|b$
$S \to \bullet \boxed{S}b, \$|a|b$
$S \to \bullet c, \$|a|b$

$\xrightarrow{S}$

$S' \to S\bullet, \$$
$S \to S\bullet a, \$|a|b$
$S \to S\bullet b, \$|a|b$

$\xrightarrow{a}$ $S \to Sa\bullet, \$|a|b$

$\xrightarrow{b}$ $S \to Sb\bullet, \$|a|b$

$\xrightarrow{c}$ $S \to c\bullet, \$|a|b$

It is CLR
LALR

It is LR(0)
SLR(1)

④ $S \to Aa \mid Bb \mid cAb$

$A \to f$

$B \to f$

It is CLR

It is LALR

LALR but not SLR

I_0:
$S' \to \cdot S, \$$
$S \to \cdot Aa, \$$
$S \to \cdot Bb, \$$
$S \to \cdot cAb, \$$
$A \to \cdot f, a$
$B \to \cdot f, b$

$I_0 \xrightarrow{S}$ $S' \to S\cdot, \$$

$I_0 \xrightarrow{A}$ $S \to A\cdot a, \$$ $\xrightarrow{a}$ $S \to Aa\cdot, \$$

$I_0 \xrightarrow{B}$ $S \to B\cdot b, \$$ $\xrightarrow{b}$ $S \to Bb\cdot, \$$

$I_0 \xrightarrow{c}$ $S \to c\cdot Ab, \$$; $A \to \cdot f, b$

$S \to c\cdot Ab, \$$ $\xrightarrow{A}$ $S \to cA\cdot b, \$$ $\xrightarrow{b}$ $S \to cAb\cdot, \$$

$S \to c\cdot Ab, \$$ $\xrightarrow{f}$ $A \to f\cdot, b$

$I_0 \xrightarrow{f}$ $A \to f\cdot, a$; $B \to f\cdot, b$

$\{a\} \cap \{b\} = \phi \Rightarrow$ no RR conflict in CLR, LALR

$Fo(A) \cap Fo(B) \neq \phi \Rightarrow$ Not SLR(1)

Conflicts checking in CLR(1) & LALR(1):

① SR conflict

Shift Item $X \rightarrow \alpha . \boxed{t} \beta , L_1$

Reduced Item $Y \rightarrow \alpha . , L_2$

If $t \in L_2 \Rightarrow$ SR conflict

② RR conflict

Reduced$_1$ $X \rightarrow \alpha . , L_1$

Reduced$_2$ $Y \rightarrow \alpha . , L_2$

If $L_1 \cap L_2 \neq \phi$
$\Rightarrow$ RR conflict

How to construct LALR(1) DFA?

Step 1: Construct CLR(1) DFA

t_1 / t_2

$\{t_1, t_2\}$

Step 2: If any 2 states are having same items (look-a-heads may be different) then merge those states by combining look-a-heads

$A \to a\cdot, t_1$ In CLR(1) $A \to a\cdot, t_2$

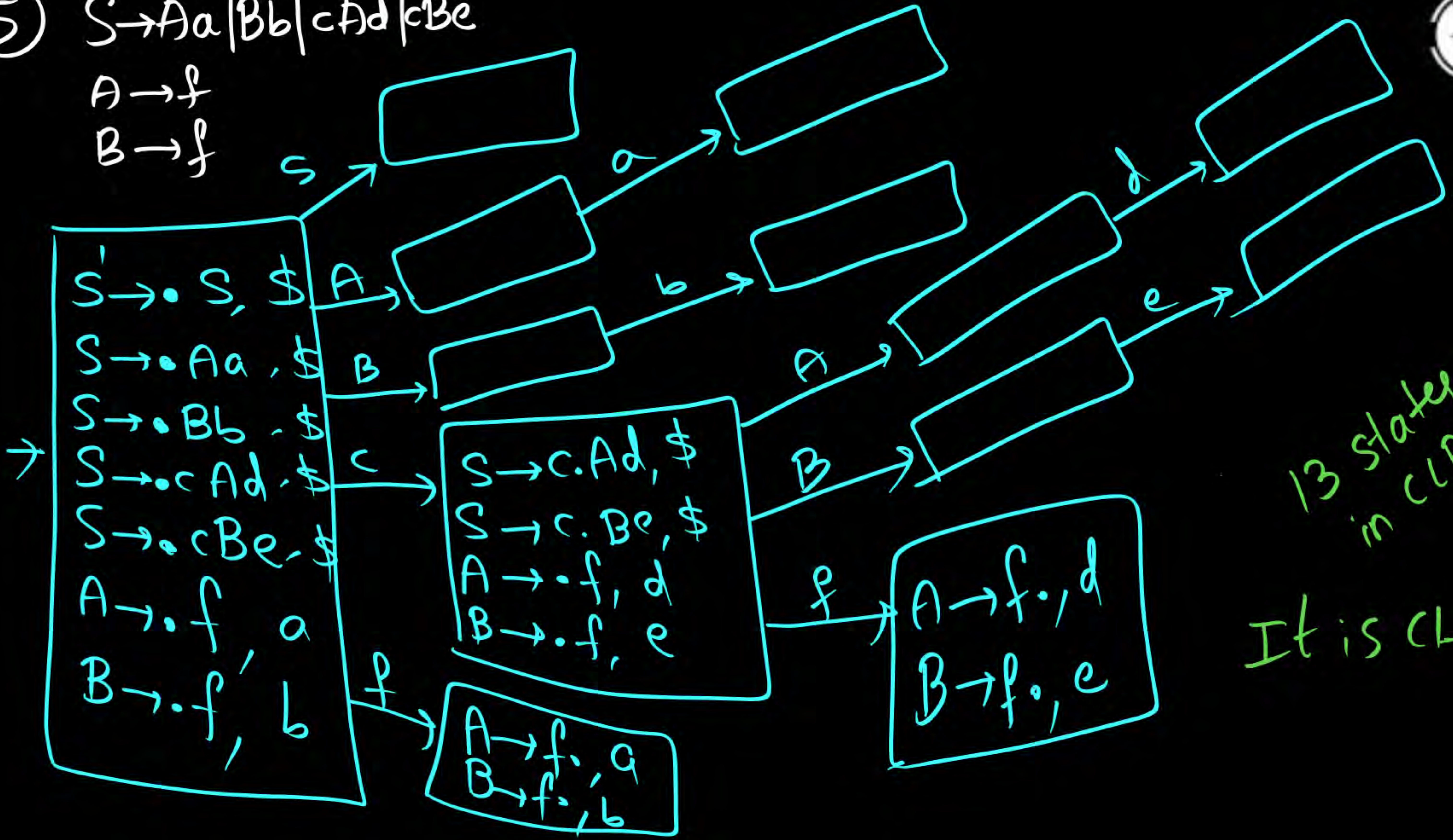
$\Downarrow$

$A \to a\cdot, t_1/t_2$ In LALR

⑤ $S \to Aa \mid Bb \mid cAd \mid cBe$

$A \to f$

$B \to f$



13 states in CLR(1)

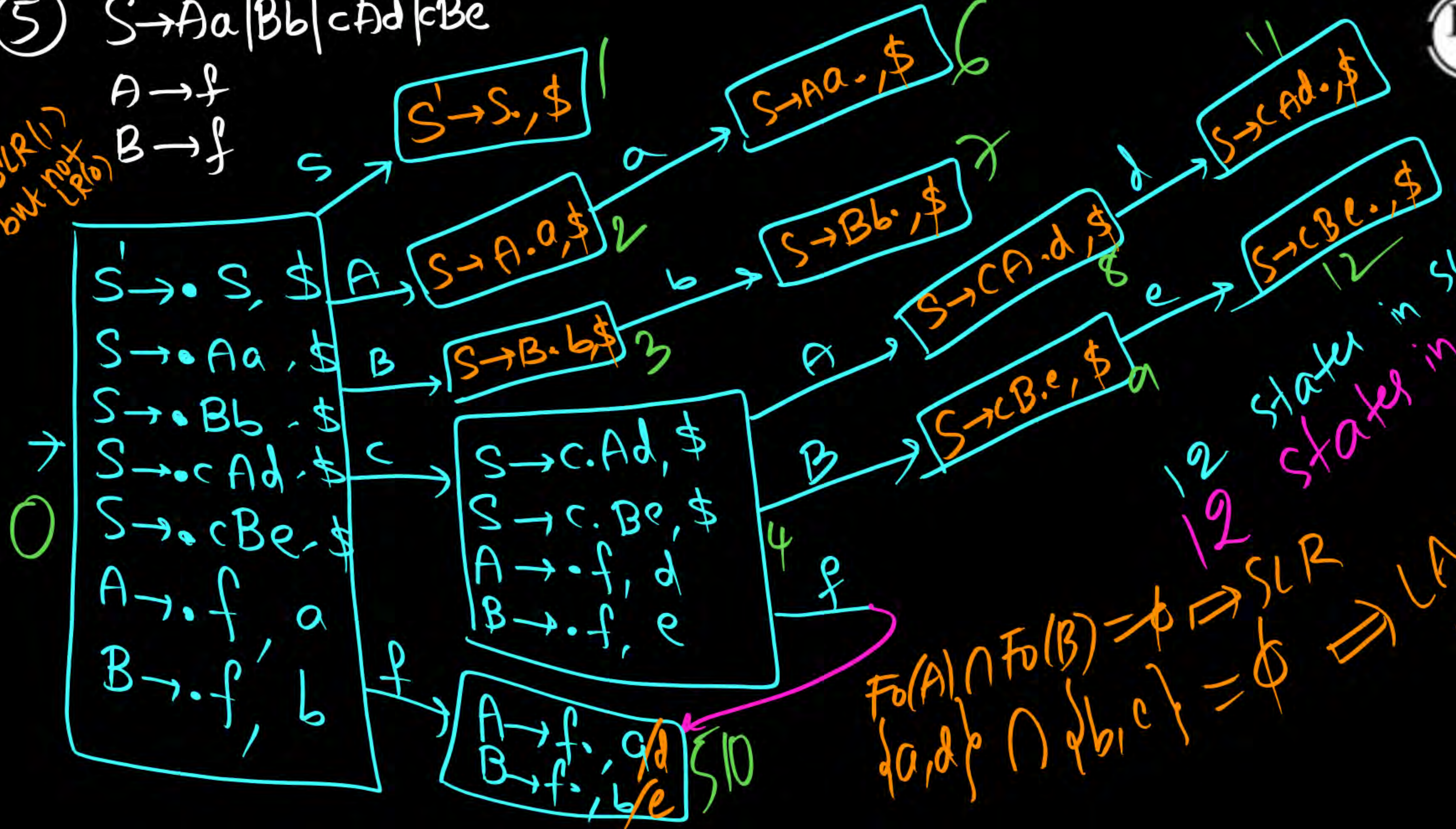
It is CLR(1)

⑤ $S \to Aa \mid Bb \mid cAd \mid cBe$

$A \to f$

$B \to f$

SLR(1) but not LR(0)



12 states in SLR

12 states in LALR

$Fo(A) \cap Fo(B) = \phi \Rightarrow SLR$

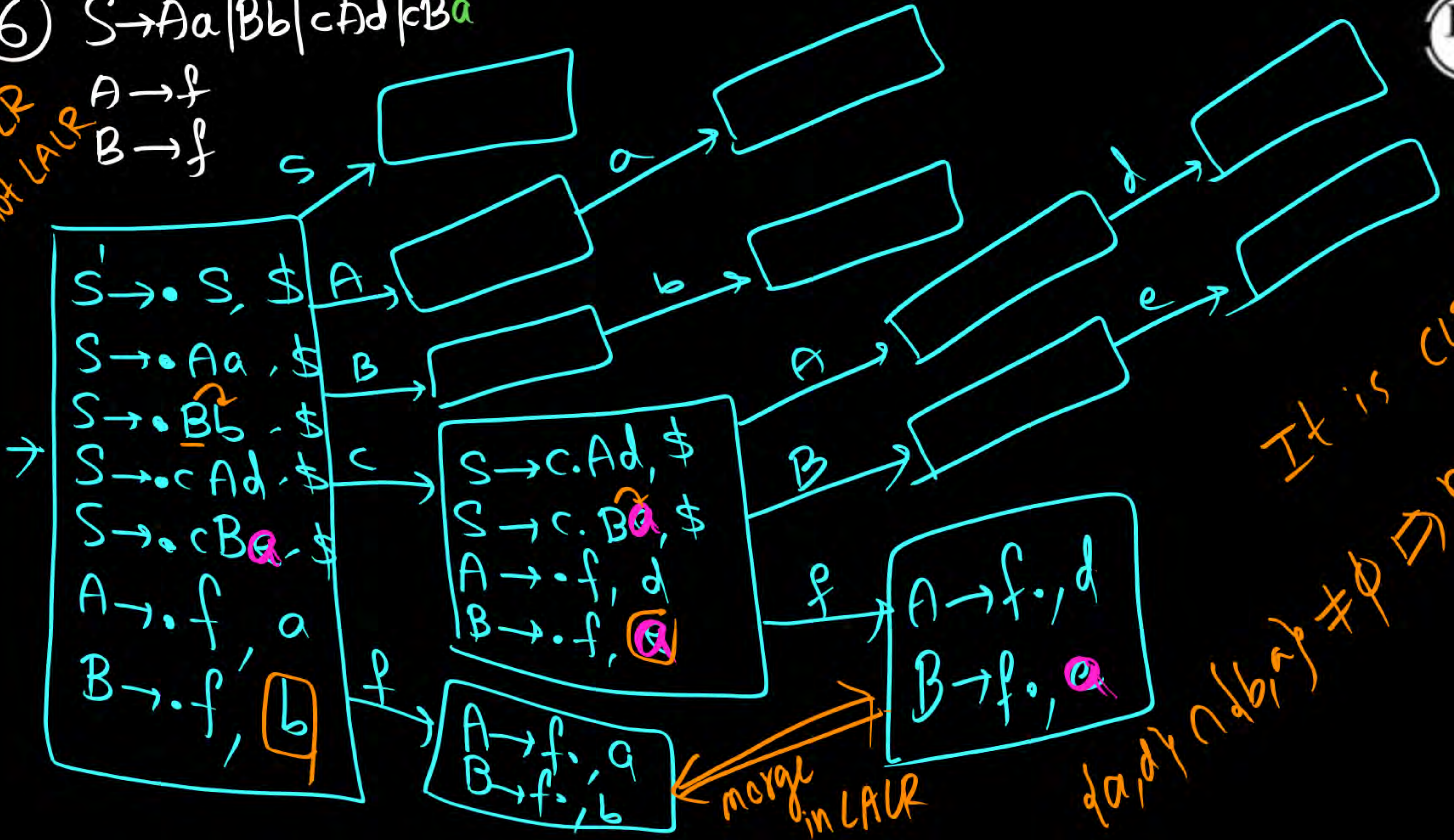
$\{a, d\} \cap \{b, c\} = \phi \Rightarrow LALR$

(6) $S \to Aa \mid Bb \mid cAd \mid cBa$

$A \to f$

$B \to f$

CLR not LALR



$\{a, d\} \cap \{b, a\} \neq \phi \Rightarrow$

It is CLR(1) not LALR

Q1) If CFG is CLR(1) then

Is it $\boxed{\text{possible}}$ RR conflicts in LALR(1)?

$X \to \alpha.\ , t_1$ $Y \to \alpha.\ , t_2$ No conflict	$X \to \alpha.\ , t_2$ $Y \to \alpha.\ , t_3$ No conflict	$\Rightarrow$ $X \to \alpha.\ , t_1/t_2$ $Y \to \alpha.\ , t_2/t_3$ RR conf in LALR

YES, Possible

Q2) If CFG is CLR(1) then

Is it possible SR conflicts in LALR(1)?

Impossible

Assume CLR is not having SR conflict :

$$\boxed{\begin{array}{l} X \to \alpha . t\beta ,\ L_1 \\ Y \to \alpha . ,\ L_2 \end{array}}$$

$t \notin L_2$

No SR conf in CLR

&

$$\boxed{\begin{array}{l} X \to \alpha . t\beta ,\ L_3 \\ Y \to \alpha . ,\ L_4 \end{array}}$$

$t \notin L_4$

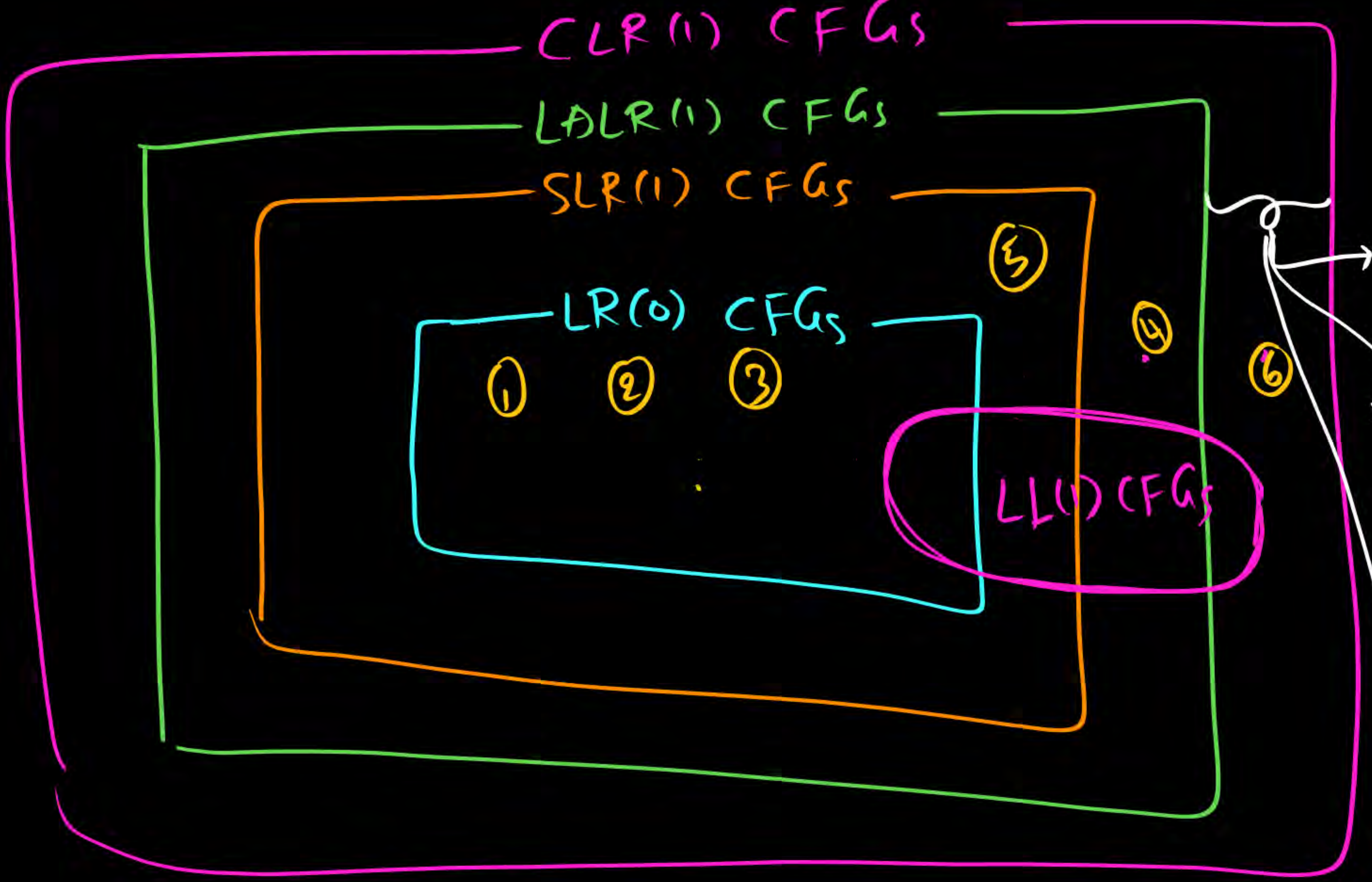
No SR conf in CLR

$\Downarrow$

$$\boxed{\begin{array}{l} X \to \alpha . t\beta ,\ L_1 \cup L_3 \\ Y \to \alpha . ,\ L_2 \cup L_4 \end{array}}$$

We can prove $t \notin L_2 \cup L_4$

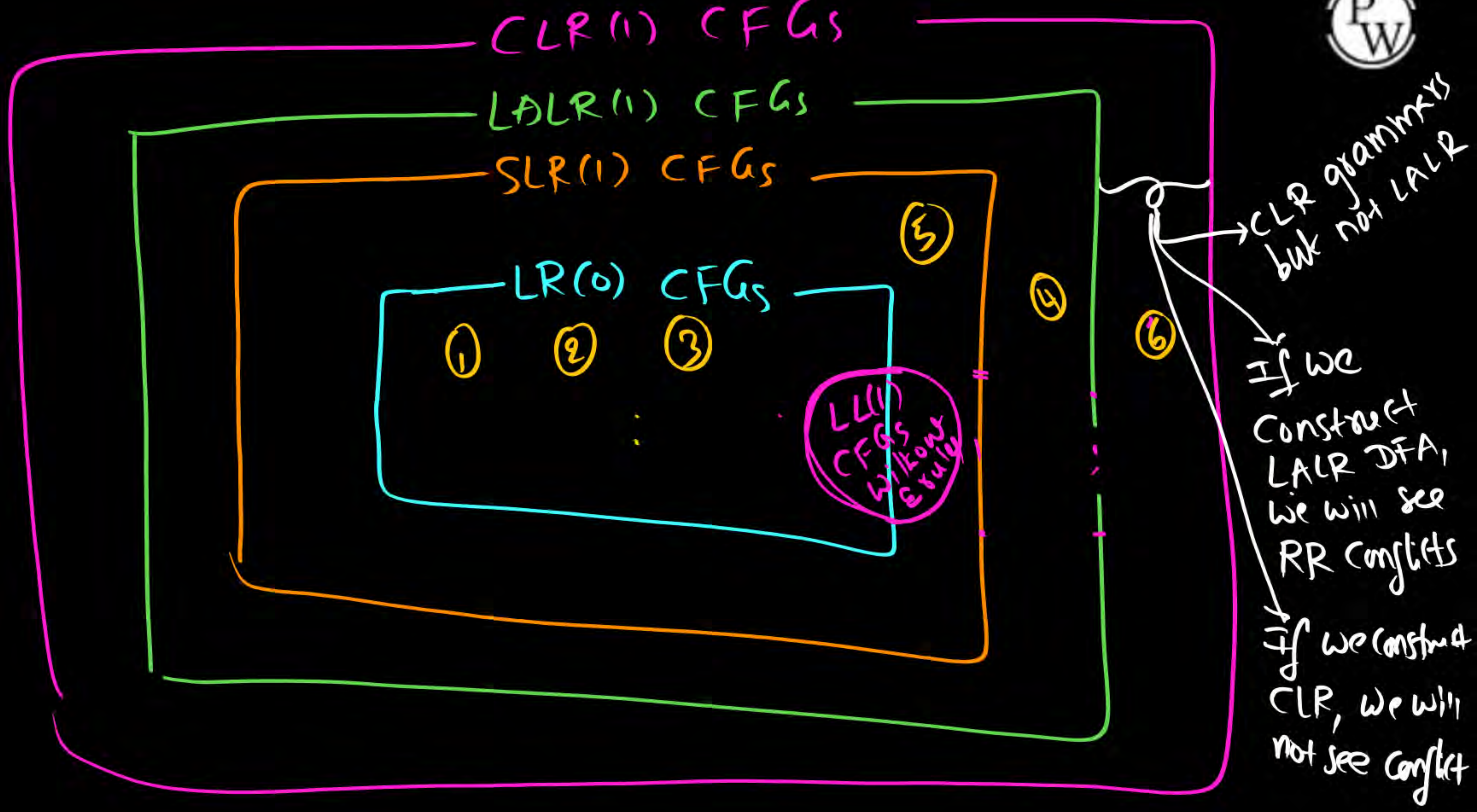
SR conflict Impossible in LALR

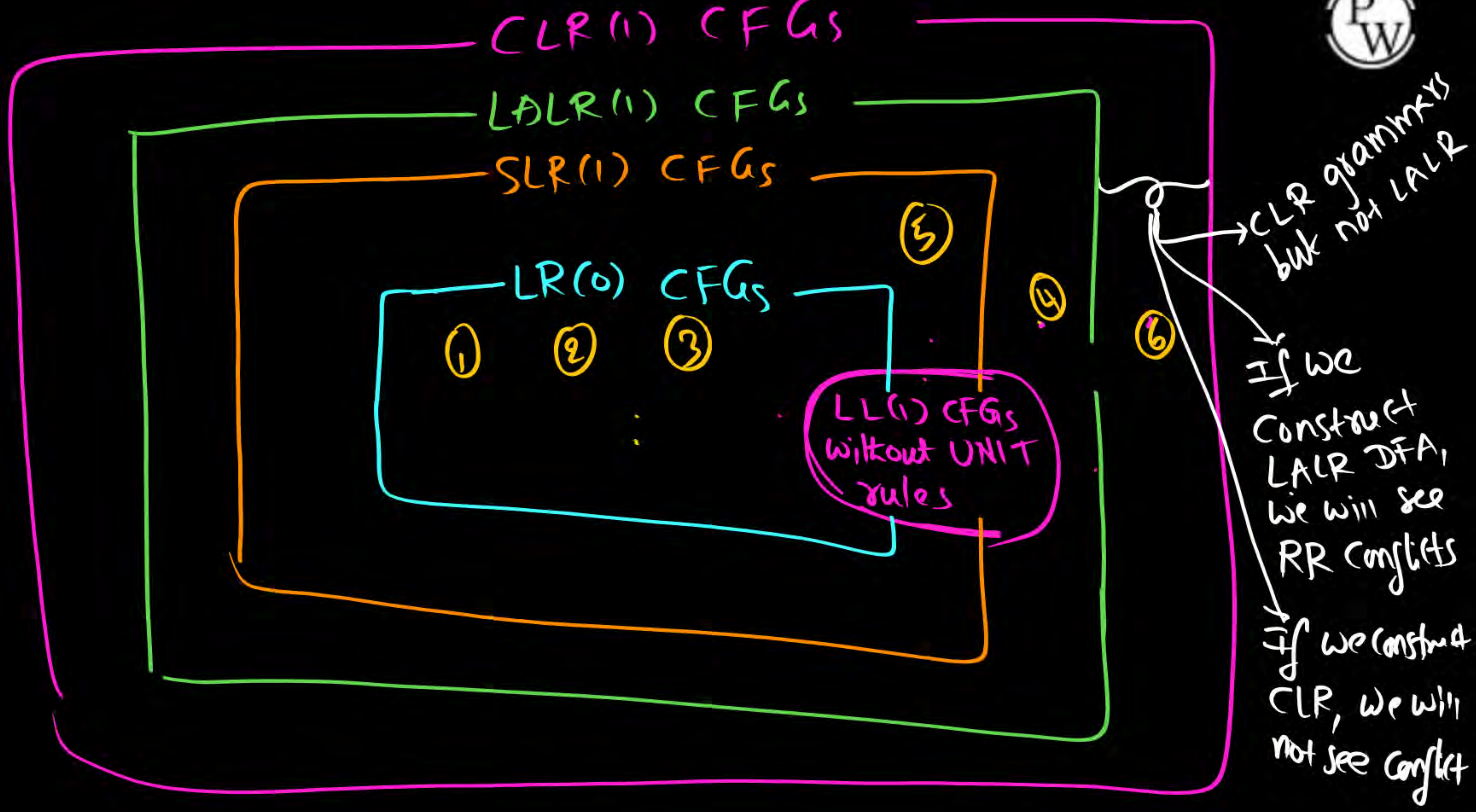


CLR grammars but not LALR

If we construct LALR DFA, we will see RR conflicts

If we construct CLR, we will not see conflict


CLR(1) CFGs
LALR(1) CFGs
SLR(1) CFGs
LR(0) CFGs
1
2
3
4
5
6
LL(1) CFGs without ε rules
CLR grammars but not LALR
If we construct LALR DFA, we will see RR conflicts
If we construct CLR, we will not see conflict


CLR(1) CFGs
LALR(1) CFGs
SLR(1) CFGs
LR(0) CFGs
1
2
3
5
4
6
LL(1) CFGs without UNIT rules
CLR grammars but not LALR
If we construct LALR DFA, we will see RR conflicts
If we construct CLR, we will not see conflict

Note : I

No.of states

n_1 = no.of states in LR(0)

n_2 = " " SLR(1)

n_3 = " " LALR

n_4 = " " CLR

$$\boxed{n_1 = n_2 = n_3} \leq n_4$$

II Expressive power

LR(0) parser < SLR(1) < LALR(1) < CLR

Less powerful

More powerful

III Class of CFGs :

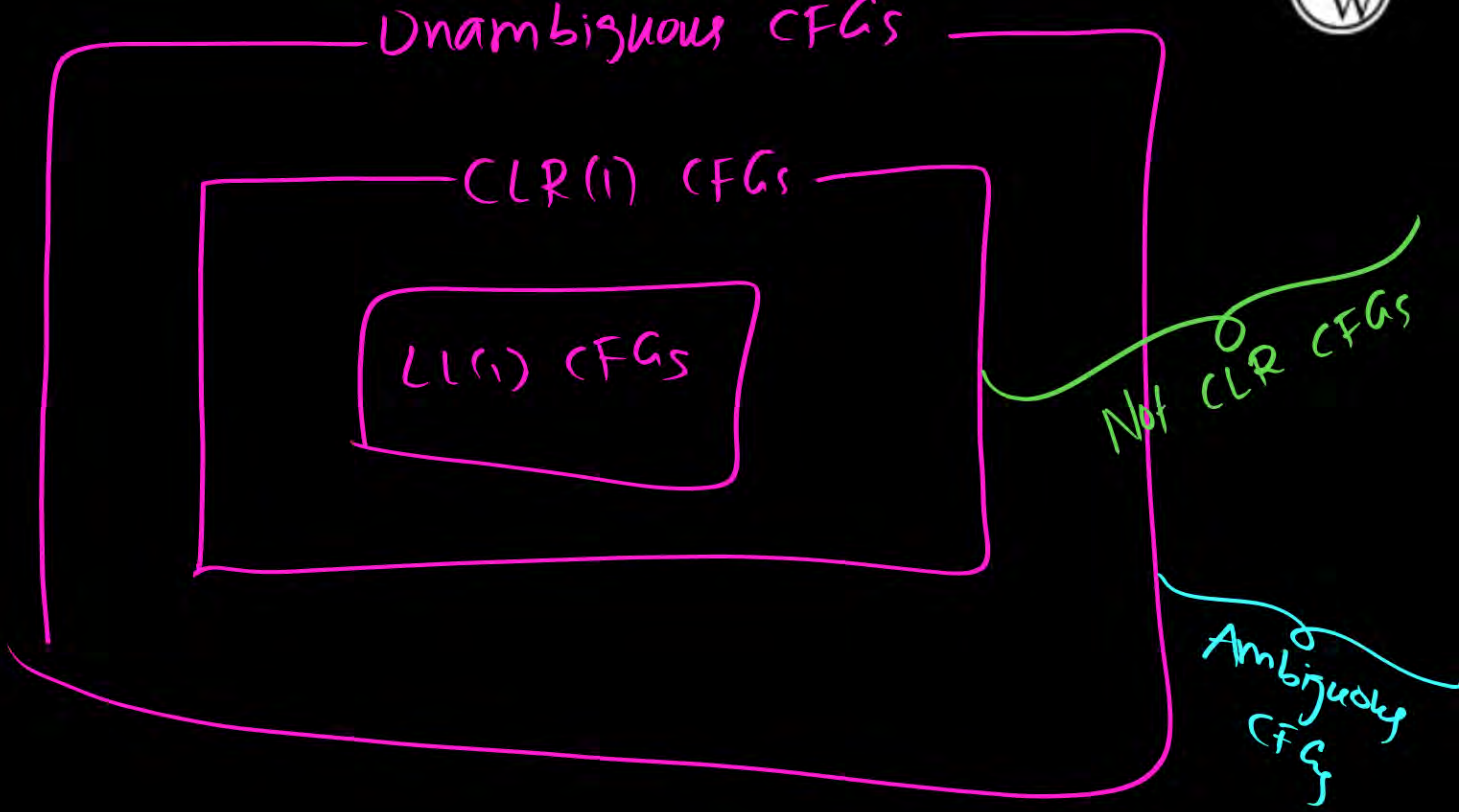
Set of all LR(0) CFGs	$\subset$	Set of SLR CFGs	$\subset$	Set of LALR CFGs	$\subset$	Set of CLR CFGs

$$\{G \mid G \text{ is } LR(0)\ CFG\} \subset \{G \mid G \text{ is } SLR(1)\} \subset \{G \mid G \text{ is } LALR\} \subset \{G \mid G \text{ is } CLR\}$$

IV) Every LL(1) is $\underbrace{\text{LR(1)}}_{\text{CLR}}$

$\boxed{\text{No relation b/w LL(1) \& LR(0), SLR, LALR}}$

V) If LL(1) CFG is not having null productions, then It is always SLR(1).


Unambiguous CFGs
CLR(1) CFGs
LL(1) CFGs
Not CLR CFGs
Ambiguous CFGs

① $S \to SS \mid a$

Ambiguous

A) LL(1)

B) LR(1)

C) LALR

D) None

② $S \to Sa \mid bS \mid c$

└→ Amb CFG

└→ not LL(1)

not LR(0)

not SLR

not LALR

not CLR

I) If G is not CLR then G is not LALR
not SLR
not CLR(0)

II) If G is LR(0) then G is SLR
LALR
CLR

III) If G is Ambiguous then G is not CLR,
not LALR,
not SLR,
not LR(0)

Summary

$\rightarrow$ LR(0) CFG? ✓

SLR(1) CFG? ✓

LALR(1) CFG? ✓

CLR(1) CFG? ✓


THANK YOU
GW
SOLDIERS !