

... ..

$A \rightarrow C$
 $B \rightarrow S | A$
 $C \rightarrow S | \epsilon$

(FL

① Eliminate ϵ -productions

$C \rightarrow \epsilon$ is a null-production

$A \xrightarrow{*} \epsilon ; B \xrightarrow{*} \epsilon$

$S \xrightarrow{*} \epsilon$ are nullable

productions

$\rightarrow OAO | OO | B | | | | BB | B$

$A \rightarrow C$
 $B \rightarrow S | A$
 $C \rightarrow S$

$S' \rightarrow S | \epsilon$

must add

$f(\hat{a})$

elimination of unit production

$$S_0 \rightarrow S \mid \epsilon$$

$$S \rightarrow OO \mid OAO \mid II \mid IB \mid B \mid BB$$

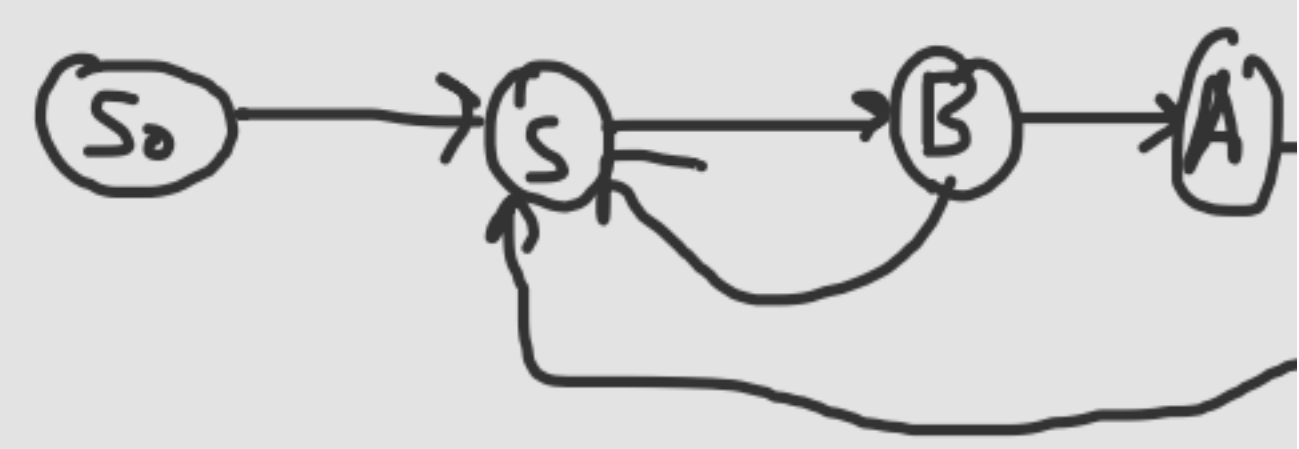
$$A \rightarrow C$$

$$B \rightarrow S \mid A$$

$$C \rightarrow S$$

$$S_0 \rightarrow S$$

$$\left\{ \begin{array}{l} S \rightarrow B \\ \underline{A \rightarrow C} \\ B \rightarrow S \\ B \rightarrow A \\ C \rightarrow S \end{array} \right\}$$



A, B, & C are generating S and there is a cycle

$$S_0 \rightarrow OO \mid OAO \mid II \mid IB \mid B \mid BB \mid \epsilon$$

$$S \rightarrow OO \mid OAO \mid II \mid IB \mid B \mid BB$$

$$A \rightarrow C$$

$$B \rightarrow OO \mid OAO \mid II \mid IB \mid B \mid BB \mid A$$

Substitution of S onto the Rule

$B \rightarrow B$ is to be

$$S \rightarrow 00 \mid 0A0 \mid 11 \mid 1B1 \mid B \mid BB \mid \epsilon$$

$$A \rightarrow C$$

$$S_0 \rightarrow B$$

$$B \rightarrow 00 \mid 0A0 \mid 11 \mid 1B1 \mid BB \mid A$$

$$C \rightarrow 00 \mid 0A0 \mid 11 \mid 1B1 \mid BB \mid B$$

Remove $A \rightarrow C$ by substitution rule

$$S_0 \rightarrow 00 \mid 0A0 \mid 11 \mid 1B1 \mid B \mid BB \mid \epsilon$$

$$\rightarrow S \rightarrow 00 \mid 0A0 \mid 11 \mid 1B1 \mid B \mid BB$$

$$A \rightarrow 00 \mid 0A0 \mid 11 \mid 1B1 \mid BB \mid B$$

$$B \rightarrow 00 \mid 0A0 \mid 11 \mid 1B1 \mid BB \mid A$$

$$\rightarrow C \rightarrow 00 \mid 0A0 \mid 11 \mid 1B1 \mid BB \mid B$$

$$\frac{B \rightarrow B}{\text{X}}$$

$$\frac{L(\hat{G}) = L(G)}{\text{X}}$$

and C
are
no
longer reachable
from S_0

$A \rightarrow \epsilon \mid 0A0 \mid 11 \mid 1B \mid BB \mid B$

$B \rightarrow 00 \mid 0A0 \mid 11 \mid 1B \mid BB \mid A$

Moreover, $A \rightarrow B$ and $B \rightarrow A$ and S_0
are not adding anything in the Grammar

$\left\{ \begin{array}{l} S_0 \rightarrow 00 \mid 0A0 \mid 11 \mid 1B \mid BB \mid \epsilon \\ A \rightarrow 00 \mid 0A0 \mid 11 \mid 1B \mid BB \\ B \rightarrow 00 \mid 0A0 \mid 11 \mid 1B \mid BB \end{array} \right.$

rules. Therefore, the occurrence of A or B may replace each other

$$S_0 \rightarrow \underline{00} / \underline{0A0} / \underline{11} / \underline{1A1} / \underline{AA} / \epsilon$$

$$A \rightarrow 00 / 0A0 / 11 / 1A1 / AA$$

$$\rightarrow S_0 \rightarrow 00 / 0S_0 / 11 / 1S_0 / S_0S_0 / \epsilon$$

(CNF)

Simplified

Useless

Unit

ϵ -production

Context free

Context sensitive

Phrase Structure

CYK

(CNF)

Check the membership of a string in a CFG

DP

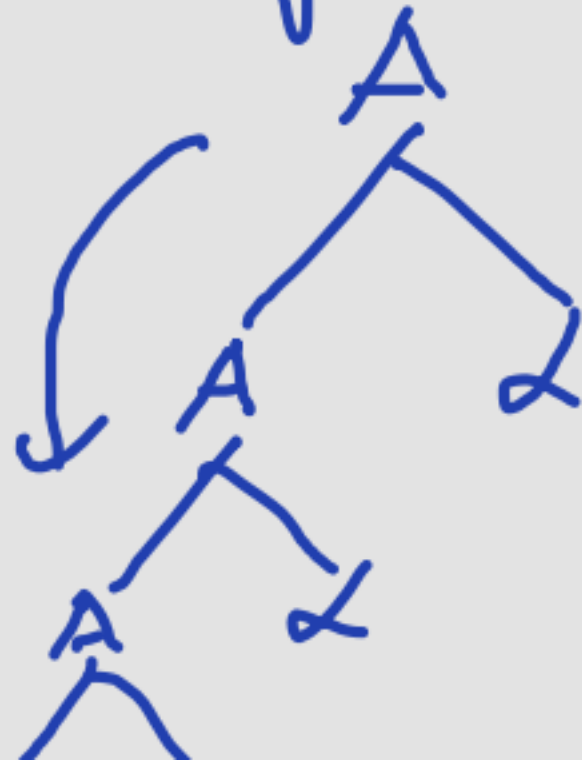
$O(n^3)$

length of string

$A \rightarrow \alpha$

$A \rightarrow A\alpha$

left recursive



$A \rightarrow BC$

Where A, B, C are each variable (non-terminal)

$$A \rightarrow B_1 \underline{B_2 \dots B_k}$$

$$R \geq 3$$

$$- A \rightarrow B_1 \underline{C_1}$$

$$- C_1 \rightarrow \underline{B_2 C_2}$$

⋮

$$- C_{k-3} \rightarrow \underline{B_{k-2} C_{k-2}}$$

$$- C_{k-2} \rightarrow \underline{B_{k-1} B_k}$$



Cascade of production

remove ϵ -productions?

$$\begin{cases} A \rightarrow aAA \mid \epsilon \\ B \rightarrow bBB \mid \epsilon \end{cases}$$

**

$$\begin{aligned} S &\rightarrow Na \\ N &\rightarrow a \mid b \end{aligned}$$

Convert to CNF?

(1) Rename

$$\begin{array}{l} S \rightarrow NA \\ \hline N \rightarrow a \mid b \\ \hline A \rightarrow a \\ \hline \end{array}$$

Step 1: Making production bodies either a single terminal or several variables

$$S \rightarrow ASA$$

$$S \rightarrow BSB$$

$$S \rightarrow a$$

$$S \rightarrow b$$

$$S \rightarrow AA$$

$$S \rightarrow BB$$

$$A \rightarrow a$$

Step 2: Making all production bodies either a single terminal or two variables

$$S \rightarrow AR_1$$

$$R_1 \rightarrow SA$$

$$S \rightarrow BR_2$$

$$R_2 \rightarrow SB$$

$$S \rightarrow AA$$

$$S \rightarrow BB$$

$$S \rightarrow a$$

$$S \rightarrow b$$

$$A \rightarrow a$$

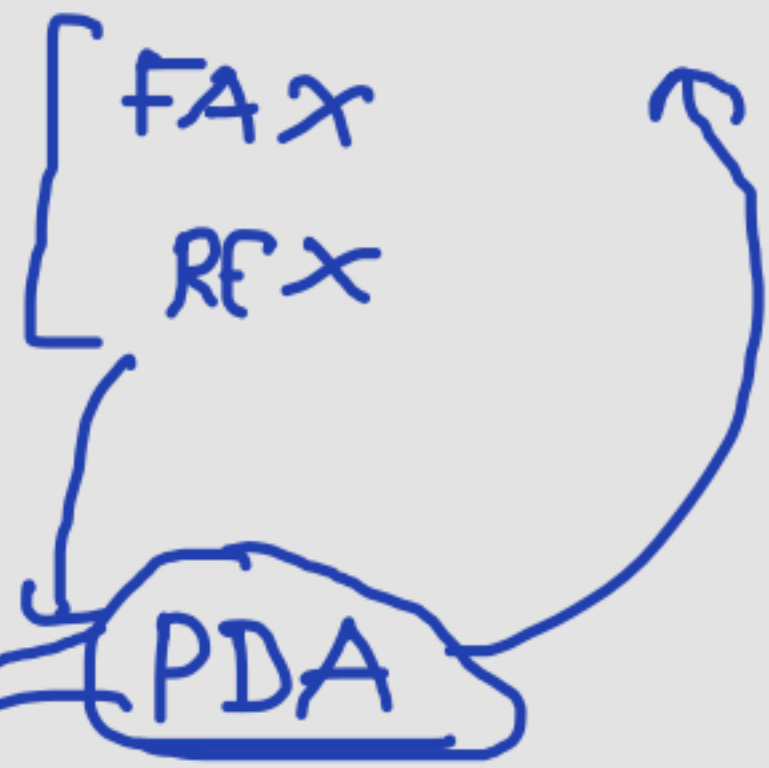
Regular language

$L = \{aab, ab, aabbb, \dots\}$

CFG \leftrightarrow

$a^n b^{n+2}$
 $a^n b^{2n}$

\downarrow
RE
FA
L



$W \subset W^R \leftarrow D-PDA$
 $W \subset W^R \leftarrow N-PDA$

Derivation

- Leftmost
- Rightmost

Parse Trees

Yield

\rightarrow Sentential

Left Right

CFG \longleftrightarrow CFL \longrightarrow Non-CFL

Non-context free language

pumping lemma

CFG	x
PDA	x

$$w = u \underbrace{\boxed{x}}_i \underbrace{\boxed{y}}_i z$$

properties of CFL

① Union

② Concatenation

③ Intersection

④ complementation

(May or May not)