

	OV	NV	Prod's
2	S, A, B, D	S, A, B, D	$S \rightarrow aAa   bBb$
3	S, A, B, D	S, A, B, D	

Identify  
 ii) <sup>1</sup> Useful variables that take part in derivation step

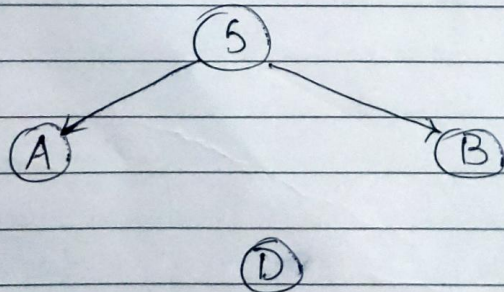
$S \rightarrow aAa | bBb | aAa | bBb$

$A \rightarrow a$

$B \rightarrow b$

$D \rightarrow a | ab | b$

Dependency graph



$\Rightarrow$  Since D is not reachable from S, hence it is considered to be useless variable

Simplified Grammar

$S \rightarrow aAa | bBb | aAa | bBb$

$A \rightarrow a$

$B \rightarrow b$

//



EXAMPLES:

$$\begin{aligned}
 \textcircled{1} \quad & S \rightarrow ABC / BaB \\
 & A \rightarrow aA / BaC / aaa \\
 & B \rightarrow bBb / a / D \\
 & C \rightarrow cA / AE \quad D \rightarrow E
 \end{aligned}$$

$$\begin{aligned}
 \textcircled{2} \quad & S \rightarrow OAO / IBJ / BB \\
 & A \rightarrow C \\
 & B \rightarrow S / A \\
 & C \rightarrow S / E
 \end{aligned}$$

$$\begin{aligned}
 \textcircled{3} \quad & S \rightarrow AAA / B \\
 & A \rightarrow aA / B \\
 & B \rightarrow E
 \end{aligned}$$

$$\begin{aligned}
 \textcircled{4} \quad & S \rightarrow AB / AC \\
 & A \rightarrow aA / bAa / a \\
 & B \rightarrow bA / aB / AB \\
 & C \rightarrow a(a / aD \\
 & D \rightarrow aD / bC
 \end{aligned}$$



## NORMAL FORMS OF CFG:

- ★ CHOMSKY NORMAL FORM - CNF ✓
- ★ GREIBACK NORMAL FORM - GNF

### CHOMSKY NORMAL FORM - CNF context-free

→ A grammar  $G$  is said to be in "CNF" if all the productions of the form  $A \rightarrow BC$  or  $A \rightarrow a$  where  $A, B, C \in V$  and  $a \in T$

Ex:

$$S \rightarrow AS|a$$

$$A \rightarrow SA|b$$

CNF ✓

$$S \rightarrow AS|AAS$$

$$A \rightarrow Sa|aa$$

Not in CNF ✗

### ★ Method to convert CFG into CNF form:

- ① Arrange that all bodies of length 2 or more consist only of variable
- ② Break bodies of length 3 or more into a cascade of prod's each with a body consisting of 2 variables



$$\begin{aligned} \textcircled{1} \quad & S \rightarrow ABa \\ & A \rightarrow aab \\ & B \rightarrow Ac \end{aligned}$$

Step ①:

$$\begin{aligned} S &\rightarrow ABB_a \\ B_a &\rightarrow a \\ A &\rightarrow B_a B_a B_b \\ B_b &\rightarrow b \\ B &\rightarrow AB_c \\ B_c &\rightarrow c \end{aligned}$$

Step ②:

$$\begin{aligned} S &\rightarrow AD_1 \\ D_1 &\rightarrow BB_a \\ B_a &\rightarrow a \\ A &\rightarrow B_a D_2 \\ D_2 &\rightarrow B_a B_b \\ B_b &\rightarrow b \\ B &\rightarrow AB_c \\ B_c &\rightarrow c \end{aligned}$$

$$\begin{aligned} \textcircled{2} \quad & E \rightarrow E + T \mid T \\ & T \rightarrow T * F \mid F \\ & F \rightarrow (E) \mid id \end{aligned}$$

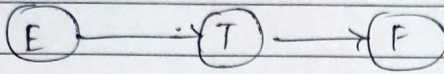
Step ③:

~~Eliminate unit prod~~  
"Eliminate unit prod" before CNF



$$E \rightarrow T \text{ ~~and~~$$

$$T \rightarrow F$$



$$E \xrightarrow{*} T$$

$$T \xrightarrow{*} F$$

$$E \rightarrow E + T \mid T * F \mid (E) \mid id$$

$$T \rightarrow T + F \mid (E) \mid id$$

Step ①:

$$E \rightarrow EB_1T \mid TB_2F \mid B_cEB_3 \mid id$$

$$B_1 \rightarrow +$$

$$T \rightarrow TB_2F \mid B_cEB_3 \mid id$$

$$B_2 \rightarrow *$$

$$F \rightarrow B_cEB_3 \mid id$$

$$B_c \rightarrow ($$

$$B_3 \rightarrow )$$

Step ②:

$$E \rightarrow ED_1 \mid TD_2 \mid B_cD_3 \mid id$$

$$D_1 \rightarrow B_1T$$

$$D_2 \rightarrow B_2F$$

$$D_3 \rightarrow EB_3$$

$$B_1 \rightarrow +$$

$$T \rightarrow TD_2 \mid B_cD_3 \mid id$$

$$B_c \rightarrow ($$

$$B_3 \rightarrow )$$

$$F \rightarrow B_cD_3 \mid id$$