

L4.1 - Conversion of CFG to Chomsky Normal Form

Conversion of CFG to Chomsky Normal Form

Convert the following CFG to CNF: $P: S \rightarrow ASA \mid aB, A \rightarrow B \mid S, B \rightarrow b \mid \epsilon$



Conversion of CFG to Chomsky Normal Form

Convert the following CFG to CNF: $P: S \rightarrow ASA \mid aB, A \rightarrow B \mid S, B \rightarrow b \mid \epsilon$

Steps to convert a given CFG to Chomsky Normal Form:

- Step 1: If the Start Symbol S occurs on some right side, create a new Start Symbol S' and a new Production $S' \rightarrow S$.
- Step 2: Remove Null Productions. (Using the Null Production Removal discussed in previous Lecture)
- Step 3: Remove Unit Productions. (Using the Unit Production Removal discussed in previous Lecture)
- Step 4: Replace each Production $A \rightarrow B_1 \dots B_n$ where $n > 2$, with $A \rightarrow B_1 C$ where $C \rightarrow B_2 \dots B_n$. Repeat this step for all Productions having two or more Symbols on the right side.
- Step 5: If the right side of any Production is in the form $A \rightarrow aB$ where 'a' is a terminal and A and B are non-terminals, then the Production is replaced by $A \rightarrow XB$ and $X \rightarrow a$. Repeat this step for every Production which is of the form $A \rightarrow aB$

Conversion of CFG to Chomsky Normal Form

Convert the following CFG to CNF: $P: S \rightarrow ASA \mid aB, A \rightarrow B \mid S, B \rightarrow b \mid \epsilon$



1) Since S appears in RHS, we add a new State S' and $S' \rightarrow S$ is added to the production

$P: S' \rightarrow S, S \rightarrow ASA \mid aB, A \rightarrow B \mid S, B \rightarrow b \mid \epsilon$

Conversion of CFG to Chomsky Normal Form

Convert the following CFG to CNF: $P: S \rightarrow ASA \mid aB, A \rightarrow B \mid S, B \rightarrow b \mid \epsilon$

1) Since S appears in RHS, we add a new State S' and $S' \rightarrow S$ is added to the production

$P: S' \rightarrow S, S \rightarrow ASA \mid aB, A \rightarrow B \mid S, B \rightarrow b \mid \epsilon$

2) Remove the Null Productions: $B \rightarrow \epsilon$ and $A \rightarrow \epsilon$:

After Removing $B \rightarrow \epsilon$: $P: S' \rightarrow S, S \rightarrow ASA \mid aB \mid a, A \rightarrow B \mid S \mid \epsilon, B \rightarrow b$

After Removing $A \rightarrow \epsilon$: $P: S' \rightarrow S, S \rightarrow ASA \mid aB \mid a \mid AS \mid SA \mid S, A \rightarrow B \mid S, B \rightarrow b$

2) Remove the Null Productions: $B \rightarrow \epsilon$ and $A \rightarrow \epsilon$:

After Removing $B \rightarrow \epsilon$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a, A \rightarrow B|S|\epsilon, B \rightarrow b$

After Removing $A \rightarrow \epsilon$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a|AS|SA|S, A \rightarrow B|S, B \rightarrow b$

3) Remove the Unit Productions: $S \rightarrow S, S' \rightarrow S, A \rightarrow B$ and $A \rightarrow S$:

After Removing $S \rightarrow S$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a|AS|SA, A \rightarrow B|S, B \rightarrow b$

After Removing $S' \rightarrow S$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow B|S, B \rightarrow b$

After Removing $A \rightarrow B$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow b|S, B \rightarrow b$

After Removing $A \rightarrow S$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow b|ASA|aB|a|AS|SA,$
 $B \rightarrow b$

2) Remove the Null Productions: $B \rightarrow \epsilon$ and $A \rightarrow \epsilon$:

After Removing $B \rightarrow \epsilon$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a, A \rightarrow B|S|\epsilon, B \rightarrow b$

After Removing $A \rightarrow \epsilon$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a|AS|SA|S, A \rightarrow B|S, B \rightarrow b$

3) Remove the Unit Productions: $S \rightarrow S, S' \rightarrow S, A \rightarrow B$ and $A \rightarrow S$:

After Removing $S \rightarrow S$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a|AS|SA, A \rightarrow B|S, B \rightarrow b$

After Removing $S' \rightarrow S$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow B|S, B \rightarrow b$

After Removing $A \rightarrow B$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow b|S, B \rightarrow b$

After Removing $A \rightarrow S$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow b|ASA|aB|a|AS|SA,$
 $B \rightarrow b$

2) Remove the Null Productions: $B \rightarrow \epsilon$ and $A \rightarrow \epsilon$:

After Removing $B \rightarrow \epsilon$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a, A \rightarrow B|S|\epsilon, B \rightarrow b$

After Removing $A \rightarrow \epsilon$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a|AS|SA|S, A \rightarrow B|S, B \rightarrow b$

3) Remove the Unit Productions: $S \rightarrow S, S' \rightarrow S, A \rightarrow B$ and $A \rightarrow S$:

After Removing $S \rightarrow S$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a|AS|SA, A \rightarrow B|S, B \rightarrow b$

After Removing $S' \rightarrow S$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow B|S, B \rightarrow b$

After Removing $A \rightarrow B$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow b|S, B \rightarrow b$

After Removing $A \rightarrow S$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow b|ASA|aB|a|AS|SA,$
 $B \rightarrow b$

2) Remove the Null Productions: $B \rightarrow \epsilon$ and $A \rightarrow \epsilon$:

After Removing $B \rightarrow \epsilon$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a, A \rightarrow B|S|\epsilon, B \rightarrow b$

After Removing $A \rightarrow \epsilon$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a|AS|SA|S, A \rightarrow B|S, B \rightarrow b$

3) Remove the Unit Productions: $S \rightarrow S, S' \rightarrow S, A \rightarrow B$ and $A \rightarrow S$:

After Removing $S \rightarrow S$: P: $S' \rightarrow S, S \rightarrow ASA|aB|a|AS|SA, A \rightarrow B|S, B \rightarrow b$

After Removing $S' \rightarrow S$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow B|S, B \rightarrow b$

After Removing $A \rightarrow B$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow b|S, B \rightarrow b$

After Removing $A \rightarrow S$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow b|ASA|aB|a|AS|SA,$
 $B \rightarrow b$

After Removing $A \rightarrow S$: P: $S' \rightarrow ASA|aB|a|AS|SA,$
 $S \rightarrow ASA|aB|a|AS|SA,$
 $A \rightarrow b|ASA|aB|a|AS|SA,$
 $B \rightarrow b$

4) Now find out the productions that has more than TWO variables in RHS

$S' \rightarrow ASA,$ $S \rightarrow ASA$ and $A \rightarrow ASA$

After removing these, we get: P: $S' \rightarrow AX|aB|a|AS|SA,$
 $S \rightarrow AX|aB|a|AS|SA,$
 $A \rightarrow b|AX|aB|a|AS|SA,$
 $B \rightarrow b,$
 $X \rightarrow SA$

4) Now find out the productions that has more than TWO variables in RHS

$S' \rightarrow ASA$, $S \rightarrow ASA$ and $A \rightarrow ASA$

After removing these, we get: P: $S' \rightarrow AX|aB|a|AS|SA$,
 $S \rightarrow AX|aB|a|AS|SA$,
 $A \rightarrow b|AX|aB|a|AS|SA$,
 $B \rightarrow b$,
 $X \rightarrow SA$

5) Now change the productions $S' \rightarrow aB$, $S \rightarrow aB$ and $A \rightarrow aB$

Finally we get:

P: $S' \rightarrow AX|YB|a|AS|SA$,
 $S \rightarrow AX|YB|a|AS|SA$,
 $A \rightarrow b|AX|YB|a|AS|SA$,
 $B \rightarrow b$,
 $X \rightarrow SA$,
 $Y \rightarrow a$

4) Now find out the productions that has more than TWO variables in RHS

$S' \rightarrow ASA$, $S \rightarrow ASA$ and $A \rightarrow ASA$

After removing these, we get: P: $S' \rightarrow AX|aB|a|AS|SA$,
 $S \rightarrow AX|aB|a|AS|SA$,
 $A \rightarrow b|AX|aB|a|AS|SA$,
 $B \rightarrow b$,
 $X \rightarrow SA$

5) Now change the productions $S' \rightarrow aB$, $S \rightarrow aB$ and $A \rightarrow aB$

Finally we get:

P: $S' \rightarrow AX|YB|a|AS|SA$,
 $S \rightarrow AX|YB|a|AS|SA$,
 $A \rightarrow b|AX|YB|a|AS|SA$,
 $B \rightarrow b$,
 $X \rightarrow SA$,
 $Y \rightarrow a$

which is the required Chomsky Normal Form for the given CFG



Questions????