

Motivation

$A \rightarrow Ba \mid d$   
 $B \rightarrow Cb$   
 $C \rightarrow Ac$

$\{ d, dcba,$   
 $A$   
 $Ba$   
 $Cba$   
 $Acba$   
 $dcba$

• INDIRECT LEFT RECURSION ELIMINATION

The Algorithm.

$A_i$ : non-terminals

$\delta \ \gamma$ : sequences of terminals + non-terminals.

- Enumerate all non-terminals from  $A_1$  to  $A_n$

- FOR  $i \leftarrow 1$  TO  $n$  DO

    FOR  $j \leftarrow 1$  TO  $i-1$  DO

        Let current  $A_j$  productions be:

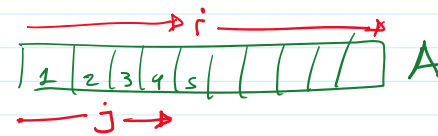
$A_j \rightarrow \delta_1 \mid \delta_2 \mid \delta_3 \mid \dots \mid \delta_k$

        Replace each production of the form  $A_i \rightarrow A_j \gamma$

        by:  $A_i \rightarrow \delta_1 \gamma \mid \delta_2 \gamma \mid \delta_3 \gamma \mid \dots \mid \delta_k \gamma$

    • Remove direct left recursion in  $A_i$

    // NOTE: This can insert a new rule into the list.



TRACE:

$i=1$   
• rdlr ✓

$i=2$   
 $j=1$  ✓

$i=3$   
 $j=1$

$C \rightarrow \underline{B}ac \mid dc$

$j=2$   
 $C \rightarrow \underline{C}bac \mid dc$

rdlr

$C \rightarrow dcC'$   
 $C' \rightarrow bacC' \mid \lambda$

$i=4$   
 $j=1$  ✓  
 $2$  ✓  
 $3$  ✓

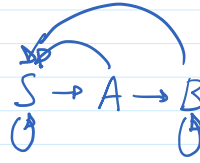
rdlr.

$1 A \rightarrow Ba \mid d$   
 $2 B \rightarrow Cb$   
 $3 C \rightarrow \underline{A}c$

$1 A \rightarrow Ba \mid d$   
 $2 B \rightarrow Cb$   
 $C \rightarrow dcC'$   
 $C' \rightarrow bacC' \mid \lambda$

# TRACE #2

$S \rightarrow Sx \mid Ay \mid \perp$   
 $A \rightarrow \underline{Sa} \mid Bb \mid c$   
 $B \rightarrow Bp \mid \underline{Sq} \mid r$



$A_i = S \quad \neg \text{DLR}$   
 $S \rightarrow AyS' \mid S'$   
 $S' \rightarrow xS' \mid \perp$

$A_i = S'$   
 $A_j = S \quad \checkmark$   
 $\neg \text{DLR} \quad \checkmark$

$A_i = A$   
 $A_j = S$   
 $A \rightarrow AySa \mid Sa \mid Bb \mid c$   
 $A_j = S'$   
 $A \rightarrow AySa \mid xSa \mid a \mid Bb \mid c$   
 $\neg \text{DLR}$   

- $A \rightarrow xSaA' \mid aA' \mid BbA' \mid cA'$
- $A' \rightarrow ySaA' \mid \perp$

- Enumerate all non-terminals from  $A_1$  to  $A_n$

- FOR  $i \leftarrow 1$  TO  $n$  DO

FOR  $j \leftarrow 1$  TO  $i-1$  DO

Let current  $A_j$  productions be:

$A_j \rightarrow \delta_1 \mid \delta_2 \mid \delta_3 \mid \dots \mid \delta_k$

Replace each production of the form  $A_i \rightarrow A_j \gamma$

by:  $A_i \rightarrow \delta_1 \gamma \mid \delta_2 \gamma \mid \delta_3 \gamma \mid \dots \mid \delta_k \gamma$

• Remove direct left recursion in  $A_i$

// NOTE: this can insert a new rule into the list.

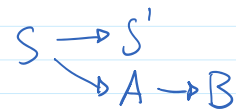
$A_i = A'$   
 $A_j = S \quad \checkmark$   
 $A_j = S' \quad \checkmark$   
 $A_j = A \quad \checkmark$   
 $\neg \text{DLR}$

$A_i = B$   
 $A_j = S$   
 $B \rightarrow Bp \mid AyS'q \mid S'q \mid r$   
 $A_j = S'$   
 $B \rightarrow Bp \mid AyS'q \mid xS'q \mid q \mid r$   
 $A_j = A$   
 $B \rightarrow Bp \mid xSaA'yS'q \mid aA'yS'q \mid BbA'yS'q \mid cA'yS'q \mid xS'q \mid q \mid r$   
 $A_j = A' \quad \checkmark$   
 $\neg \text{DLR} \quad B$   
 $B \rightarrow xSaA'yS'qB' \mid aA'yS'qB' \mid cA'yS'qB' \mid xS'qB' \mid qB' \mid rB'$   
 $B' \rightarrow pB' \mid bA'yS'qB' \mid \perp$

$A_i = B'$   
 $A_j = S \quad \checkmark$   
 $A_j = S' \quad \checkmark$   
 $A_j = A \quad \checkmark$   
 $A_j = A' \quad \checkmark$   
 $A_j = B \quad \checkmark$   
 $\neg \text{DLR}$

In Conclusion:

$S \rightarrow AyS' \mid S'$   
 $S' \rightarrow xS' \mid \perp$   
 $A \rightarrow \perp c a A' \mid a A' \mid r B A' \mid c A'$



$$S \rightarrow AyS' \mid S'$$

$$S' \rightarrow xS' \mid \perp$$

$$A \rightarrow xS'aA' \mid aA' \mid BbA' \mid cA'$$

$$A' \rightarrow yS'aA' \mid \perp$$

$$B \rightarrow xS'aA'yS'qB' \mid aA'yS'qB' \mid cA'yS'qB' \mid xS'qB' \mid qB' \mid rB'$$

$$B' \rightarrow pB' \mid bA'yS'qB' \mid \perp$$

$$\rightarrow A \rightarrow B$$

— EOF —