# 12 Indirect Left Recursion Elimination

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Eg ⓪

$A \to Ba \mid d$ $\{d, dcba, dcbacba, dcbacbacba, \dots\}$
$B \to Cb$
$C \to Ac$

parse_A()
↳ parse B()
 ↳ parse C()
  ↳ parse A()
   ↳

A
Ba
Cba
Acba
dcba

- Remedy: Indirect Left Recursion Elimination

The Algorithm:

notation
$A_i$ : non_terminal
$\delta\ \gamma$ : Sequences of terminals & non-terminals

· Enumerate all non-terminals $A_1$ to $A_n$
· FOR $i \leftarrow 1$ to $n$ DO
  FOR $j \leftarrow 1$ to $i-1$ DO
    Let $A_j$ productions be
      $A_j \to \delta_1 \mid \delta_2 \mid \delta_3 \mid \dots \mid \delta_k$
    Replace each production of the form
      $A_i \to A_j \gamma$
    by $A_i \to \delta_1\gamma \mid \delta_2\gamma \mid \dots \delta_k\gamma$
  Elimate Direct left recursion in $A_i$
    // Note: This will insert a new rule in our sequence.

$i$
$A_1, A_2, A_3, A_4, \dots, A_n$
$j$

Example of inner loop:

$A_j \to \overbrace{a}^{\delta_1} \mid \overbrace{b}^{\delta_2}$

$A_i \to A_j \underbrace{x}_{\gamma}$

$\Downarrow$

$A_i \to ax \mid bx$

Trace #1

1 $A \to Ba \mid d$
2 $B \to Cb$
3 $C \to Ac$

$i=1$ A

A
Ba
Cba

1 $A \to Ba \mid a$
2 $B \to Cb$
3 $C \to Ac$

$\Downarrow$

$A \to Ba \mid d$
$B \to Cb$
$C \to dcC'$
$C' \to bacC' \mid \lambda$

A
Ba
Cba
dcC'ba
dcbacC'ba
dcbacba

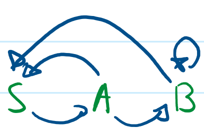
Ba
Cba
Acba
dcba

A
Ba
Cba
dcC'ba
dcba

i=1 A
 edlr $\varnothing$
i=2 B
 j=1 A
 edlr $\varnothing$
i=3 C
 j=1 A
 $C \to Bac \mid dc$
 j=2 B
 $C \to Cbac \mid dc$
 edlr
 $C \to dcC'$
 $C' \to bacC' \mid \lambda$
i=4 C'
 j=1 : A
 j=2 : B
 j=3 : C
 edlr

## Trace #2

1 $S \to Sx \mid Ay \mid Az$
2 $A \to Sa \mid Bb \mid \lambda$
3 $B \to Bp \mid Sq \mid r$




$A_i = S$
 edlr
 $S \to AyS' \mid AzS'$
 $S' \to xS' \mid \lambda$
$A_i = S'$
 $A_j = S$
 edlr
$A_i = A$
 $A_j = S$
 $A \to AyS'a \mid AzS'a \mid Bb \mid \lambda$
 $A_j = S'$
 edlr
 $A \to BbA' \mid A'$
 $A' \to yS'aA' \mid zS'aA' \mid \lambda$

· FOR $i \leftarrow 1$ to $n$ DO
 FOR $j \leftarrow 1$ to $i-1$ DO
 Let $A_j$ productions be
 $A_j \to \delta_1 \mid \delta_2 \mid \delta_3 \mid \ldots \mid \delta_k$
 Replace each production of the form
 $A_i \to A_j \gamma$

$A \to BbA \mid A'$

$A' \to yS'aA' \mid zS'aA' \mid \lambda$

$A_i = A'$

$A_j = S$

$A_j = S'$

$A_j = A$

edlr

$A_i = B$

$A_j = S$ $\quad B \to Bp \mid AyS'q \mid AzS'q \mid r$

$A_j = S'$ $\quad B \to Bp \mid BbA'yS'q \mid A'yS'q \mid BbA'zS'q \mid A'zS'q \mid r$

$A_j = A$

$A_j = A'$ $\quad B \to Bp \mid BbA'yS'q \mid yS'aA'yS'q \mid zS'aA'yS'q \mid yS'q \mid BbA'zS'q$

$\mid yS'aA'zS'q \mid zS'aA'zS'q \mid zS'q \mid r$

edlr $\quad B \to yS'aA'yS'qB' \mid zS'aA'yS'qB' \mid yS'qB' \mid yS'aA'zS'qB' \mid zS'aA'zS'qB' \mid zS'qB' \mid rB'$

$B' \to pB' \mid bA'yS'qB' \mid bA'zS'qB' \mid \lambda$

$A_i = B'$

$A_j = S$

$A_j = S'$

$A_j = A$

$A_j = A'$

$A_j = B$

edlr ✓

Replace each production of the form

$A_i \to A_j \gamma$

by $A_i \to \delta_1\gamma \mid \delta_2\gamma \mid \dots \delta_k\gamma$

Elimate Direct left recursion in $A_i$

$S \to Sx \mid Ay \mid Az$

$A \to Sa \mid Bb \mid \lambda$

$B \to Bp \mid Sq \mid r$

$S \to AyS' \mid AzS'$

$S' \to xS' \mid \lambda$

$A \to BbA' \mid A'$

$A' \to yS'aA' \mid zS'aA' \mid \lambda$

$B \to yS'aA'yS'qB' \mid zS'aA'yS'qB' \mid yS'qB' \mid yS'aA'zS'qB' \mid zS'aA'zS'qB' \mid zS'qB' \mid rB'$

$B' \to pB' \mid bA'yS'qB' \mid bA'zS'qB' \mid \lambda$

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