12 Indirect Left Recursion Elimination

Friday, October 18, 2024 12:22 PM

E.g. Q

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

{d, dcba, dcbacba, dcbacbacba, ...}

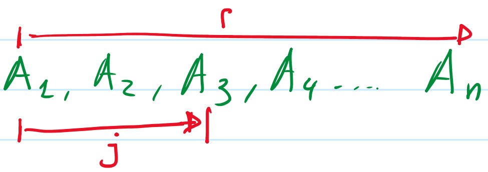
A
Ba
Cba
Acba
dcba

```
parse_A()
 ↳ parse_B()
   ↳ parse_C()
     ↳ parse_A()
```

Remedy: Indirect Left Recursion Elimination:

The Algorithm: A_i: non_terminal
δ γ : 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 $A_j$ 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: $A_i \to \delta_1\gamma \mid \delta_2\gamma \mid \delta_3\gamma \mid \dots \mid \delta_k\gamma$
      Eliminate direct left recursion of $A_i$
          // NOTE: This will insert a new rule into the list of rules
```



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

i = 1 A

edlr $\emptyset$

i = 2 B

j = 1 A

edlr $\emptyset$

i = 3 C

j = 1 A

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

j = 2 B

$C \to \underline{C}bac \mid dc$

edlr

$C \to dcC'$

4 $C' \to bacC' \mid \lambda$

i = 4 C'

j = 1 A

j = 2 B

j = 3 C

edlr $\emptyset$

1 $A \to Ba \mid d$

2 $B \to Cb$

3 $C \to Ac$

A

Ba

Cba

$Acba$

$dcba$

$A \to Ba \mid d$

$B \to Cb$

$C \to dcC'$

$C' \to bacC' \mid \lambda$

A

Ba

Cba

$dcC'ba$

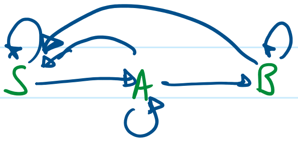
$dcba$

Trace #2

$S \to Sx \mid Ay \mid \lambda$

$A \to Sa \mid Bb \mid Az$

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



$A_i = S$

edlr S

$S \to AyS' \mid S'$

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

$A_i = S'$

$A_j = S$

edlr S'

$A_i = A$

$A_j = S$

$A \to AyS'a \mid \underline{S}'a \mid Bb \mid Az$

$A_j = S'$

$A \to \underline{A}yS'a \mid xS'a \mid a \mid Bb \mid \underline{A}z$

edlr A

```
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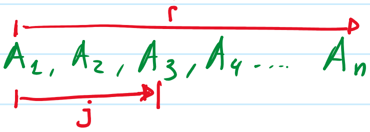

$A \to \underline{A}yS'a \mid xS'a \mid a \mid Bb \mid \underline{A}z$

edlr A

$A \to xS'aA' \mid aA' \mid BbA'$

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

$A_i = A'$

$A_j = S$

$A_j = S'$

$A_j = A$

edlr A'

$A_i = B$

$A_j = S$

$B \to Bp \mid \overset{S}{\overline{AyS'}}q \mid \overset{S}{\overline{\underline{S'}}}q \mid r$

$A_j = S'$

$B \to Bp \mid \underline{A}yS'q \mid xS'q \mid q \mid r$

$A_j = A$

$B \to \underline{B}p \mid xS'aA'yS'q \mid aA'yS'q \mid \underline{B}bA'yS'q \mid xS'q \mid q \mid r$

$A_j = A'$

edlr B

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

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

$A_i = B'$

$A_j = S$

$A_j = S'$

$A_j = A$

$A_j = A'$

$A_j = B$

edlr B'

$S \to AyS' \mid S'$

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

$A \to xS'aA' \mid aA' \mid BbA'$

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

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

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

Trace #3

$S \to SA \mid AS \mid x$

$A \to SA \mid AA \mid BA \mid a$

$S \rightarrow SA \mid AS \mid x$

$A \rightarrow SA \mid AA \mid BA \mid y$

$B \rightarrow SB \mid BB \mid z$

$A_i = S$

edlrs $S \rightarrow ASS' \mid xS'$

$S' \rightarrow AS' \mid \lambda$

$A_i = S'$

$A_j = S$

edlr S'

$A_i = A$

$A_j = S$

$A \rightarrow \overline{\underline{A}SS'}A \mid \overline{xS'}A \mid \underline{A}A \mid BA \mid y$

$A_j = S'$

edlr A

$A \rightarrow xS'AA' \mid BAA' \mid yA'$

$A' \rightarrow \underline{S}S'AA' \mid AA' \mid \lambda$

$A_i = A'$

$A_j = S$

$A' \rightarrow \underline{A}SS'S'AA' \mid xS'S'AA' \mid \underline{A}A' \mid \lambda$

$A_j = S'$

$A_j = A$

$A' \rightarrow xS'AA'SS'S'AA' \mid BAA'SS'S'AA' \mid yA'SS'S'AA' \mid xS'S'AA' \mid$

$xS'AA'A' \mid BAA'A' \mid yA'A' \mid \lambda$