12 Indirect Left Recursion

Wednesday, March 13, 2024 12:37 PM

E.g. Q

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

$\{d,\ dcba,\ \dots\}$

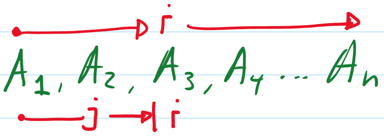
A
Ba
Cba
$Acba$
$dcba$

```
parse-A()
  parse-B()
    parse-C()
      parse-A()
        ⋮
```

- 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 ← 1 to n DO
    FOR j ← 1 to i-1 DO
        Let current $A_j$ 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 in $A_i$
        // NOTE: this can insert a new rule to the list.
```



Example of inner loop.

$A_j \to a \mid b$

$A_i \to A_j x$

$\Downarrow$

$A_i \to ax \mid bx$

TRACE #1

A

TRACE #1

i = 1 A
  edlr $\emptyset$
i = 2 B
  j = 1 $\emptyset$
  edlr $\emptyset$
i = 3 C
  j = 1
    $C \to \underline{B}ac \mid dc$
  j = 2
    $C \to \underline{C}bac \mid dc$
  edlr
    $C \to dcC'$
    4 $C' \to bacC' \mid \lambda$
i = 4 C'
  j = 1
  j = 2
  j = 3 $\emptyset$
  edlr $\emptyset$

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

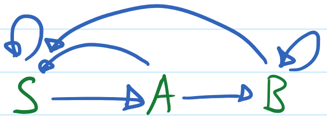
A
Ba
Cba
Acba
dcba

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

A
Ba
Cba
dcC'ba
dcba

TRACE #2

$S \to Sx \mid Ay \mid c$
$A \to \overset{\frown}{S}a \mid Bb \mid \lambda$
$B \to Bp \mid Sq \mid r$



$A_i = S$
  edlr
    $S \to AyS' \mid cS'$
    $S' \to xS' \mid \lambda$
$A_i = S'$
  $A_j = S$ ✓
  edlr ✓
$A_i = A$
  $A_j = S$
    $\underline{A} \to \underline{A}yS'a \mid cS'a \mid Bb \mid \lambda$
  $A_j = S'$ $\emptyset$
  edlr
    $A \to cS'aA' \mid BbA' \mid A'$
    $A' \to yS'aA' \mid \lambda$
$A_i = A'$
  $A_j = S$ ✓

```
- Enumerate all non-terminals from $A_1$ to $A_n$
- FOR $i \leftarrow 1$ to $n$ DO
    FOR $j \leftarrow 1$ to $\underline{i-1}$ DO
        Let current $A_j$ productions be
            $A_j \to \delta_1 \mid \delta_2 \mid \delta_3 \mid \ldots \mid \delta_k$
        Replace each production of the form:
            $A_i \to A_j\gamma$
        by: $A_i \to \delta_1\gamma \mid \delta_2\gamma \mid \delta_3\gamma \mid \ldots \mid \delta_k\gamma$
```

$A_i = A'$

$A_j = S$ ✓

$A_j = S'$ ✓

$A_j = A$ ✓

edlr A' ✓

$A_i = B$

$A_j = S$

$B \rightarrow Bp \mid \underline{A}yS'q \mid cS'q \mid r$

$A_j = S'$

$A_j = A$

$B \rightarrow Bp \mid \underline{cS'aA'}yS'q \mid \underline{BbA'}yS'q \mid \underline{A'}yS'q \mid cS'q \mid r$

$A_j = A'$

$B \rightarrow \underline{B}p \mid cS'aA'yS'q \mid \underline{B}bA'yS'q \mid yS'aA'yS'q \mid yS'q \mid cS'q \mid r$

edlr $\overline{B}$

$B \rightarrow cS'aA'yS'qB' \mid yS'aA'yS'qB' \mid yS'qB' \mid cS'qB' \mid rB'$

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

$A_i = B'$

$A_j = S$

$A_j = S'$

$A_j = A$

$A_j = A'$

$A_j = B$

edlr B'

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

- Eliminate Direct Left Recursion in A_i

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

In Conclusion:

$S \rightarrow AyS' \mid cS'$

$S' \rightarrow xS' \mid \lambda$

$A \rightarrow cS'aA' \mid BbA' \mid A'$

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

$B \rightarrow cS'aA'yS'qB' \mid yS'aA'yS'qB' \mid yS'qB' \mid cS'qB' \mid rB'$

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

$S \rightarrow A \rightarrow B \quad B'$

$S' \quad A'$

—o— EOF