语法分析
(4. ANTLR4 递归下降语法分析器)

魏恒峰

hfwei@nju.edu.cn

2021 年 11 月 26 日

ANTLR3 语法分析器是如何工作的?

ANTLR3 语法分析器是如何工作的?

ANTLR4 是如何处理**左递归与优先级**的?

ANTLR3 语法分析器是如何工作的?

ANTLR4 是如何处理**左递归与优先级**的?

ANTLR4 是如何进行**错误报告与恢复**的?

ANTLR3 语法分析器是如何工作的?

带记忆功能的可回溯的递归下降的语法分析器

(适用于 ANTLR3 与部分 ANTLR4)

甚至可以使用谓词解析器处理上下文相关文法

$LL(1)$

`tpdsl: rd/NameList.g4`

$LL(1)$

`tpdsl: rd/NameList.g4`

`tpdsl: rd/ListParser.java`
(`elements()`)

$LL(1)$

`tpdsl: rd/NameList.g4`

`tpdsl: rd/ListParser.java`
(`elements()`)

`tpdsl: rd/NameListParser.java`

$LL(k = 2)$

`tpdsl: multi/NameListWithAssign.g4`

$LL(k = 2)$

`tpdsl: multi/NameListWithAssign.g4`

`tpdsl: multi/LAParser.java`
(`element()`)

$LL(k = 2)$

`tpdsl: multi/NameListWithAssign.g4`

`tpdsl: multi/LAParser.java`
(`element()`)

`tpdsl: multi/NameListWithAssignParser.java`
(`.adaptivePredict()`)

Backtrack (回溯)

`tpdsl: backtrack/NameListWithParallelAssign.g4`

Backtrack (回溯)

tpdsl: backtrack/NameListWithParallelAssign.g4

tpdsl: backtrack/BacktrackParser.java
(stat())

Backtrack (回溯)

`tpdsl: backtrack/NameListWithParallelAssign.g4`

`tpdsl: backtrack/BacktrackParser.java`
(`stat()`)

`tpdsl: backtrack/NameListWithParallelAssignParser.java`
(`.adaptivePredict()`)

Backtrack (回溯)

tpdsl: backtrack/NameListWithParallelAssign.g4

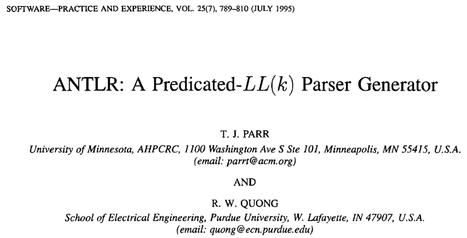
tpdsl: backtrack/BacktrackParser.java

(stat())

tpdsl: backtrack/NameListWithParallelAssignParser.java

(.adaptivePredict())

ANTLR4 不需要回溯，这是 ANTLR4 的一大创新之处



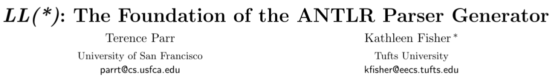
SOFTWARE—PRACTICE AND EXPERIENCE, VOL. 25(7), 789–810 (JULY 1995)

ANTLR: A Predicated-$LL(k)$ Parser Generator

T. J. PARR
University of Minnesota, AHPCRC, 1100 Washington Ave S Ste 101, Minneapolis, MN 55415, U.S.A.
(email: parrt@acm.org)

AND

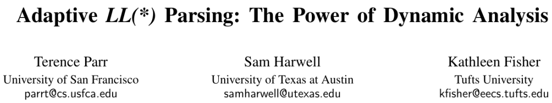
R. W. QUONG
School of Electrical Engineering, Purdue University, W. Lafayette, IN 47907, U.S.A.
(email: quong@ecn.purdue.edu)



***LL(*)*: The Foundation of the ANTLR Parser Generator**

Terence Parr
University of San Francisco
parrt@cs.usfca.edu

Kathleen Fisher [*]
Tufts University
kfisher@eecs.tufts.edu

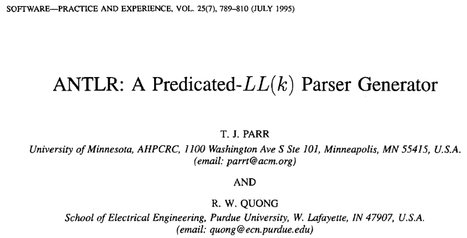


Adaptive *LL(*)* Parsing: The Power of Dynamic Analysis

Terence Parr
University of San Francisco
parrt@cs.usfca.edu

Sam Harwell
University of Texas at Austin
samharwell@utexas.edu

Kathleen Fisher
Tufts University
kfisher@eecs.tufts.edu

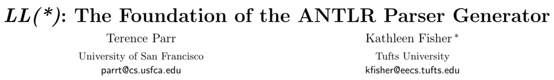

SOFTWARE—PRACTICE AND EXPERIENCE, VOL. 25(7), 789–810 (JULY 1995)

ANTLR: A Predicated-$LL(k)$ Parser Generator

T. J. PARR
University of Minnesota, AHPCRC, 1100 Washington Ave S Ste 101, Minneapolis, MN 55415, U.S.A.
(email: parrt@acm.org)

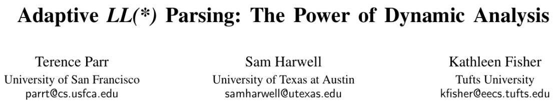
AND

R. W. QUONG
School of Electrical Engineering, Purdue University, W. Lafayette, IN 47907, U.S.A.
(email: quong@ecn.purdue.edu)


***LL(*)*: The Foundation of the ANTLR Parser Generator**

Terence Parr
University of San Francisco
parrt@cs.usfca.edu

Kathleen Fisher *
Tufts University
kfisher@eecs.tufts.edu


Adaptive *LL(*)* Parsing: The Power of Dynamic Analysis

Terence Parr
University of San Francisco
parrt@cs.usfca.edu

Sam Harwell
University of Texas at Austin
samharwell@utexas.edu

Kathleen Fisher
Tufts University
kfisher@eecs.tufts.edu

courses-at-nju-by-hfwei/compilers-papers-we-love

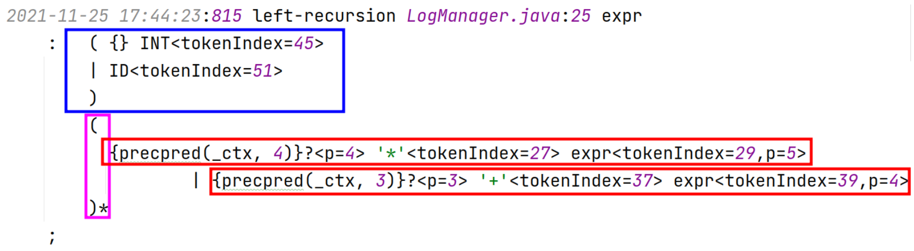
ANTLR4 是如何处理**左递归与优先级**的?

parserllantlr/LRExpr.g4

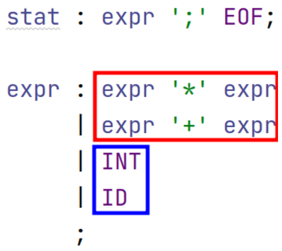
```
parserllantlr/LRExpr.g4
```

```
antlr4 LRExpr -Xlog
```

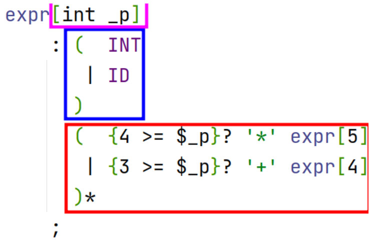
Grammar Rewriting



```
2021-11-25 17:44:23:815 left-recursion LogManager.java:25 expr
    :   ( {} INT<tokenIndex=45>
        | ID<tokenIndex=51>
        )
        (
         {precpred(_ctx, 4)}?<p=4> '*'<tokenIndex=27> expr<tokenIndex=29,p=5>
                  | {precpred(_ctx, 3)}?<p=3> '+'<tokenIndex=37> expr<tokenIndex=39,p=4>
        )*
    ;
```

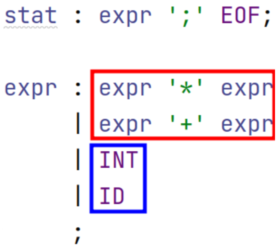


```
stat : expr ';' EOF;

expr : expr '*' expr
     | expr '+' expr
     | INT
     | ID
     ;
```

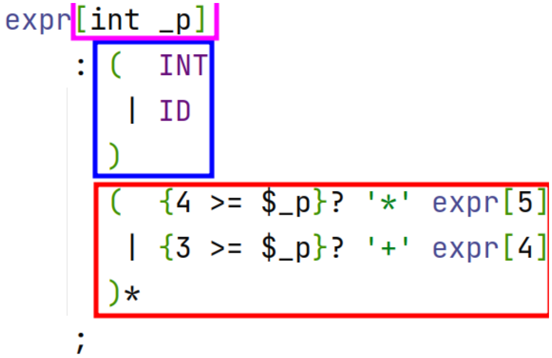


```
expr[int _p]
    : ( INT
      | ID
      )
      ( {4 >= $_p}? '*' expr[5]
      | {3 >= $_p}? '+' expr[4]
      )*
    ;
```

`expr[int _p]`



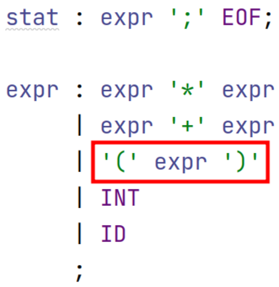
```
stat : expr ';' EOF;

expr : expr '*' expr
     | expr '+' expr
     | INT
     | ID
     ;
```



```
expr[int _p]
    : ( INT
      | ID
      )
      ( {4 >= $_p}? '*' expr[5]
      | {3 >= $_p}? '+' expr[4]
      )*
    ;
```

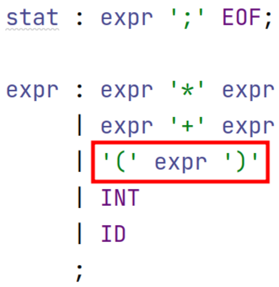
$$1 + 2 + 3 \qquad 1 + 2 * 3 \qquad 1 * 2 + 3$$

parserllantlr/LRExprParen.g4



```
stat : expr ';' EOF;

expr : expr '*' expr
     | expr '+' expr
     | '(' expr ')'
     | INT
     | ID
     ;
```

parserllantlr/LRExprParen.g4



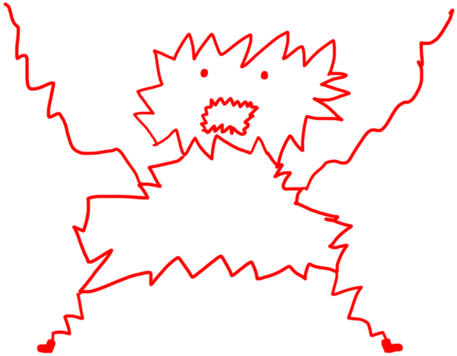
```
stat : expr ';' EOF;

expr : expr '*' expr
     | expr '+' expr
     | '(' expr ')'
     | INT
     | ID
     ;
```

antlr4 LRExprParen -Xlog

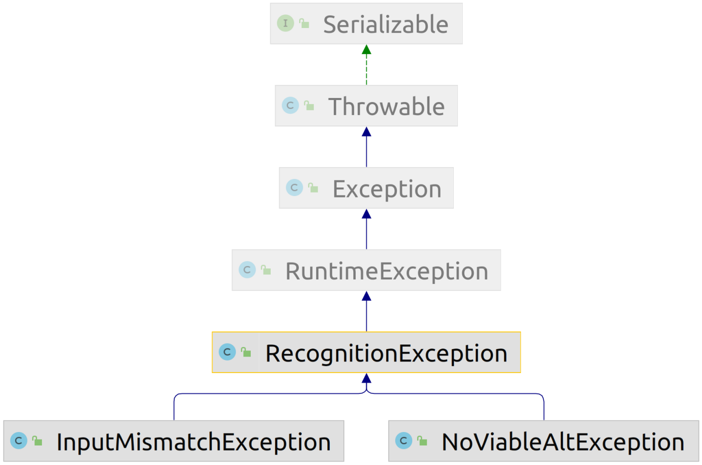
ANTLR4 是如何进行**错误报告与恢复**的?

语法分析阶段的主题之三: **错误恢复**

报错、**恢复**、继续分析



恐慌/应急 (Panic) 模式: 假装成功、调整状态、继续进行


Serializable
Throwable
Exception
RuntimeException
RecognitionException
InputMismatchException
NoViableAltException

InputMismatchException

InputMismatchException

如果下一个词法单元符合预期，

则采用 "单词法符号移除" 或 "单词法符号补全" 策略

InputMismatchException

如果下一个词法单元符合预期,

则采用 "单词法符号移除" 或 "单词法符号补全" 策略

`Class.g4`

`Class-RemoveToken.txt`

`Class-AddToken.txt`

NoViableAltException

NoViableAltException

采用 “同步-返回 (sync-and-return)” 策略,

从当前非终结符中恢复

NoViableAltException

采用 "同步-返回 (sync-and-return)" 策略,
从当前非终结符中恢复

`Group.g4`

`Group-Sync.txt`

NoViableAltException

采用 "同步-返回 (sync-and-return)" 策略，
从当前非终结符中恢复

`Group.g4`

`Group-Sync.txt`

注意 FOLLOW (静态) 集合与 FOLLOWING (动态) 集合的区别

如何从子规则中优雅地恢复出来?

`Class.g4` (`member+`)

如何从子规则中优雅地恢复出来?

`Class.g4` (`member+`)

`Class-Subrule-Start.txt` ("单词法符号移除")

如何从子规则中优雅地恢复出来?

`Class.g4` (`member+`)

`Class-Subrule-Start.txt` ("单词法符号移除")

`Class-Subrule-Loop.txt` ("另一次 `member` 迭代")

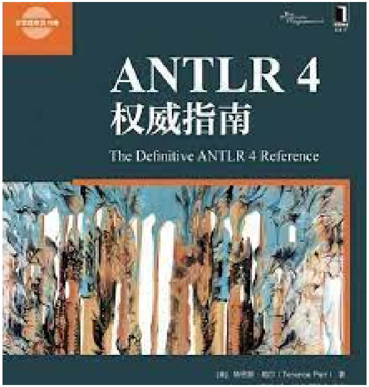
如何从子规则中优雅地恢复出来?

`Class.g4` (`member+`)

`Class-Subrule-Start.txt` ("单词法符号移除")

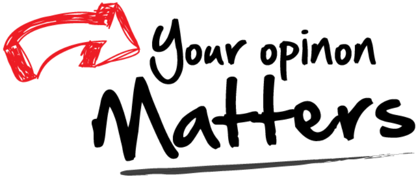
`Class-Subrule-Loop.txt` ("另一次 `member` 迭代")

`Class-Subrule-End.txt` ("退出当前 `classDef` 规则")



第 9 章: 错误报告与恢复

Thank
You!



Office 926

hfwei@nju.edu.cn