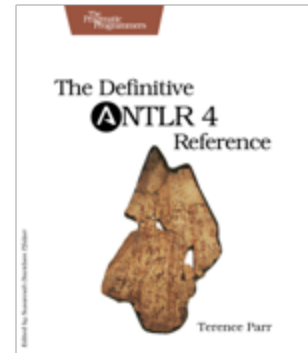


# Introduction to ANTLR 4



The latest and last (sic!) revision

Oliver Zeigermann  
Code Generation Cambridge 2013

# Outline

- Introduction to parsing with ANTLR4
- Use case: Interpreter
- Use case: Code Generator
- The tiniest bit of theory: Adaptive LL(\*)
- Comparing ANTLR4

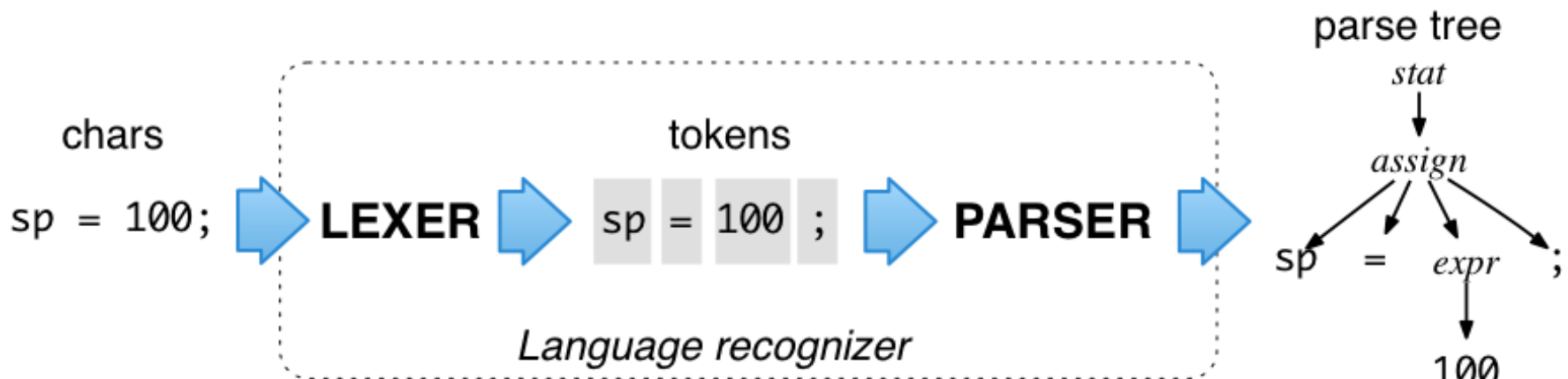
# ANTLR 4: Management Summary

- Parser generator
- Language tool
- Design goals
  - ease-of-use over performance
  - simplicity over complexity
- Eats all context free grammars
  - with a small caveat

# What does parsing with ANTLR4 mean?

Identify and reveal the implicit structure of an input in a parse tree

- Structure is described as a grammar
- Recognizer is divided into lexer and parser
- Parse tree can be auto generated



# **Practical example #1: An expression interpreter**

## **Build an interpreter from scratch**

- complete and working
- parses numerical expressions
- does the calculation

# Lexical rule for integers

`INT : ( '0' .. '9' ) + ;`

- Rule for token *INT*
- Composed of digits 0 to 9
- At least one digit

# Syntactic rule for expressions

```
expr  : expr ( '*' | '/' ) expr  
      | expr ( '+' | '-' ) expr  
      | INT  
      ;
```

- Three options
- Operator precedence by order of options
- Notice left recursion

grammar Expressions;

start : expr ;

expr : left=expr op=('\*'|'/') right=expr #opExpr  
      | left=expr op=('+'|'-') right=expr #opExpr  
      | atom=INT #atomExpr  
      ;

INT : ('0'..'9')+ ;

WS : [ \t\r\n]+ -> skip ;



# Doing something based on input

## Options for separation of actions from grammars in ANTLR4

1. Listeners (SAX style)
2. **Visitors (DOM style)**

# Introducing Visitors

**Yes, that well known pattern**

- Actions are separated from the grammar
- Visitors actively control traversal of parse tree
  - if and
  - how
- Calls of visitor methods can return values

# Visitor: actively visiting tree

```
int visitOpExpr(OpExprContext ctx) {  
    int left = visit(ctx.left);  
    int right = visit(ctx.right);  
    switch (ctx.op) {  
        case '*': return left * right;  
        case '/': return left / right;  
        case '+': return left + right;  
        case '-': return left - right;  
    }  
}
```

# Visitor methods pseudo code

```
int visitStart(StartContext ctx) {  
    return visitChildren(ctx);  
}  
  
int visitAtomExpr(AtomExprContext ctx) {  
    return Integer.parseInt(ctx.atom.getText());  
}  
  
int visitOpExpr(OpExprContext ctx) {  
    // what we just saw  
}
```

**Live Demo**

# Practical example #2: Code generation from Java

## Generate interface declarations for existing class definitions

- Adapted from ANTLR4 book
- Like a large scale refactoring or code generation
- Keep method signature *exactly* as it is
- Good news
  - You can use an existing Java grammar
  - You just have to figure out what is/are the rule(s) you are interested in: *methodDeclaration*

# **Doing something based on input**

## **Options for separation of actions from grammars**

- 1. Listeners (SAX style)**
- 2. Visitors (DOM style)**

# Introducing listeners



**Yes, that well known pattern (aka Observer)**

- Automatic depth-first traversal of parse tree
- walker fires events that you can handle



# Listener for method declaration, almost real code

```
void enterMethodDeclaration(  
    MethodDeclarationContext ctx) {  
    // gets me the text of all the tokens that have  
    // been matched while parsing a  
    // method declaration  
    String fullSignature =  
        parser.getTokenStream().getText(ctx);  
    print(fullSignature + ";\");  
}
```

**That's it!**

(plus minor glue code)

**Live Demo**

# ANTLR4 Adaptive LL(\*) or ALL(\*)

- Generates recursive descent parser
  - like what you would build by hand
- does dynamic grammar analysis while parsing
  - saves results like a JIT does
- allows for direct left recursion
  - indirect left recursion not supported
- parsing time typically near-linear

# Comparing to ANTLR3

**top-down SLL(\*) parser with optional backtracking and memoization**

- **ANTLR4**
  - can handle a larger set of grammars
  - supports lexer modes
- **ANTLR3**
  - relies on embedded actions
  - has tree parser and transformer
  - can't handle left recursive grammars

# Comparision Summary

- PEG / packrat
  - can't do left recursion
  - similar to ANTLR3 with backtracking
  - error recovery or reporting hard
- GLR
  - bottom-up like yacc
  - can do all grammars
  - debugging on the declarative specification only
- GLL
  - top-down like ANTLR
  - can do all grammars

# Comparing to PEG / packrat

**top-down parsing with backtracking and memoization**

- Sometimes scanner-less
- also can not do left recursion
- Uses the first option that matches
- Error recovery and proper error reporting very hard
- ANTLR4 much more efficient

# Comparing to GLR

## **a generalized LR parser**

- does breadth-first search when there is a conflict in the LR table
- can deliver all possible derivation on ambiguous input
- debugging on the declarative specification
  - no need to debug state machine
- can do indirect left recursion



# Comparing to GLL

## **a generalized LL parser**

- mapping to recursive descent parser not obvious (not possible?)
- can do indirect left recursion

# Wrap-Up

- ANTLR 4 is easy to use
- You can use listeners or visitors for actions
- ANTLR 4 helps you solve **practical** problems

# Why is ANTLR4 called "Honey Badger"?

- The *animal* "Honey Badger" is the most fearless animal of all
- ANTLR4 named after it
  - <http://www.youtube.com/watch?v=4r7wHMg5Yjg>
- It takes any grammar you give it. "It just doesn't give a damn."

# Resources

- Terence Parr speaking about ANTLR4
  - <http://vimeo.com/m/59285751>
- ANTLR4-Website
  - <http://www.antlr.org>
- Book
  - <http://pragprog.com/book/tpantlr2/the-definitive-antlr-4-reference>
- ANTLRWorks
  - <http://tunnelvisionlabs.com/products/demo/antlrworks>
- Examples of this talk on github
  - <https://github.com/DJCordhose/antlr4-sandbox>

# Questions / Discussion

Oliver Zeigermann  
zeigermann.eu

Java example and some illustrations provided as a courtesy of Terence Parr