ANTLR and Tiger

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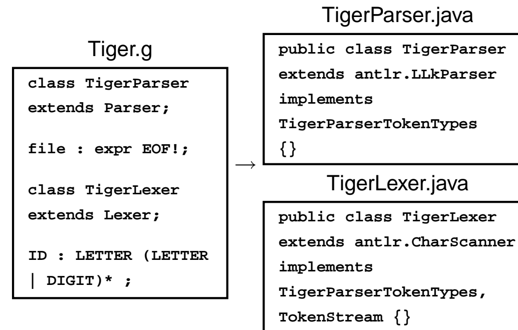
ANTLR



ANTLR Lexer Specifications

Look like

```
class MyLexer extends Lexer;
options {
  option = value
}

Token1 : ’char’ ’char’ ;
Token2 : ’char’ ’char’ ;
Token3 : ’char’ (’char’)? ;
```

Tries to match all non-protected tokens at once.

ANTLR Parser Specifications

Look like

```
class MyParser extends Parser;
options {
  option = value
}

rule1 : Token1 Token2
      | Token3 rule2 ;
rule2 : (Token1 Token2)* ;
rule3 : rule1 ;
```

Looks at the next k tokens when deciding which option to consider next.

An ANTLR grammar for Esterel

Esterel: Language out of France. Programs look like

```
module ABRO:
input A, B, R;
output O;

loop
  [ await A || await B ];
  emit O
each R

end module
```

A Lexer for Esterel

Operators from the langauge reference manual:

```
. # + - / * || < > , = ; : := ( )
[ ] ? ?? <= >= <> =>
```

Main observation: none longer than two characters. Need $k = 2$ to disambiguate, e.g., `?` and `??`.

```
class EsterelLexer extends Lexer;
options {
  k = 2;
}
```

A Lexer for Esterel

Next, I wrote a rule for each punctuation character:

```
PERIOD :       ’.’ ;
POUND :        ’#’ ;
PLUS :         ’+’ ;
DASH :         ’-’ ;
SLASH :        ’/’ ;
STAR :         ’*’ ;
PARALLEL :     "||" ;
```

A Lexer for Esterel

Identifiers are standard:

```
ID
  : (’a’..’z’ | ’A’..’Z’)
    (’a’..’z’ | ’A’..’Z’ | ’_’ | ’0’..’9’)*
  ;
```

A Lexer for Esterel

String constants must be contained on a single line and may contain double quotes, e.g.,

```
"This is a constant with ""double quotes"""
```

ANTLR makes this easy: annotating characters with ! discards them from the token text:

```
StringConstant
  : ’"’!
    ( ~(’"’ | ’\n’)
    | (’"’! ’"’)
    )*
    ’"’!
  ;
```

A Lexer for Esterel

I got in trouble with the ~ operator, which inverts a character class. Invert with respect to what?

Needed to change options:

```
options {
  k = 2;
  charVocabulary = '\3'..'\377';
  exportVocab = Esterel;
}
```

A Lexer for Esterel

Another problem: ANTLR scanners check each recognized token's text against keywords by default.

A string such as **"abort"** would scan as a keyword!

```
options {
  k = 2;
  charVocabulary = '\3'..'\377';
  exportVocab = Esterel;
  testLiterals = false;
}

ID options { testLiterals = true; }
  : ('a'..'z' | 'A'..'Z') /* ... */ ;
```

A Parser for Esterel

Esterel's syntax started out using **;** as a separator and later allowed it to be a terminator.

The language reference manual doesn't agree with what the compiler accepts.

Grammar from the LRM

NonParallel:
AtomicStatement
Sequence

Sequence:
SequenceWithoutTerminator **;** *opt*

SequenceWithoutTerminator:
AtomicStatement **;** *AtomicStatement*
SequenceWithoutTerminator **;** *AtomicStatement*

AtomicStatement:
nothing
pause
...

Grammar from the LRM

But in fact, the compiler accepts

```
module TestSemicolon1:
  nothing;
end module
module TestSemicolon2:
  nothing; nothing;
end module
module TestSemicolon3:
  nothing; nothing
end module
```

Rule seems to be "one or more statements separated by semicolons except for the last, which is optional."

Grammar for Statement Sequences

Obvious solution:

```
sequence
  : atomicStatement
    (SEMICOLON atomicStatement)*
    (SEMICOLON)?
  ;
```

```
warning: nondeterminism upon
k==1:SEMICOLON
between alt 1 and exit branch of block
```

Which option do you take when there's a semicolon?

Nondeterminism

```
sequence : atomicStatement
    (SEMICOLON atomicStatement)*
    (SEMICOLON)? ;
```

Is equivalent to

```
sequence : atomicStatement seq1 seq2 ;

seq1 : SEMICOLON atomicStatement seq1
     | /* nothing */ ;

seq2 : SEMICOLON
     | /* nothing */ ;
```

Nondeterminism

```
sequence : atomicStatement seq1 seq2 ;
seq1 : SEMICOLON atomicStatement seq1
     | /* nothing */ ;
seq2 : SEMICOLON
     | /* nothing */ ;
```

How does it choose an alternative in **seq1**?

First choice: next token is a semicolon.

Second choice: next token is one that may follow seq1.

But this may also be a semicolon!

Nondeterminsm

Solution: tell ANTLR to be greedy and prefer the iteration solution.

```
sequence
  : atomicStatement
    ( options { greedy=true; }
    : SEMICOLON! atomicStatement )*
    (SEMICOLON!)?
  ;
```

Nondeterminism

Delays can be “A” “X A” “immediate A” or “[A and B].”

```
delay : expr bSigExpr
      | bSigExpr
      | "immediate" bSigExpr ;

bSigExpr : ID
         | "[" signalExpression "]" ;

expr : ID | /* ... */ ;
```

Which choice when next token is an ID?

Nondeterminism

```
delay : expr bSigExpr
      | bSigExpr
      | "immediate" bSigExpr ;
```

What do we really want here?

If the delay is of the form “expr bSigExpr,” parse it that way.

Otherwise try the others.

Nondeterminism

```
delay : ( (expr bSigExpr) => delayPair
        | bSigExpr
        | "immediate" bSigExpr
        ) ;

delayPair : expr bSigExpr ;
```

The `=>` operator means “try to parse this first. If it works, choose this alternative.”

The Syntax of the Tiger Language

Tiger Expressions

```
"hello"
1024
nil
foo
-(1+2)
1 * 3
foo := 10
bar(10,20)
(a := 5; b := 3; c := 2)
if a then 20 else 30
while a < 5 do a := a + 1
for i := 1 to 5 do i + 2
break
let ... in ... end
```

lvalues

“Something that may appear on the left side of an assignment”

lvalue:

id

lvalue . id

lvalue `[` *expr* `]`

```
foo := 3
bar.baz := 5
biff[10] := 20
derf[5].x := 3
```

Object Constructors

Tiger has array and record types.

```
let
  type ia = array of integer
  type point = { x : integer, y : integer }
  var a := ia [5] of 0
  var p := point { x = 1, y = 2 }
in
  0
end
```

Tiger AST

```
lvalue
: ID
| #( FIELD lvalue ID )      // lvalue.field
| #( SUBSCRIPT lvalue expr) // lvalue[expr]
;

expr
: "nil"
| lvalue
| STRING
| NUMBER
| #( NEG expr )        // - e
| #( BINOP expr expr ) // e+e, e*e
```

Tiger AST

```
| #( ASSIGN lvalue expr ) // l := e
| #( CALL ID (expr)* )    // f(e, e)
| #( SEQ (expr)* )        // (e ; e)
| #( RECORD ID            // t { a=b, c=d }
     (#(FIELD ID expr))* )
| #( NEWARRAY ID expr expr ) // t [e] of e
| #( "if" expr expr (expr)? )
| #( "while" expr expr )
| #( "for" ID expr expr expr )
| "break"
| #( "let" #(DECLS (#(DECLS (decl)+ ))* ) expr )
;
```

Tiger AST

```
decl
: #( "type" ID type )
| #( "var" ID (ID | "nil") expr )
| #( "function" ID fields (ID | "nil") expr )
;

type
: ID
| fields                    //  a:b, c:d
| #( "array" ID )          // array of type
;

fields : #( FIELDS ( #(FIELD ID ID) )* ) ;
```