COMP 520: Compilers
Compiler Project - Assignment 2

Assigned: Tue Feb 4, 2014
Due: Sat Feb 22, 2014

The second milestone in the compiler project is to create an abstract syntax tree (AST) for syntactically valid miniJava programs. You will need to extend your parser to construct the miniJava AST using a set of AST classes outlined in this document and available as a package on our course website. You will need to modify the miniJava grammar to incorporate Java operator precedence rules in order to build the correct AST.

1. miniJava syntax changes

The grammar for this assignment is the miniJava grammar from the first assignment. However, you should no longer allow "`--`" to be parsed as two subtraction operators. In full Java "`--`" is a prefix and postfix operator applied to a variable to predecrement or postdecrement the value of a variable referenced in an expression, respectively. Since we will not implement this operator in miniJava, any expression involving "`--`" should be disallowed in miniJava. Here are some examples.

Valid miniJava expressions:

```
        -b     -(-b)        - -b         a-(-b)       !b     !!b
```

Invalid miniJava expressions (but valid Java expressions)

```
        --b    a - --b      a---b        a--+--b
```

2. Operator precedence in expressions

In Java the evaluation order of expressions is controlled by parentheses and by standard operator precedence rules from arithmetic and predicate logic. The following table lists the precedence order of the miniJava operators from lowest to highest.

class	**operator(s)**
disjunction	`||`
conjunction	&&
equality	`==, !=`
relational	`<=, <, >, >=`
additive	`+, -`
multiplicative	`*, /`
unary	`-, !`

Binary operators are left associative and reflect precedence, so that `1-2+3` means `(1-2)+3`, and `1+3*4/2` means `1+((3*4)/2)`. Unary operators are right associative. The challenge in this part of the assignment is to construct a stratified grammar reflecting the precedence shown above that also accommodates explicit precedence specified using parentheses. The correct AST can be constructed in the course of parsing such a grammar.

3. Abstract syntax tree classes

The set of classes needed to build miniJava ASTs are provided in the `AbstractSyntaxTrees` package available through the course website. Components of the AST "grammar" are organized by the class hierarchy shown on the last page (right side). Abstract classes (shown with an "A" superscript next to the class icon) represent nonterminals of the AST grammar, such as *Statement*. The rule for *Statement* below shows the particular kinds of statements that may be created in an AST; each corresponds to a concrete class in the hierarchy. For example, a *WhileStmt* is a specific kind of *Statement*, and consists of an *Expression* (for the condition controlling execution of the loop) and a *Statement* (for the body of the loop).

Statement	::=		
		Reference Expression	AssignStmt
	|	Statement*	BlockStmt
	|	Reference Expression*	CallStmt
	|	Expression Statement Statement?	IfStmt
	|	VarDecl Expression	VarDeclStmt
	|	Expression Statement	WhileStmt

If we look inside the AST class *WhileStmt* we find the following:

```java
public class WhileStmt extends Statement {
{
    public WhileStmt(Expression e, Statement s, SourcePosition posn){
        super(posn);
        cond = e;
        body = s;
    }

    public Expression cond;
    public Statement body;
}
```

The constructor creates a `WhileStmt` node, and its two fields provide access to the AST subtrees of the node (the expression `cond` controlling the loop repetition and the statement `body` to be executed in each repetition). Note the nomenclature, each kind of Statement has a particular name suggesting its kind (e.g. "`While`") that is joined to "`Stmt`" to show the nonterminal from which it derives.

Consult the documentation, source files, and AST constructed for the sample program to make sure you understand the contents and structure of the AST classes. Some auxiliary classes are included to provide a convenient way to create lists of nonterminals such as the `StatementList` in the `BlockStmt`. The "start symbol" of the AST grammar is `Package`.

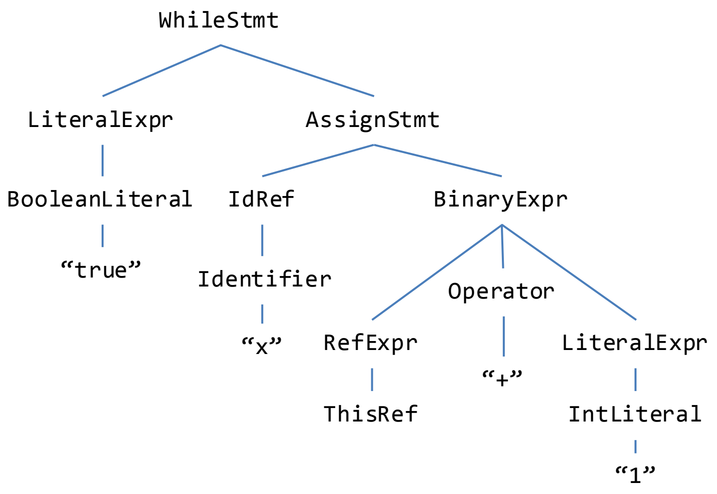
4. The AST Visitor

The `AbstractSyntaxTrees` package defines the `Visitor` interface that can be implemented to create AST traversals. Contextual analysis and code generation will be structured as AST traversals. ASTDisplay is an AST traversal implemented in the AbstractSyntaxTrees package to print a textual representation of an AST (or any AST subtree). Use this facility to inspect the ASTs you generate.

The text representation is created by a depth-first traversal of the AST. A node is displayed as its class name on a single line. The attributes and children of the node are shown in subsequent lines, indented two spaces to the right. Since the traversal is depth-first, the entire representation of the left subtree will be shown before starting the representation of the right subtree. For example, the Statement below has the AST shown on the right with text representation of the AST on the left. Note that near the leaves the text representation is compacted somewhat to improve readability.

```
while (true) x = this + 1;
```

```
WhileStmt
  LiteralExpr
    "true" BooleanLiteral
  AssignStmt
    IdRef
      "x" Identifier
    BinaryExpr
      "+" Operator
        RefExpr
          ThisRef
        LiteralExpr
          "1" IntLiteral
```



ASTDisplay can also list the source positions for each AST node if you enable the capability within ASTDisplay and provide an appropriate toString() method for SourcePosition. For these values to be meaningful, you need to set the source position for every AST node correctly in the parser. It is useful for every AST node to have an associated source position (really an interval in the source text) that can be used for error reporting in later stages. At this stage it is not required and will, by default, not be displayed in the AST. However to create an AST you will have to provide at least a null SourcePosition for each node.

5. Programming Assignment

For PA2 your Compiler mainclass should determine if the input source file constitutes a syntactically valid miniJava program as defined by PA1 and definitions above. If so, it should display the constructed AST for using the showTree method in the ASTDisplay class, and terminate via System.exit(0). (Note: in your submission, disable the display of source position). If the input source file is not syntactically valid miniJava, you should write a diagnostic error message and terminate via System.exit(4). You may output any additional information you wish, but do not alter any aspect of the AbstractSyntaxTrees package for the PA2 submission. Our testing will check that valid miniJava programs construct the correct AST.

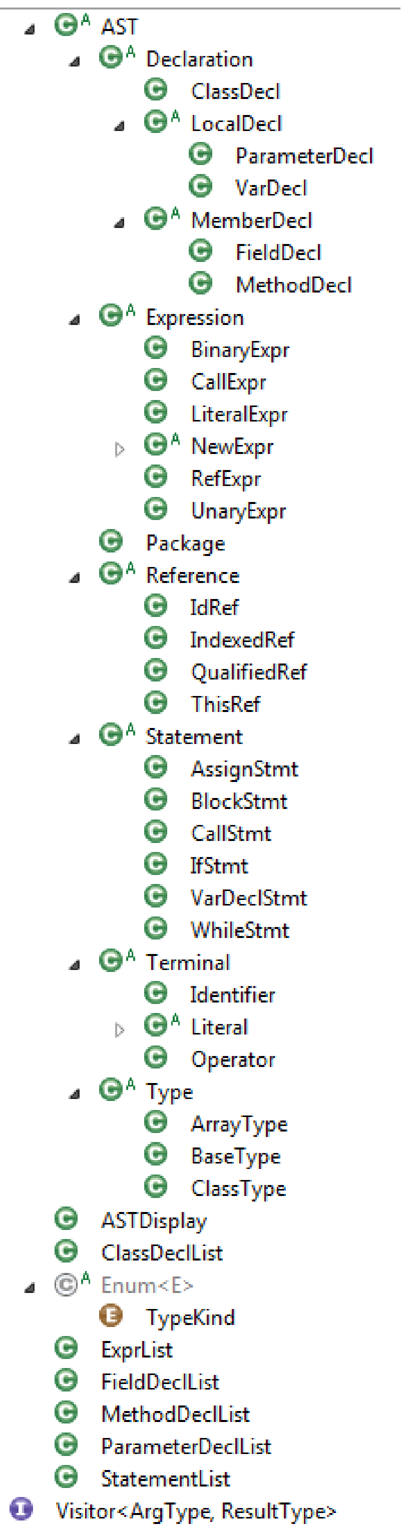
```
// simple PA2 example
class PA2 {

    public boolean c;

    public static void main(String[] args){
        if (x > 1)
            x = 1 + 2 * x;
        else
            b[3].a = 4;
    }
}


======= AST Display =========================
Package
  ClassDeclList [1]
  . ClassDecl
  .   "PA2" classname
  .   FieldDeclList [1]
  .   . (public) FieldDecl
  .   .   BOOLEAN BaseType
  .   .   "c" fieldname
  .   MethodDeclList [1]
  .   . (public static) MethodDecl
  .   .   VOID BaseType
  .   .   "main" methodname
  .   .   ParameterDeclList [1]
  .   .   . ParameterDecl
  .   .   .   ArrayType
  .   .   .     ClassType
  .   .   .       "String" classname
  .   .   .   "args"parametername
  .   .   StmtList [1]
  .   .   . IfStmt
  .   .   .   BinaryExpr
  .   .   .     ">" Operator
  .   .   .       RefExpr
  .   .   .         IdRef
  .   .   .           "x" Identifier
  .   .   .       LiteralExpr
  .   .   .         "1" IntLiteral
  .   .   .   AssignStmt
  .   .   .     IdRef
  .   .   .       "x" Identifier
  .   .   .     BinaryExpr
  .   .   .       "+" Operator
  .   .   .         LiteralExpr
  .   .   .           "1" IntLiteral
  .   .   .         BinaryExpr
  .   .   .           "*" Operator
  .   .   .             LiteralExpr
  .   .   .               "2" IntLiteral
  .   .   .             RefExpr
  .   .   .               IdRef
  .   .   .                 "x" Identifier
  .   .   .   AssignStmt
  .   .   .     QualifiedRef
  .   .   .       "a" Identifier
  .   .   .       IndexedRef
  .   .   .         LiteralExpr
  .   .   .           "3" IntLiteral
  .   .   .         IdRef
  .   .   .           "b" Identifier
  .   .   .     LiteralExpr
  .   .   .       "4" IntLiteral
=============================================
```

Example miniJava program and AST



```
AST
  Declaration
    ClassDecl
    LocalDecl
      ParameterDecl
      VarDecl
    MemberDecl
      FieldDecl
      MethodDecl
  Expression
    BinaryExpr
    CallExpr
    LiteralExpr
    NewExpr
    RefExpr
    UnaryExpr
  Package
  Reference
    IdRef
    IndexedRef
    QualifiedRef
    ThisRef
  Statement
    AssignStmt
    BlockStmt
    CallStmt
    IfStmt
    VarDeclStmt
    WhileStmt
  Terminal
    Identifier
    Literal
    Operator
  Type
    ArrayType
    BaseType
    ClassType
ASTDisplay
ClassDeclList
Enum<E>
  TypeKind
ExprList
FieldDeclList
MethodDeclList
ParameterDeclList
StatementList
Visitor<ArgType, ResultType>
```

AbstractSyntaxTrees
class hierarchy