CS3310 - Language translator Lab

Introduction to Tools

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Acknowledgement

Source taken from Jens Palsberg @UCLA

Outline

The Java Compiler Compiler (JavaCC)

- Can be thought of as “Lex and Yacc for Java.”
- It is based on LL(k) rather than LALR(1).
- Grammars are written in EBNF.
- The Java Compiler Compiler transforms an EBNF grammar into an LL(k) parser.
- TheJavaCC grammar can have embedded action code writtenin Java, just like a Yacc grammar can have embedded action code written in C.
- The lookahead can be changed by writing LOOKAHEAD(. . .).
- The whole input is given in just one file (not two).

JavaCC input

One file
- header
- token specification for lexical analysis
- grammar

Example of a token specification:

```
TOKEN : {
  < INTEGER_LITERAL: ( ["1"-"9"] (["0"-"9"])* | "0" ) >
}
```

Example of a production:

```
void StatementListReturn() :
{}
{
  ( Statement() )* "return" Expression() ";"
}
```


Generating a parser with JavaCC

javacc fortran.jj // generates a parser with a specified name

```
// Sample Main.java
public class Main {
   public static void main(String [] args) {
      try {
         new FortranParser(System.in).Goal();
         System.out.println("Program parsed successfully");
      }
      catch (ParseException e) {
         System.out.println(e.toString());
      }
   }
}
```

javac Main.java // Main.java contains a call of the parser
java Main < **prog.f** // parses the program prog.f

Outline

The Visitor Pattern

- The visitor design pattern is a way of separating an algorithm from an object structure on which it operates.
- Implication: the ability to add new operations to existing object structures without modifying those structures.
- Interesting in object oriented programming and software engineering.

Requirements
- The set of classes must be fixed in advance, and
- each class must have an `accept` method.

Motivate Visitor by summing an integer list

```
interface List {}

class Nil implements List {}

class Cons implements List {
  int head;
  List tail;
}
```


1/3 approach: instanceof and type casts

```
List l;       // The List-object
int sum = 0;
boolean proceed = true;
while (proceed) {
  if (l instanceof Nil)
     proceed = false;
  else if (l instanceof Cons) {
     sum = sum + ((Cons) l).head;
     l = ((Cons) l).tail;
     // Notice the two type casts!
  }
}
```

Adv: The code is written without touching the classes `Nil` and `Cons`.
Drawback: The code constantly uses explicit type cast and `instanceof` operations.

2/3 approach: dedicated methods

- The first approach is NOT object-oriented!
- Classical method to access parts of an object: dedicated methods which both access and act on the subobjects.

```
interface List {
  int sum();
}
```

- We can now compute the sum of all components of a given List-object `ll` by writing `ll.sum()`.

2/3 approach: dedicated methods (contd)

```
class Nil implements List {
  public int sum() {
    return 0;
  }
}
class Cons implements List {
  int head;
  List tail;
  public int sum() {
    return head + tail.sum();
  }
}
```

- **Adv:** The type casts and instanceof operations have disappeared, and the code can be written in a systematic way.
- **Drawback**: For each new operation, new dedicated methods have to be written, and all classes must be recompiled.

3/3 approach: Visitor pattern

The Idea:

- Divide the code into an object structure and a Visitor.
- Insert an accept method in each class. Each accept method takes a Visitor as argument.
- A Visitor contains a `visit` method for each class (overloading!) A `visit` method for a class C takes an argument of type C.

```
interface List {
  void accept(Visitor v);
}
interface Visitor {
  void visit(Nil x);
  void visit(Cons x);
}
```


3/3 approach: Visitor pattern

- The purpose of the accept methods is to invoke the visit method in the Visitor which can handle the current object.

```
class Nil implements List {
  public void accept(Visitor v) {
    v.visit(this);
  }
}
class Cons implements List {
  int head;
  List tail;
  public void accept(Visitor v) {
    v.visit(this);
  }
}
```


3/3 approach: Visitor pattern

- The control flow goes back and forth between the visit methods in the Visitor and the accept methods in the object structure.

```
class SumVisitor implements Visitor {
  int sum = 0;
  public void visit(Nil x) {}
  public void visit(Cons x) {
    sum = sum + x.head;
    x.tail.accept(this);
  }
}
.....
SumVisitor sv = new SumVisitor();
l.accept(sv);
System.out.println(sv.sum);
```

The visit methods describe both
1) actions, and 2) access of subobjects.

3/3 approach: Visitor pattern control flow

```
interface List {
  void accept(Visitor v); }
interface Visitor {
  void visit(Nil x);
  void visit(Cons x); }
```

```
class Nil implements List {
  public void accept(Visitor v) {
    v.visit(this); } }
class Cons implements List {
  int head;
  List tail;
  public void accept(Visitor v) {
    v.visit(this); } }
```

```
class SumVisitor implements Visitor {
  int sum = 0;
  public void visit(Nil x) {}
  public void visit(Cons x) {
    sum = sum + x.head;
    x.tail.accept(this); } }
.....
SumVisitor sv = new SumVisitor();
l.accept(sv);
```

Comparison

#	detail	Frequent type casts	Frequent recompilation
1.	Instanceof + type-cast	Yes	No
2.	Dedicated methods	No	Yes
3.	Visitor pattern	No	No

- The Visitor pattern combines the advantages of the two other approaches.
- **Advantage** of Visitors: New methods without recompilation!
- **Requirement** for using Visitors: All classes must have an accept method.

Tools that use the Visitor pattern:

- JJTree (from Sun Microsystems), the Java Tree Builder (from Purdue University), both frontends for The JavaCC from Sun Microsystems.
- ANTLR generates default visitors for its parse trees.

Visitors: Summary

- Visitor makes adding new operations easy. Simply write a new visitor.
- A visitor gathers related operations. It also separates unrelated ones.
- Adding new classes to the object structure is hard. Key consideration: are you most likely to change the algorithm applied over an object structure, or are you most like to change the classes of objects that make up the structure.
- Visitors can accumulate state.
- Visitor can break encapsulation. Visitor's approach assumes that the interface of the data structure classes is powerful enough to let visitors do their job. As a result, the pattern often forces you to provide public operations that access internal state, which may compromise its encapsulation.

Outline

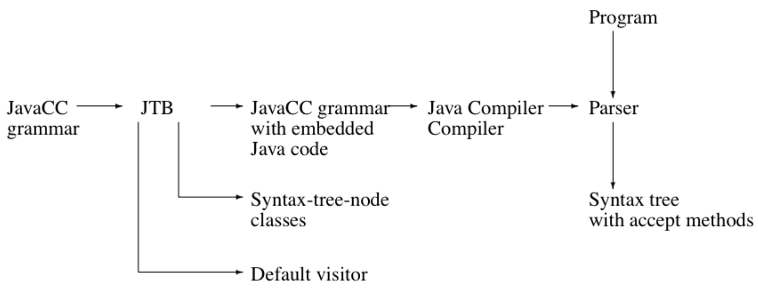
Java Tree builder

- The Java Tree Builder (JTB) has been developed here at Purdue (my ex group).
- JTB is a frontend for The Java Compiler Compiler.
- JTB supports the building of syntax trees which can be traversed using visitors. Q: Why is it interesting?
- JTB transforms a bare JavaCC grammar into three components:
  - a JavaCC grammar with embedded Java code for building a syntax tree;
  - one class for every form of syntax tree node; and
  - a default visitor which can do a depth-first traversal of a syntax tree.

The Java Tree Builder

The produced JavaCC grammar can then be processed by the Java Compiler Compiler to give a parser which produces syntax trees.

The produced syntax trees can now be traversed by a Java program by writing subclasses of the default visitor.



Invoking JTB

```
jtb fortran.jj      // generates jtb.out.jj
javacc jtb.out.jj  // generates a parser with a specified name
//  Sample Main.java:
public class Main {
   public static void main(String [] args) {
      try {
         Node root = new FortranParser(System.in).Goal();
         System.out.println("Program parsed successfully");
         root.accept(new GJNoArguDepthFirst());
      }
      catch (ParseException e) {
         System.out.println(e.toString());
      }
   }
}

javac Main.java      //Main.java contains a call of the parser
                      and calls to visitors
java Main < prog.f  //builds a syntax tree for prog.f, and
                      executes the visitors
```


(simplified) Example

For example, consider the Java production

```
void Assignment() : {}
   {PrimaryExpression() AssignmentOperator() Expression()}
```

JTB produces:

```
Assignment Assignment () :
{ PrimaryExpression n0;
  AssignmentOperator n1;
  Expression n2; {} }
{ n0=PrimaryExpression()
  n1=AssignmentOperator()
  n2=Expression()
  { return new Assignment(n0,n1,n2); }
}
```

Notice that the production returns a syntax tree represented as an Assignment object.

(simplified) Example

JTB produces a syntax-tree-node class for Assignment:

```
public class Assignment implements Node {
  PrimaryExpression f0; AssignmentOperator f1;
  Expression f2;
  public Assignment(PrimaryExpression n0,
                    AssignmentOperator n1,
                    Expression n2)
  { f0 = n0; f1 = n1; f2 = n2; }
  public void accept(visitor.Visitor v) {
      v.visit(this);
} }
```

Notice the `accept` method; it invokes the method `visit` for `Assignment` in the default visitor.

(simplified) Example

The default visitor looks like this:

```
public class DepthFirstVisitor implements Visitor {
  ...
   //
   // f0 -> PrimaryExpression()
   // f1 -> AssignmentOperator()
   // f2 -> Expression()
   //
   public void visit(Assignment n) {
      n.f0.accept(this);
      n.f1.accept(this);
      n.f2.accept(this);
} }
```

Notice the body of the method which visits each of the three subtrees of the `Assignment` node.

(simplified) Example (multiple visitors in action)

Here is an example of a program which operates on syntax trees for Java programs. The program prints the right-hand side of every assignment. The entire program is six lines:

```
public class VprintAssignRHS extends DepthFirstVisitor {
   void visit(Assignment n) {
      VPrettyPrinter v = new VPrettyPrinter();
      n.f2.accept(v); v.out.println();
      n.f2.accept(this);
} }
```

When this visitor is passed to the root of the syntax tree, the depth-first traversal will begin, and when `Assignment` nodes are reached, the method `visit` in `VprintAssignRHS` is executed.

`VPrettyPrinter` is a visitor that pretty prints Java programs.

JTB is bootstrapped.