Chapter 5: JavaCC and JTB

The Java Compiler Compiler

- 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.
- The JavaCC grammar can have embedded action code written in 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).

The JavaCC input format

One file:

- header
- token specifications for lexical analysis
- grammar

The JavaCC input format

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

The Visitor Pattern

For **object-oriented programming**,

the Visitor pattern **enables**

the definition of a **new operation**

on an **object structure**

without changing the classes

of the objects.

Gamma, Helm, Johnson, Vlissides:
Design Patterns, 1995.

Sneak Preview

When using the **Visitor** pattern,

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

First Approach: Instanceof and Type Casts

The running Java example: summing an integer list.

```
interface List {}

class Nil implements List {}

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

First 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!
  }
}
```

Advantage: The code is written without touching the classes `Nil` and `Cons`.

Drawback: The code constantly uses type casts and `instanceof` to determine what class of object it is considering.

Second Approach: Dedicated Methods

The first approach is **not** object-oriented!

To access parts of an object, the classical approach is to use 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 `l` by writing `l.sum()`.

Second Approach: Dedicated Methods

```
class Nil implements List {
  public int sum() {
    return 0;
  }
}

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

Advantage: The type casts and `instanceof` operations have disappeared, and the code can be written in a systematic way.

Disadvantage: For each new operation on `List`-objects, new dedicated methods have to be written, and all classes must be recompiled.

Third Approach: The Visitor Pattern

The Idea:

- Divide the code into an object structure and a Visitor (akin to Functional Programming!)
- 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 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);
}
```

Third Approach: The 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);
  }
}
```

Third Approach: The 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);
```

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

Comparison

The Visitor pattern combines the advantages of the two other approaches.

	Frequent type casts?	Frequent recompilation?
Instanceof and type casts	Yes	No
Dedicated methods	No	Yes
The Visitor pattern	No	No

The 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) and the Java Tree Builder (from Purdue University), both frontends for The Java Compiler Compiler from Sun Microsystems.

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.

The Java Tree Builder

The Java Tree Builder (JTB) has been developed here at Purdue in my group.

JTB is a frontend for The Java Compiler Compiler.

JTB supports the building of syntax trees which can be traversed using visitors.

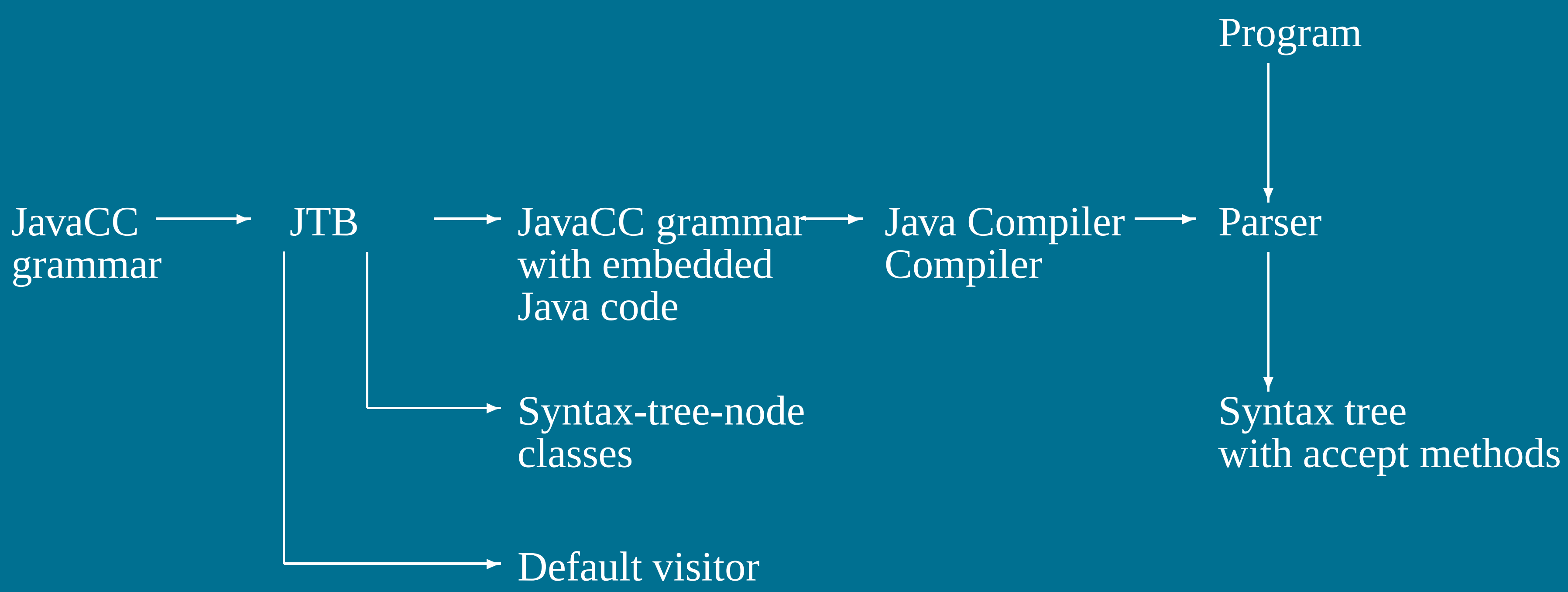
JTB transforms a bare JavaCC grammar into three components:

- 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.



Using JTB

```
jtb fortran.jj        // generates jtb.out.jj
javacc jtb.out.jj     // generates a parser with a specified name
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
```

Example (simplified)

For example, consider the Java 1.1 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.

Example (simplified)

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.

Example (simplified)

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.

Example (simplified)

Here is an example of a program which operates on syntax trees for Java 1.1 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.

Notice the use of `VPrettyPrinter`. It is a visitor which pretty prints Java 1.1 programs.

JTB is bootstrapped.