# 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);
```

visit(x.tail);

**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

JTB is a frontend for The Java Compiler Compiler.

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

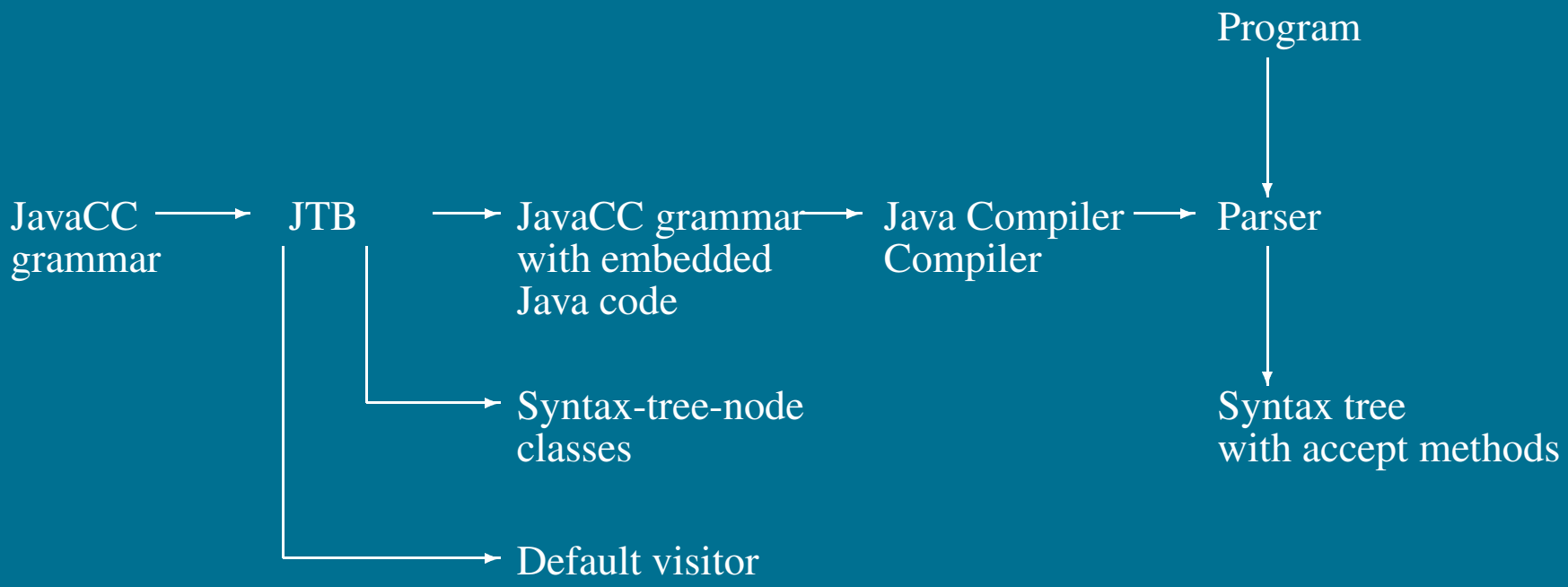
JTB transforms a bare JavaCC grammar into three components:

- 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.