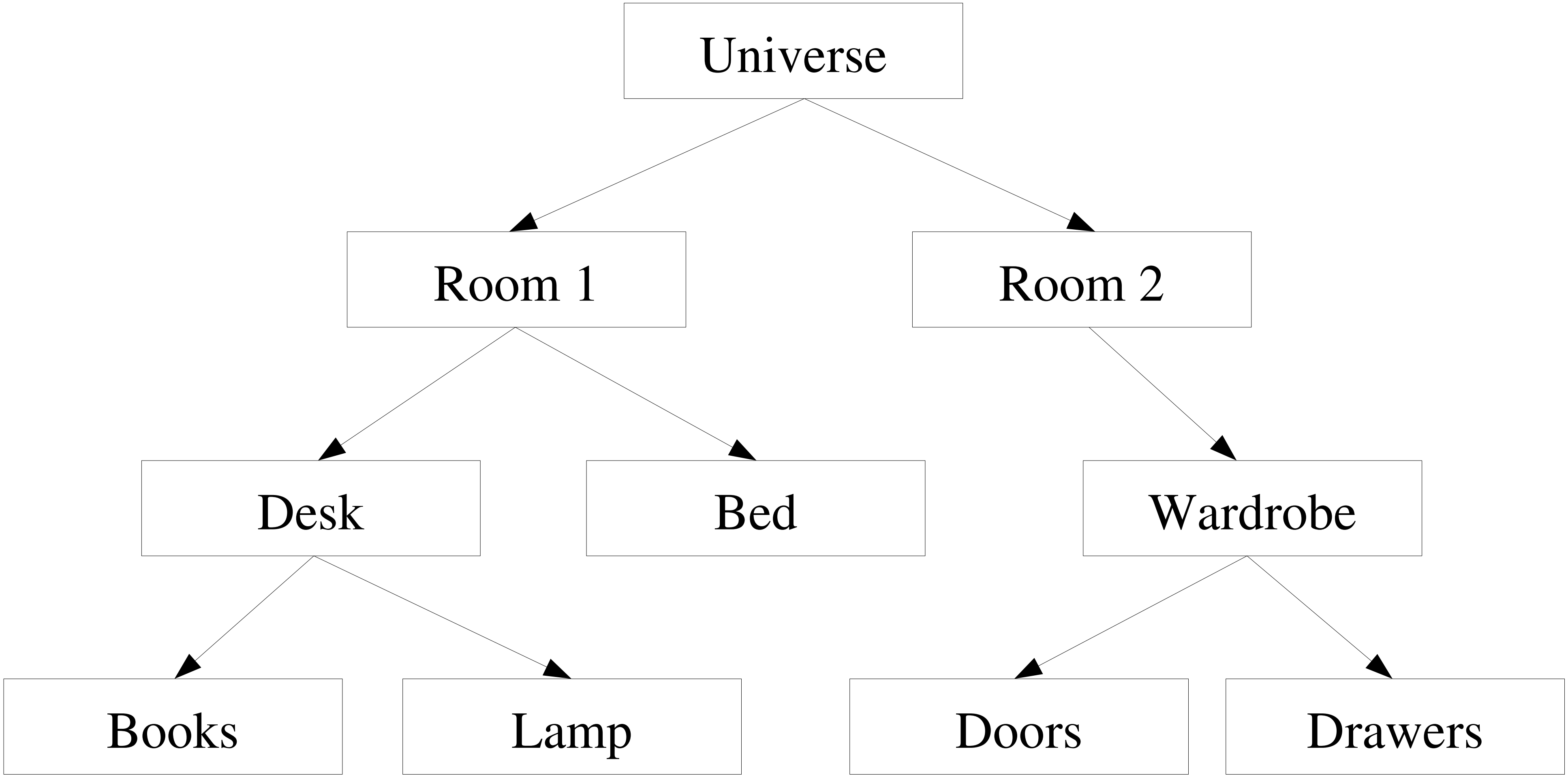
Visitor

3D Room

Scene Graphs


Universe

Room 1

Room 2

Desk

Bed

Wardrobe

Books

Lamp

Doors

Drawers

What if?

- I want to print out the content of the universe.
- To do this, I need to build a string containing a list of the items in the room.
- How do I do this?
- universe.toString() (recursive)

The Challenge

- The class calling the universe.toString() method should not have information on how data is stored in the universe.
- Thus, universe.toString() should take care of traversing the tree.
- This means that each node will need to have its own toString() method.
- If I want to calculate the weight of the universe, I will also need to add a getWeight() function to each node.
- Is there a generic way I can traverse a tree without having to add new methods?

Visitor Pattern

- Represent an operation to be performed on the elements of an object structure.
- In other words, it allows you to separate the algorithm from the data structure.

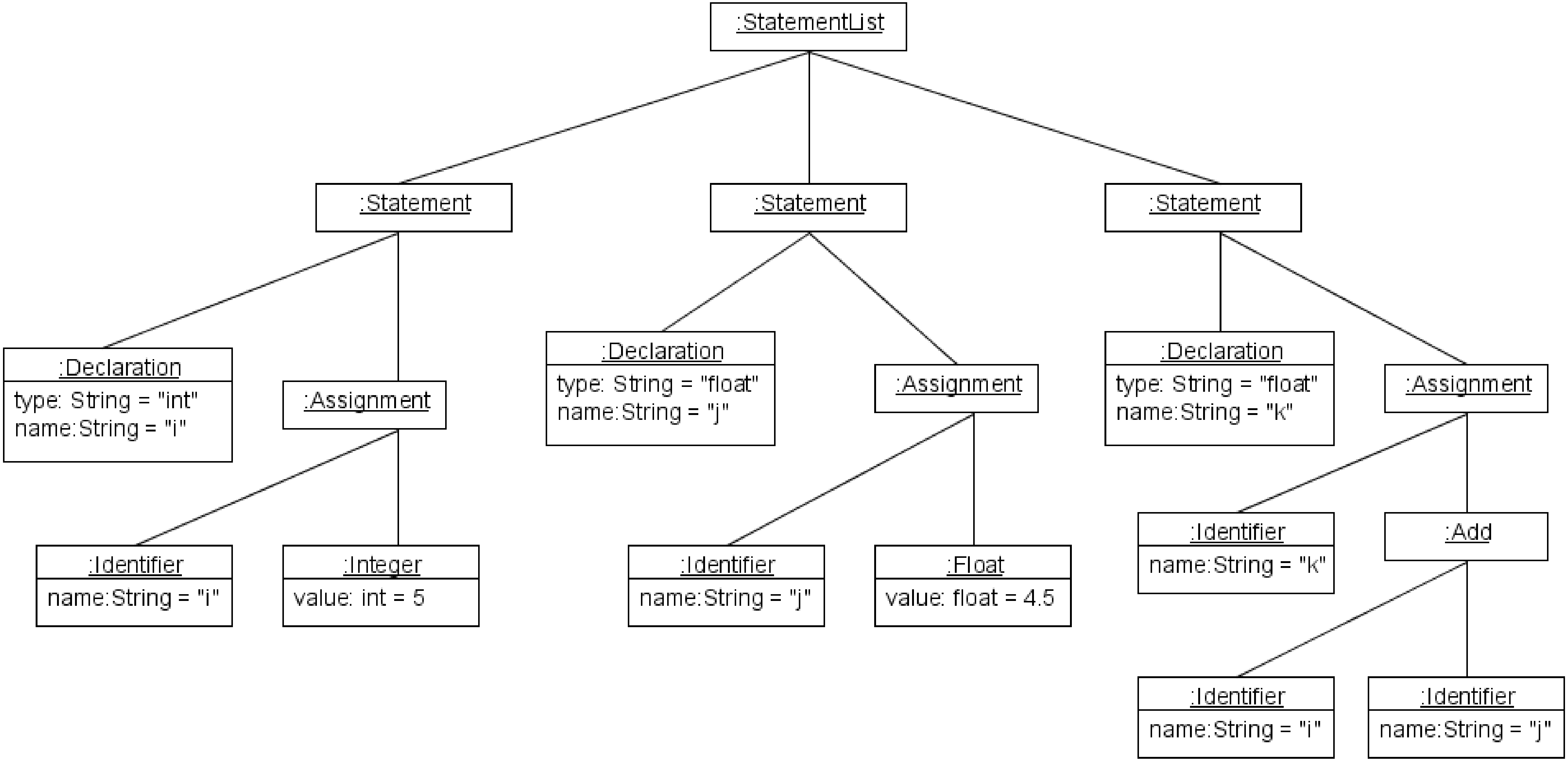
Introduction to Compilers

- A compiler is a tool that transforms a program from a high level representation to a lower level representation.
  - Java -> Bytecode
  - C -> Assembler
- The first step of a compiler is to take the grammar of a language and transform the code into an abstract syntax tree.
  - Flex + Bison in C
  - SableCC in Java

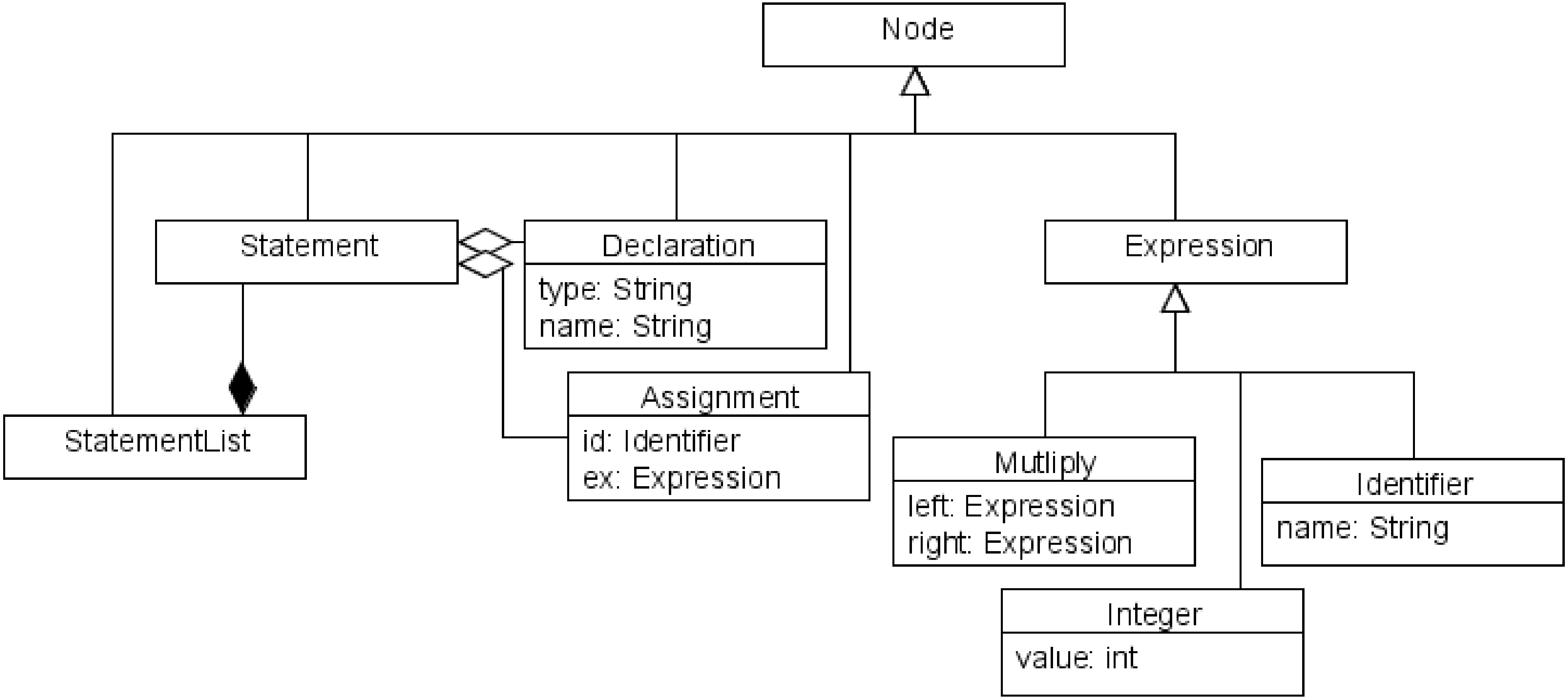
The Code (input to compiler)

```
int i = 5;
float j = 4.5;
float k = i + j;
```

The constructed AST



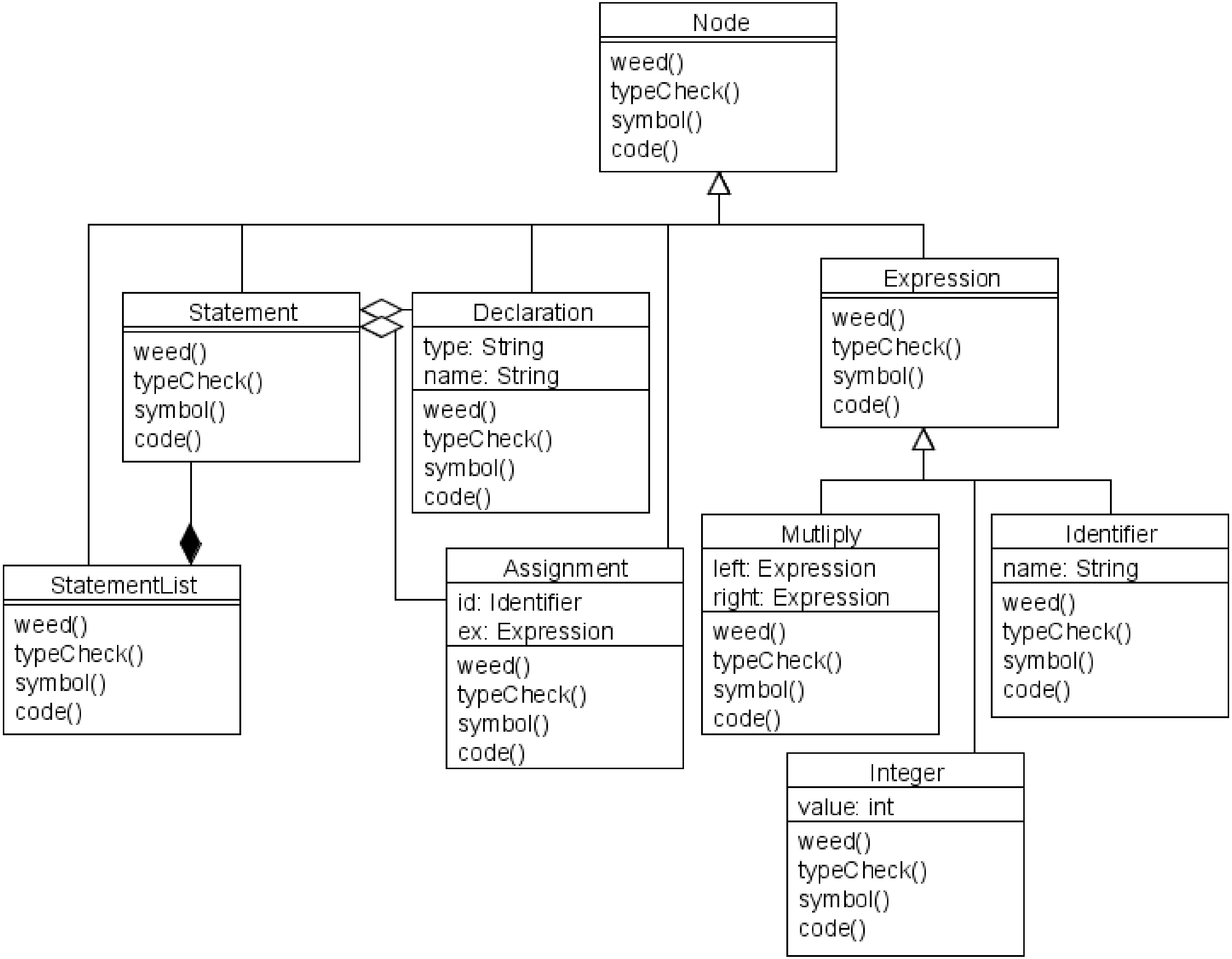
Class Diagram of the AST



Compilers Continued

- Further operations are done by traversing the tree
  - Weeding
  - Type Checking
  - Symbol Table Generation
  - Code Generation
- Do we want to add (recursive) methods to every node we need to traverse?
  - This would be the intuitive solution
  - We would need the following methods: weed(), typeCheck(), symbol(), code()

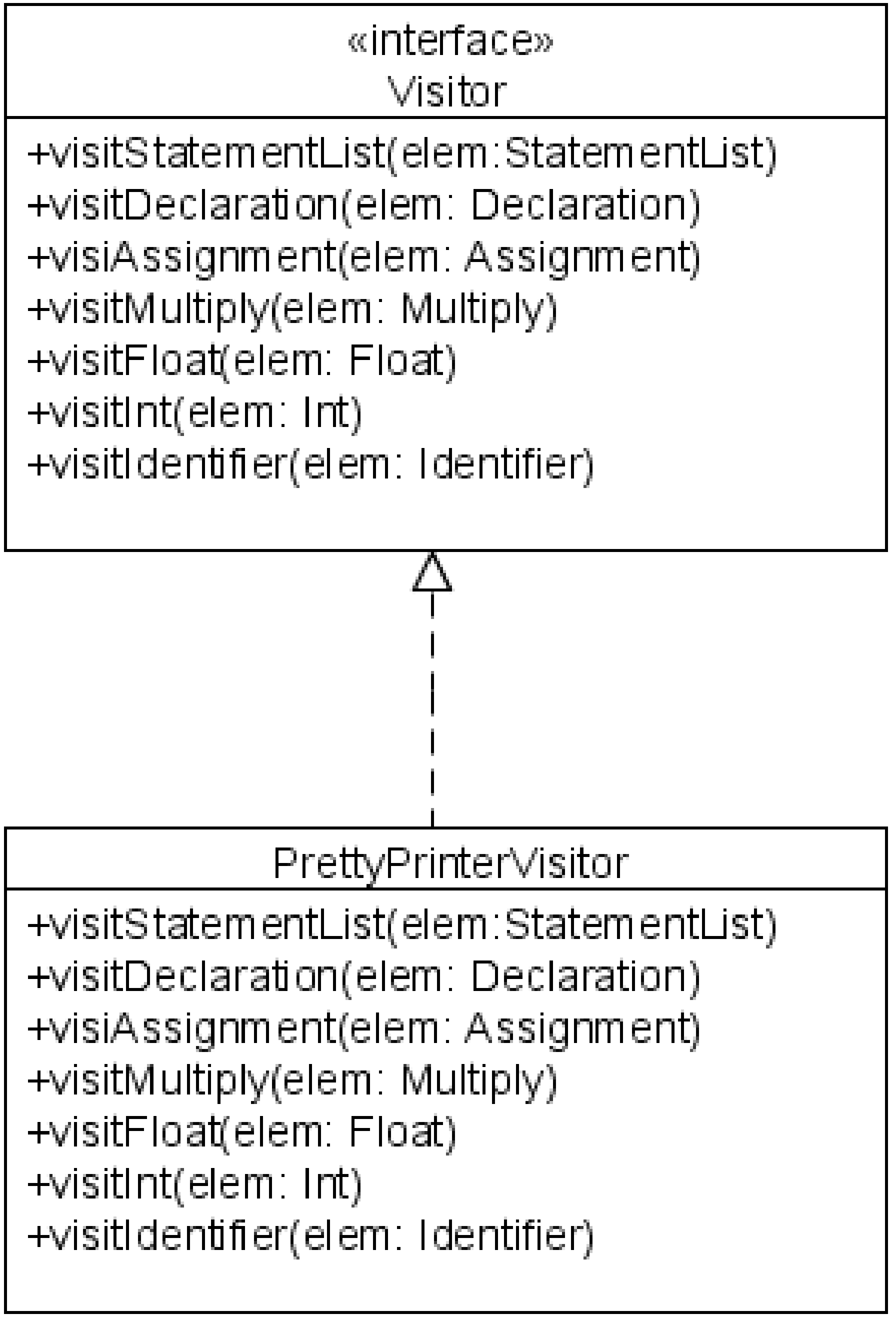
Intuitive Solution



Problem

- Each node class is 'polluted' with several methods.
- The implementation of an algorithm is spread over all classes.
  - i.e. The weeding algorithm is spread across several nodes.
- To keep track of the traversal, either
  - must use global variables
  - must pass arguments by reference in each method call

Visitor Pattern Solution



«interface»
Visitor

+visitStatementList(elem:StatementList)
+visitDeclaration(elem: Declaration)
+visiAssignment(elem: Assignment)
+visitMultiply(elem: Multiply)
+visitFloat(elem: Float)
+visitInt(elem: Int)
+visitIdentifier(elem: Identifier)

PrettyPrinterVisitor

+visitStatementList(elem:StatementList)
+visitDeclaration(elem: Declaration)
+visiAssignment(elem: Assignment)
+visitMultiply(elem: Multiply)
+visitFloat(elem: Float)
+visitInt(elem: Int)
+visitIdentifier(elem: Identifier)

Advantages

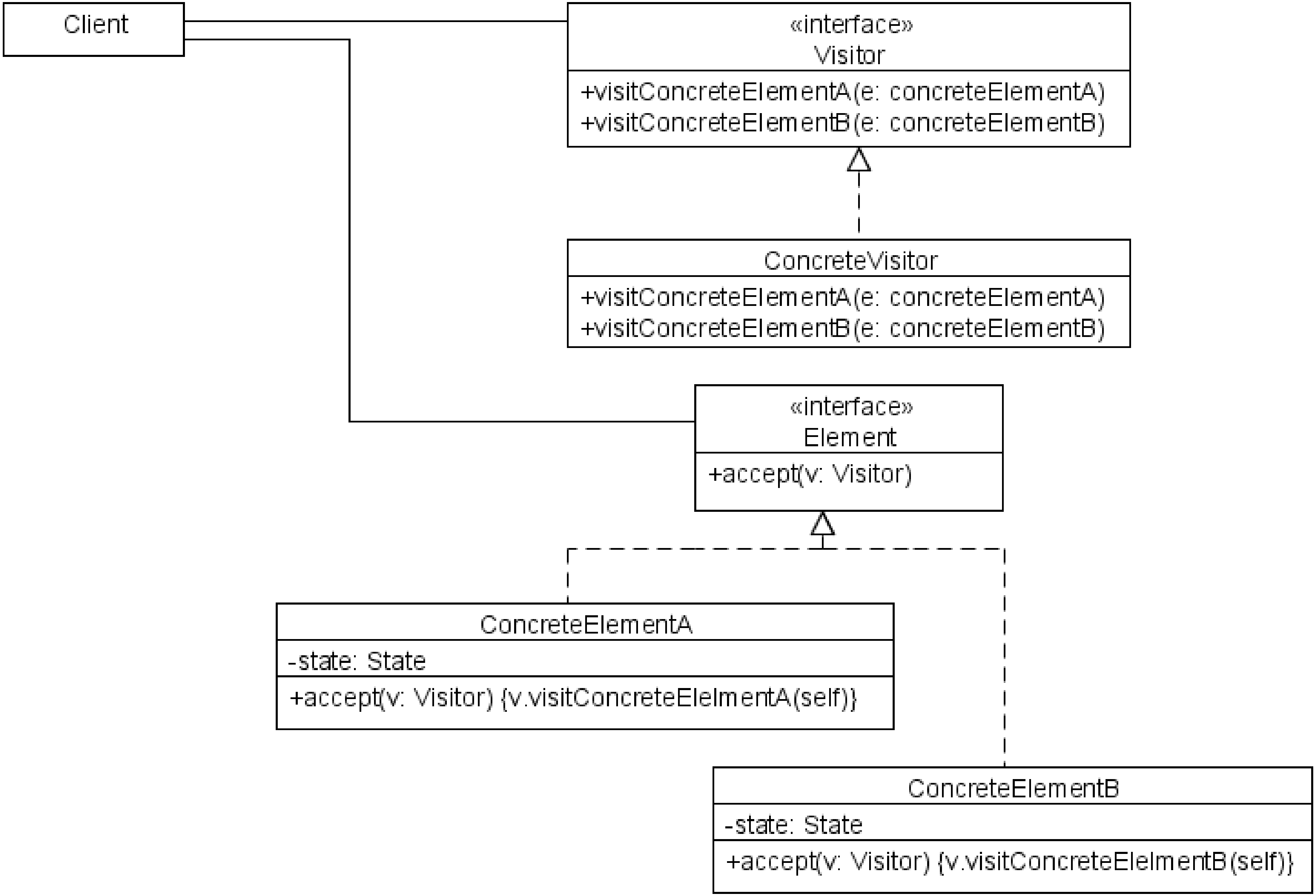
- The algorithm is now located in a single class.
  - All variables needed to execute the algorithm are also in the class.
  - No need for global variables anymore (or variables passed by reference).
- The AST class structure (tree) was not modified!

  It could even be pre-compiled!
- It's easy to add new operations.

Disadvantages

- However, if a new subtype of Node is added, all the visitors must be modified.
  - For instance, we might want to add an 'Addition' node.
  - This would require a new function 'visitAddition' in each visitor.
- Encapsulation could be broken if a visitor needs to access an element internal state.

Class Diagram



Client

«interface»
Visitor

+visitConcreteElementA(e: concreteElementA)
+visitConcreteElementB(e: concreteElementB)

ConcreteVisitor

+visitConcreteElementA(e: concreteElementA)
+visitConcreteElementB(e: concreteElementB)

«interface»
Element

+accept(v: Visitor)

ConcreteElementA

-state: State

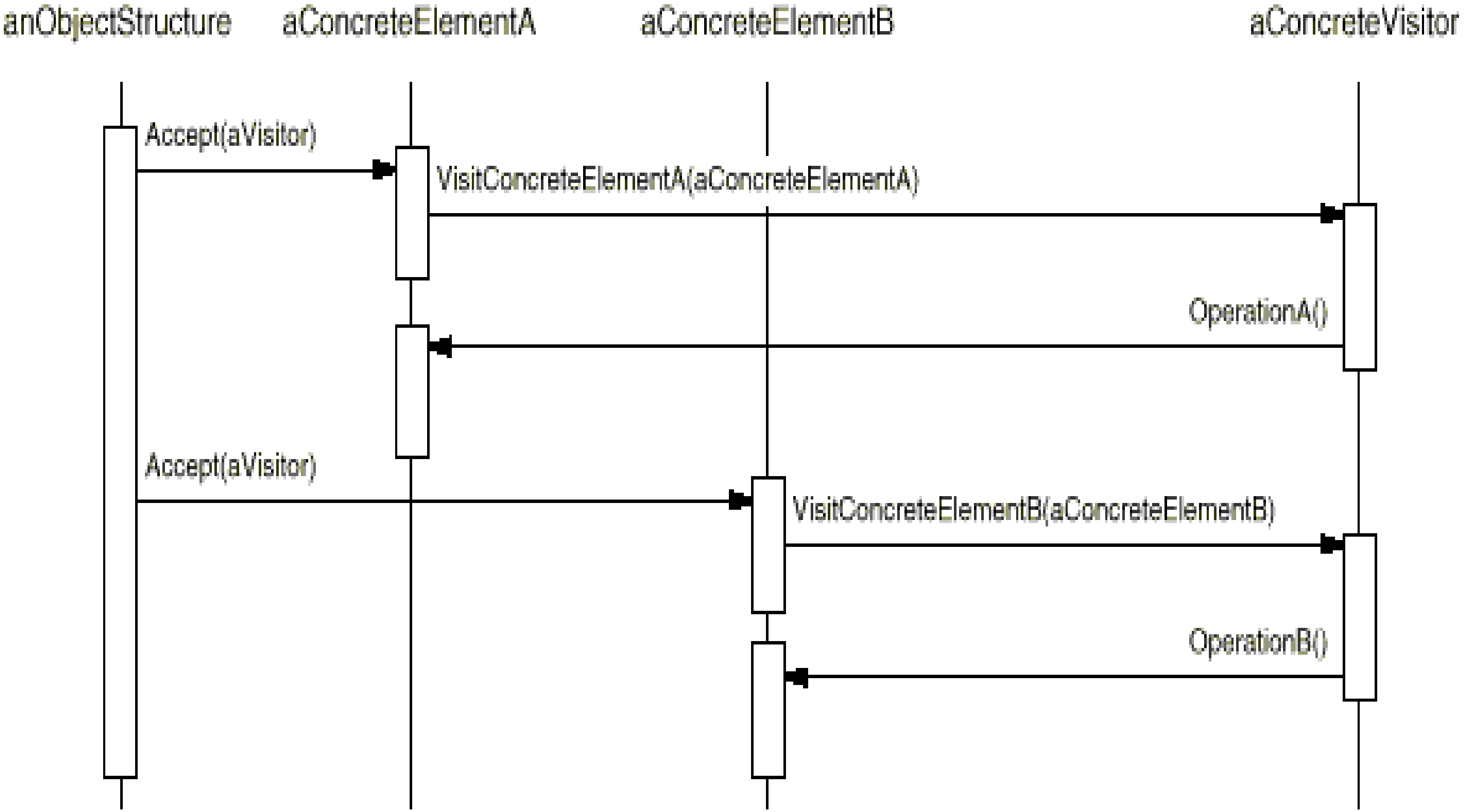
+accept(v: Visitor) {v.visitConcreteElelmentA(self)}

ConcreteElementB

-state: State

+accept(v: Visitor) {v.visitConcreteElelmentB(self)}

Sequence Diagram “double dispatch”



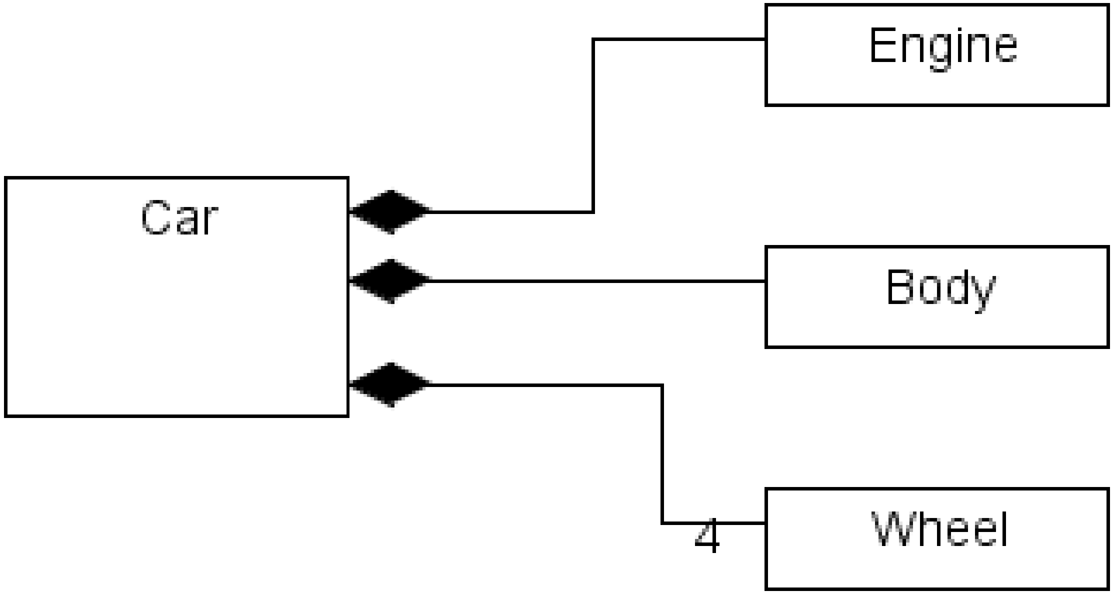
Composite Elements

- Data structures are often composite: a node contains references to other nodes (children, etc).
- For the visitor pattern to work, the accept() calls must be propagated to the children nodes (other references).
- Most often, the simplest solution is add this propagation to the accept() call of the parent.

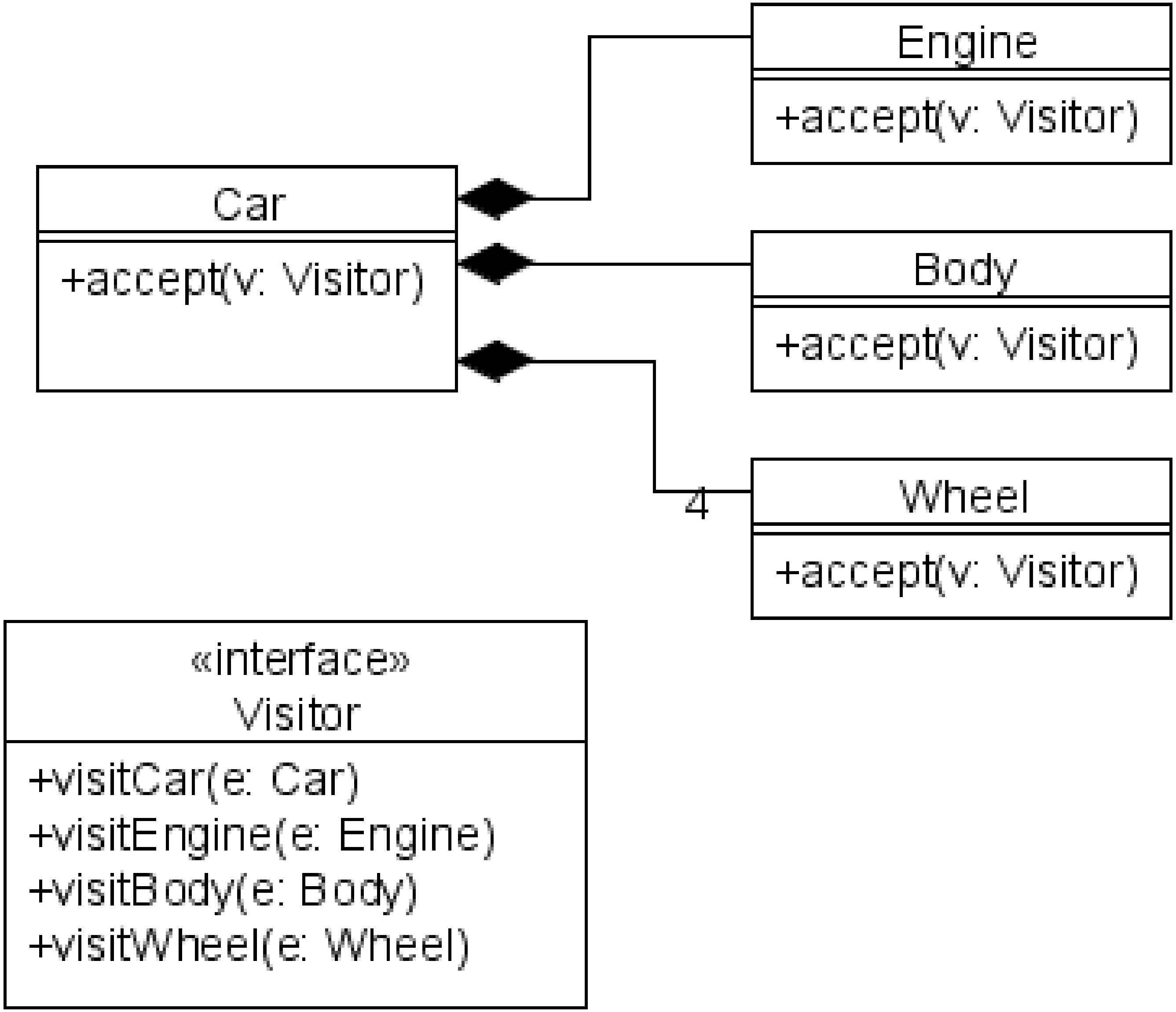
```
public void accept(Visitor visitor) {
      visitor.visit(this);

      for (Node node: nodes) {
         node.accept(visitor)
      }
}
```

Example



Add the visitor pattern



Car

+accept(v: Visitor)

Engine

+accept(v: Visitor)

Body

+accept(v: Visitor)

4

Wheel

+accept(v: Visitor)

«interface»
Visitor

+visitCar(e: Car)
+visitEngine(e: Engine)
+visitBody(e: Body)
+visitWheel(e: Wheel)

Wheel, Body, Engine

```
class Wheel {
    public void accept(Visitor visitor) {
        visitor.visitWheel(this);
    }
}

class Engine {
    public void accept(Visitor visitor) {
        visitor.visitEngine(this);
    }
}

class Body {
    public void accept(Visitor visitor) {
        visitor.visitBody(this);
    }
}
```

Car

```
class Car {

    private Engine  engine;
    private Body    body;
    private Wheel[] wheels;

    public void accept(Visitor visitor) {
        visitor.visitCar(this);
        engine.accept(visitor);
        body.accept(visitor);
        for(int i = 0; i < wheels.length; ++i) {
            wheels[i].accept(visitor);
        }
    }
}
```

Visitor

```
class PrintVisitor implements Visitor {
    private static count = 0;

    public void visitWheel(Wheel wheel) {
        count++;
        System.out.println("Visiting wheel " + count);
    }
    public void visitEngine(Engine engine) {
        System.out.println("Visiting engine");
    }
    public void visitBody(Body body) {
        System.out.println("Visiting body");
    }
    public void visitCar(Car car) {
        System.out.println("Visiting car");
    }
}
```

Caveat: multiple visits?

Composite Concerns

- When dealing with composites, who should take care of the traversal?
  - The Composite
  - An External class
  - The Visitor

Traversal encoded in Composite

- Using the composite to take care of the traversal is the simplest solution. Remember the car example.

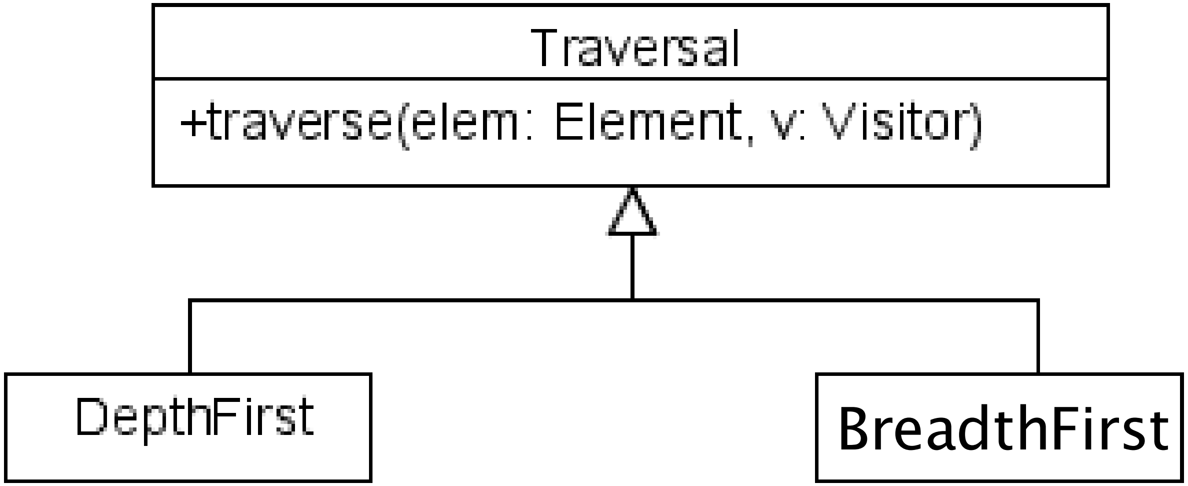
```
public void accept(Visitor visitor) {
    visitor.visitCar(this);
    engine.accept(visitor);
    body.accept(visitor);
    for(int i = 0; i < wheels.length; ++i) {
        wheels[i].accept(visitor);
    }
}
```

- Unfortunately, this only works if all the visitors need to visit the elements in the same order.

Traversal encoded in External Class

- Use an external class to define the traversal.
- That class would require internal knowledge of the data structure, but at least the visitor would remain generic.
- This traversal object could even be an iterator.

Traversal encoded in External Class



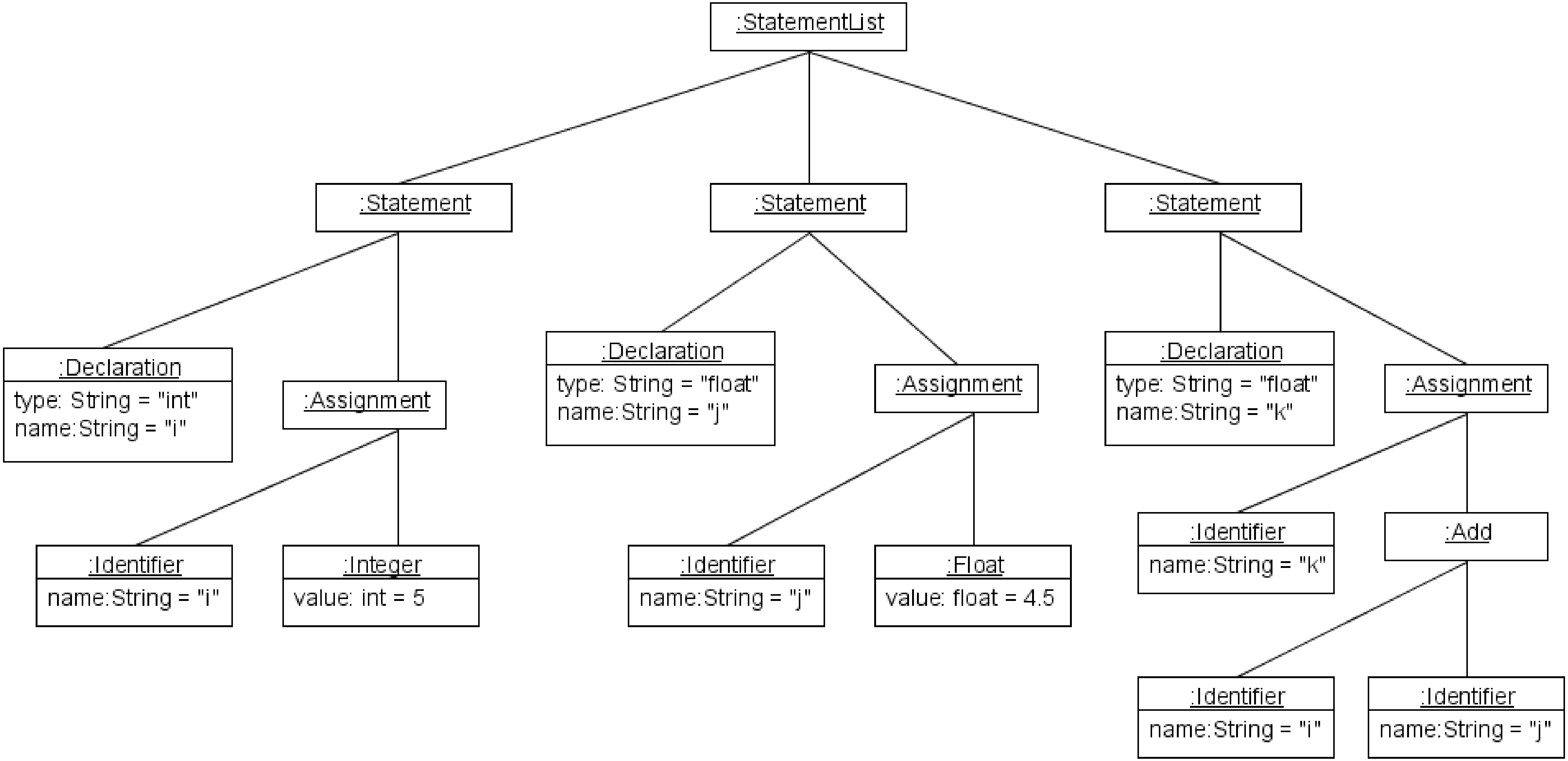
Traversal encoded in Visitor

- To allow different traversal orders (for different visitors), the traversal could be in the visitors.
- This would allow each visitor to use a specific traversal.
  - This is the only solution for very complex traversal.

Back to the AST example

```
int i = 5;
float j = 4.5;
float k = i + j;
```

AST example


:StatementList
:Statement
:Statement
:Statement
:Declaration
type: String = "int"
name:String = "i"
:Assignment
:Identifier
name:String = "i"
:Integer
value: int = 5
:Declaration
type: String = "float"
name:String = "j"
:Assignment
:Identifier
name:String = "j"
:Float
value: float = 4.5
:Declaration
type: String = "float"
name:String = "k"
:Assignment
:Identifier
name:String = "k"
:Add
:Identifier
name:String = "i"
:Identifier
name:String = "j"

Visitor

```
class PrettyPrinterVisitor implements Visitor {
   ...
   public visitStatement(Statement elem) {
      elem.def.accept(this)
      elem.assign.accept(this)
      print(“ ;”);
   }

   public visitAssignment(Assignment elem) {
      elem.id.accept(this)
      print(“ = “);
      elem.exp.accept(this)
   }
   ...
```

Drawbacks

- The visitor needs to know and understand the data structure.
  - Breaks the abstraction, creates coupling
- Each visitor must include information on how to traverse the data structure.
  - Can lead to lots of duplicate code.