Winter Semester 16/17

Software Engineering Design & Construction

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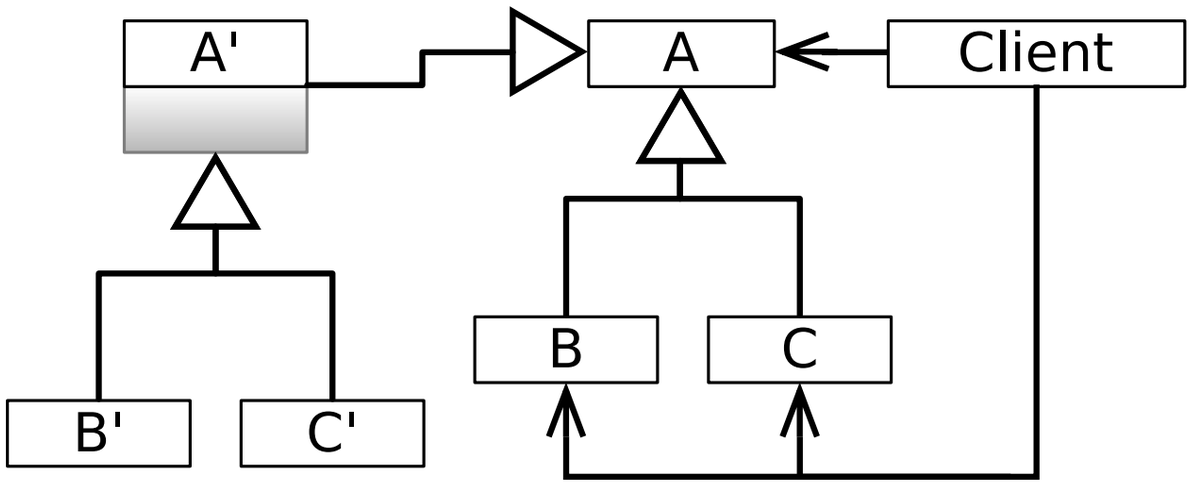
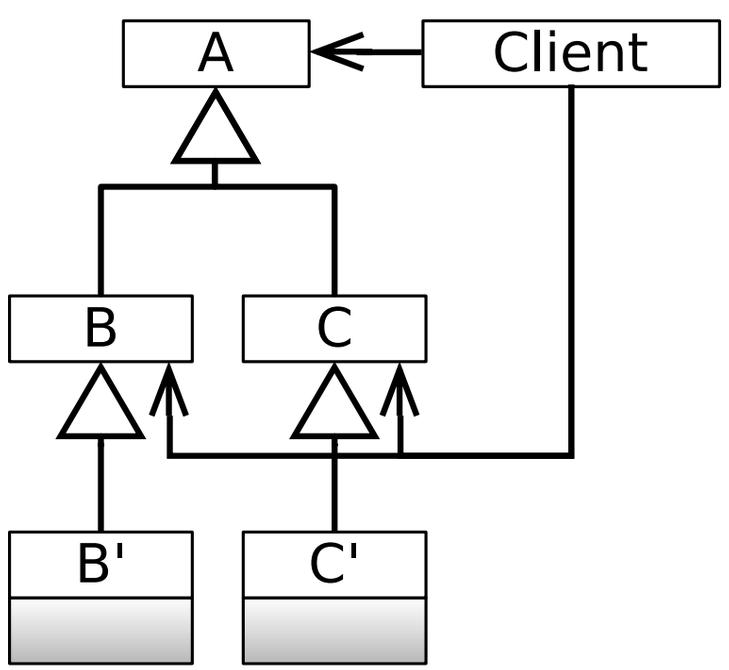
Visitor Pattern

Recall the problems of inheritance with modeling variations at the level of multiple objects (object composites).





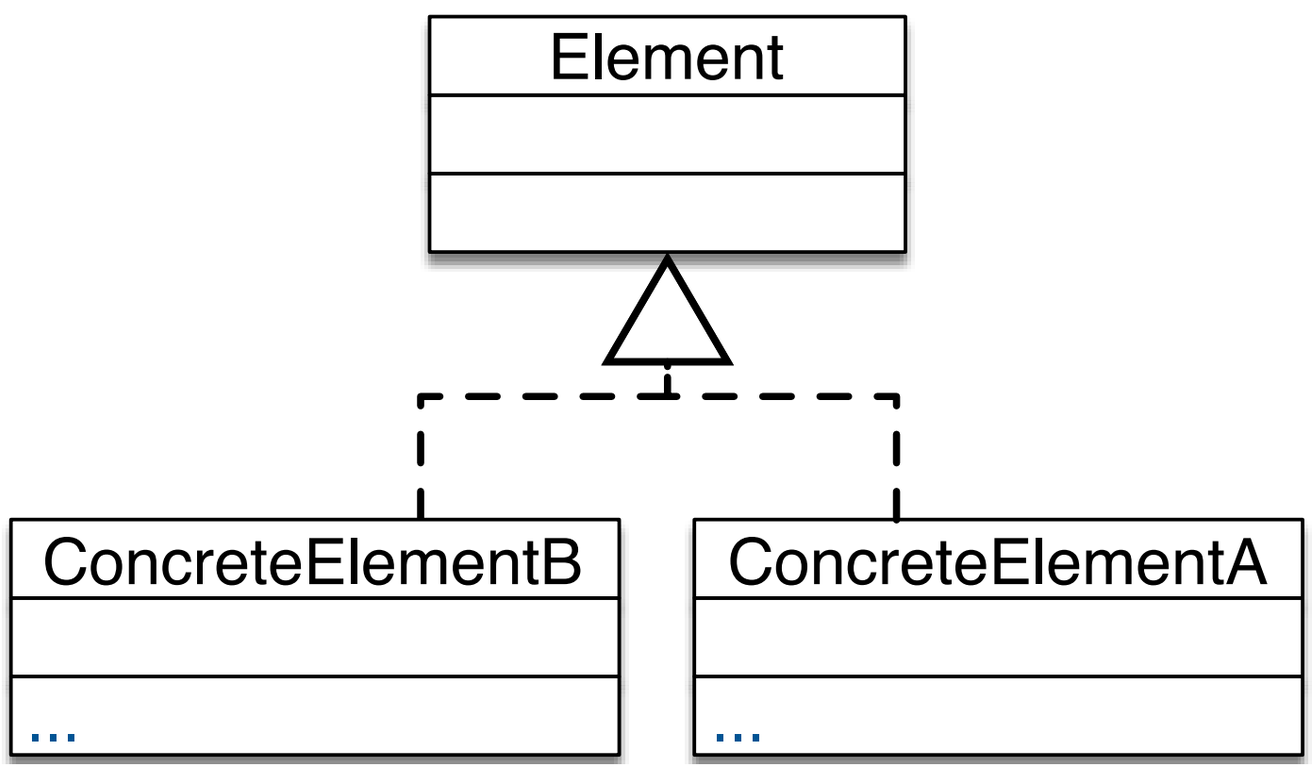
Solution Idea

Represent the additional operations to be performed on the elements of an object structure *(additional features)* as objects (of type `Visitor`).

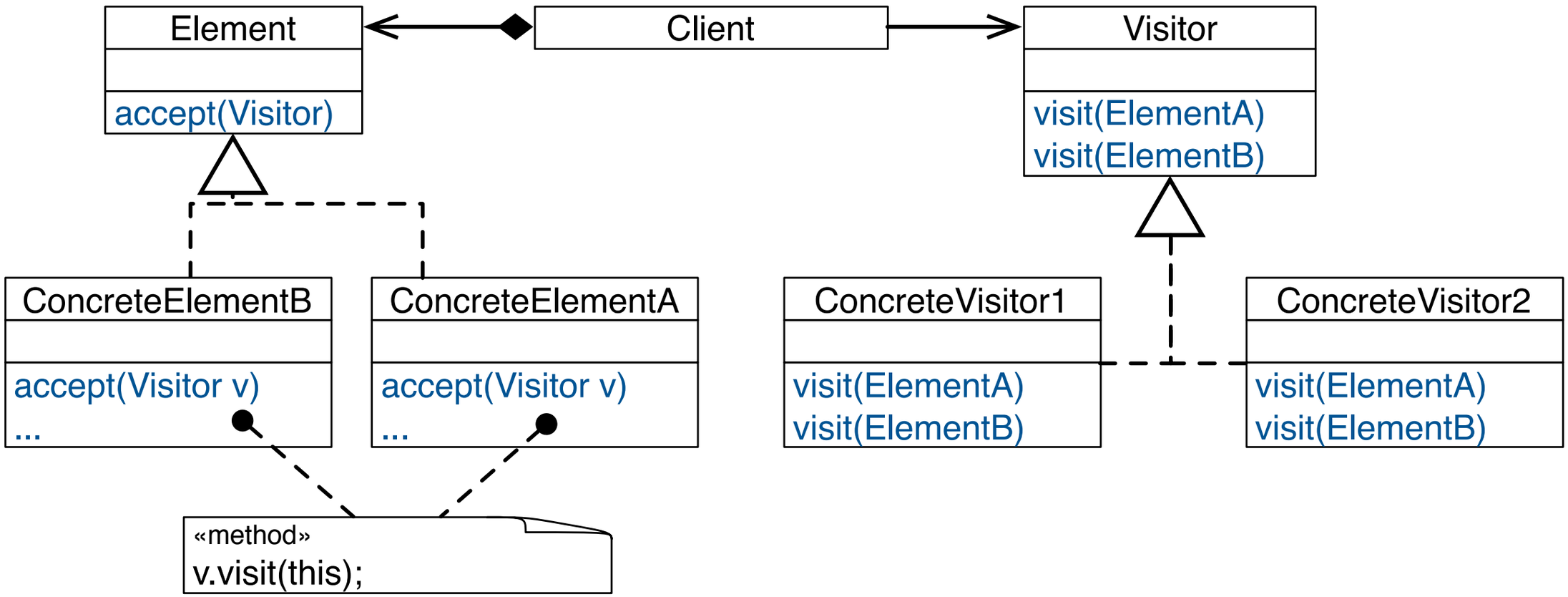
Visitor Design Pattern

The Visitor Pattern enables **to add new behavior** to existing classes in a **fixed class hierarchy** without changing this hierarchy.

Structure - the Basic Class Hierarchy

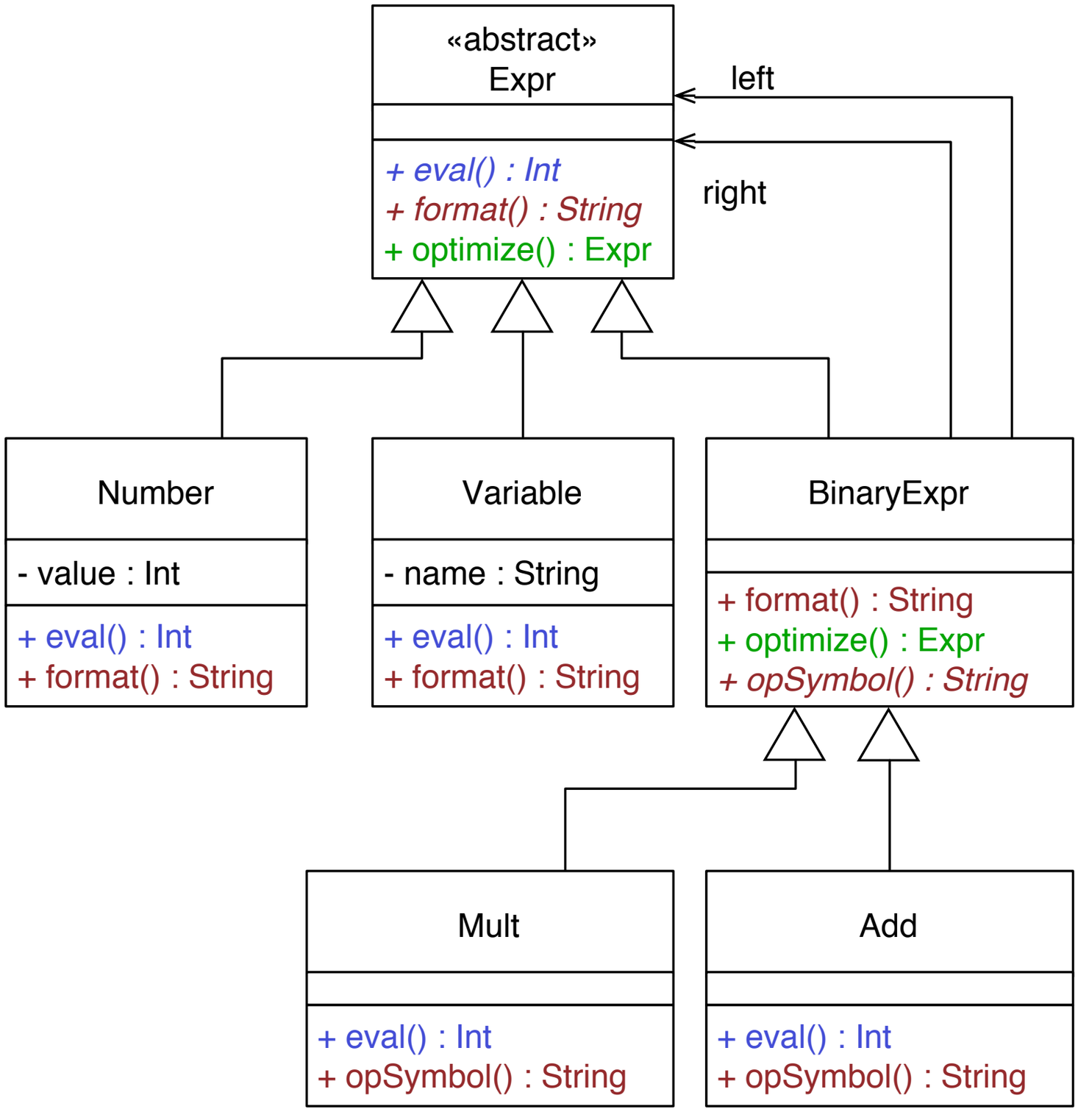


Structure

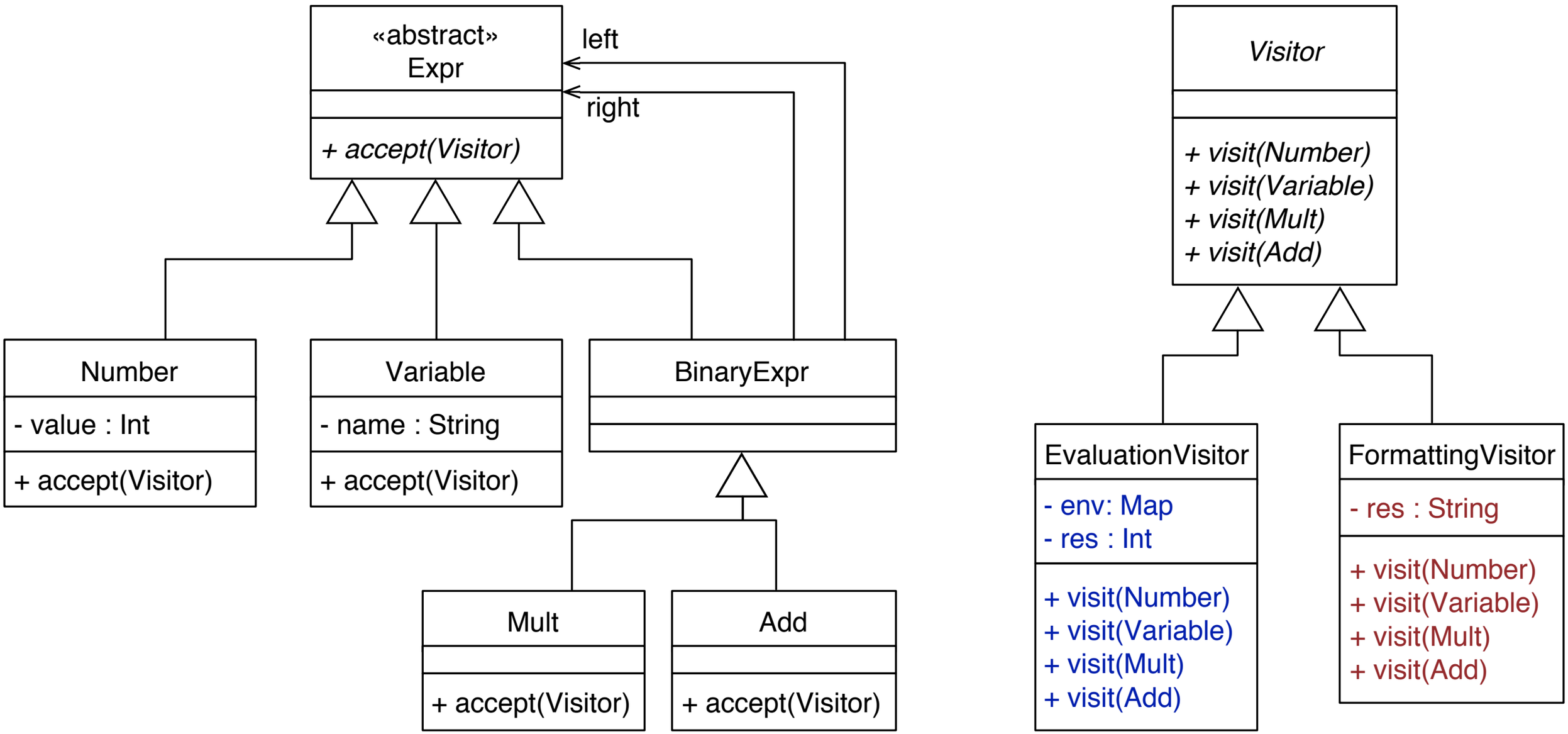



```
Element e = new ConcreteElementA(...);
Visitor v = new ConcreteVisitor1(...);
e.accept(v);
```

Case-Study: Arithmetic Expressions

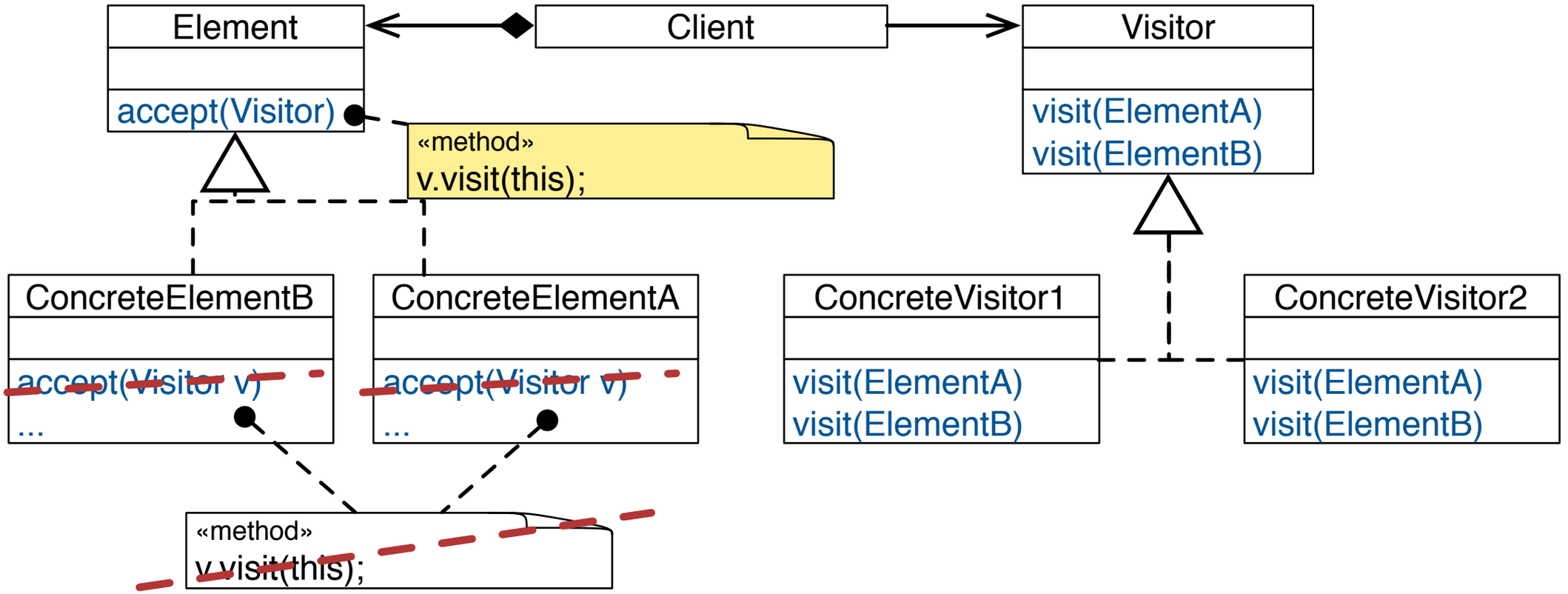


Visitor Based Design



Reflections on the Visitor Structure

Can we move the implementation of accept higher up the Element hierarchy?



Some Terminology

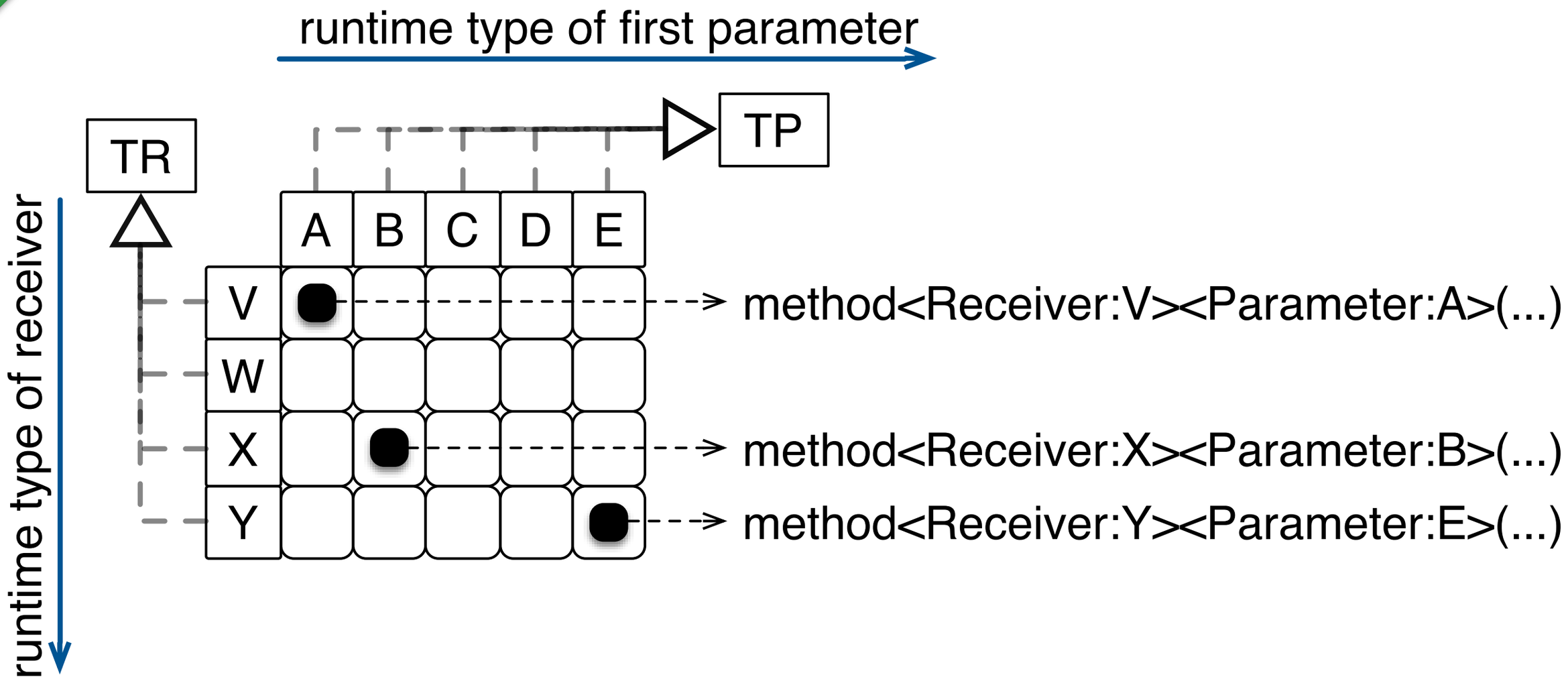
Double Dispatch

Dispatching an operation based on the **dynamic type** of two objects is called double dispatch.

Double dispatch is not supported in mainstream OO languages, e.g., Java, C#, Scala,….

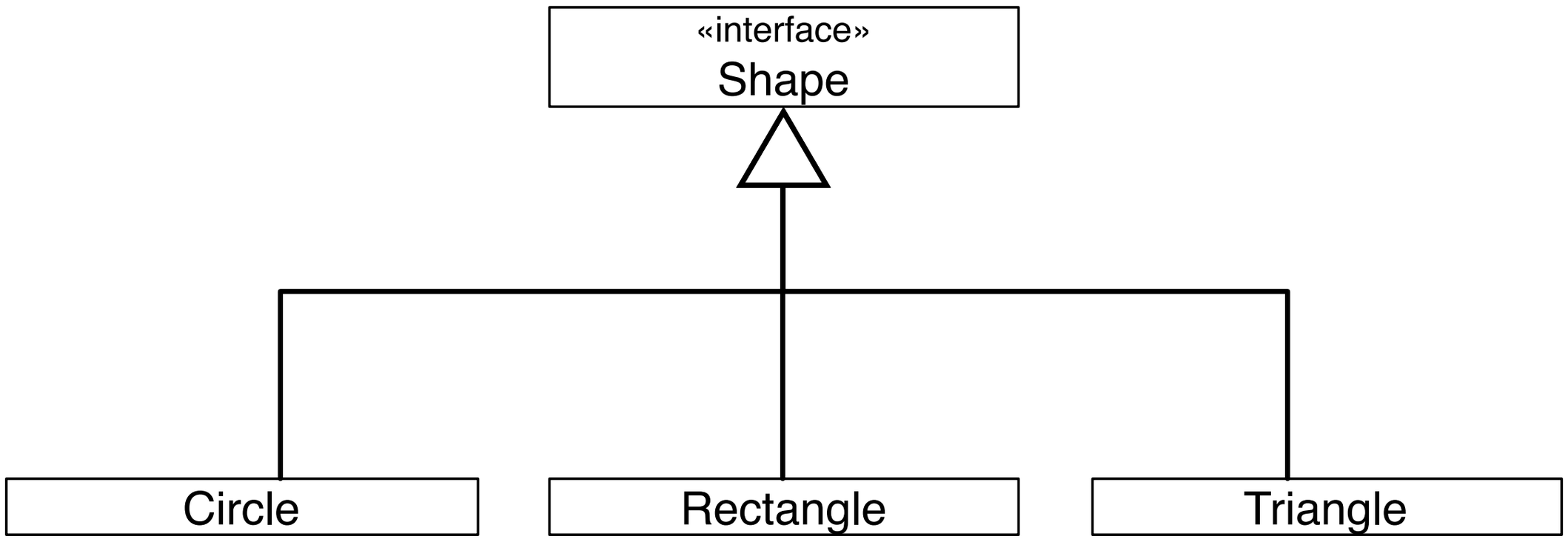
Some Terminology

Double-Dispatch



Case-Study: Calculating Shape Intersection

Task: Implement an intersect operation that calculates whether two given shapes intersect.



Case-Study: Calculating Shape Intersection

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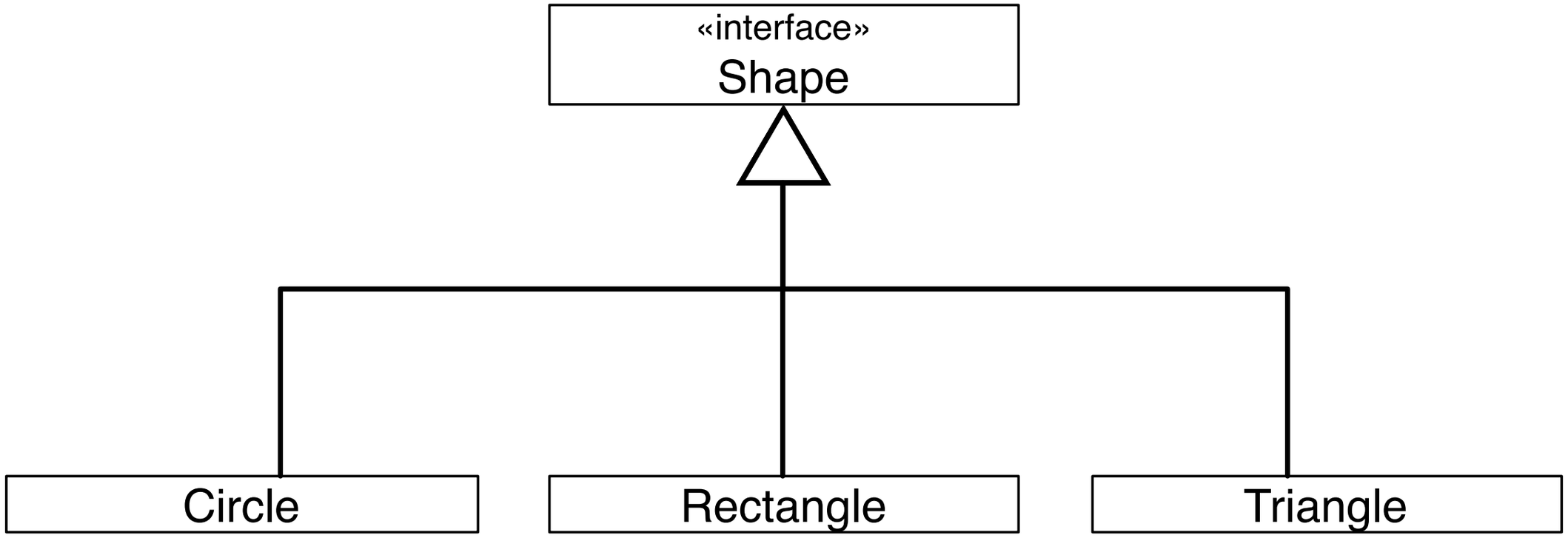
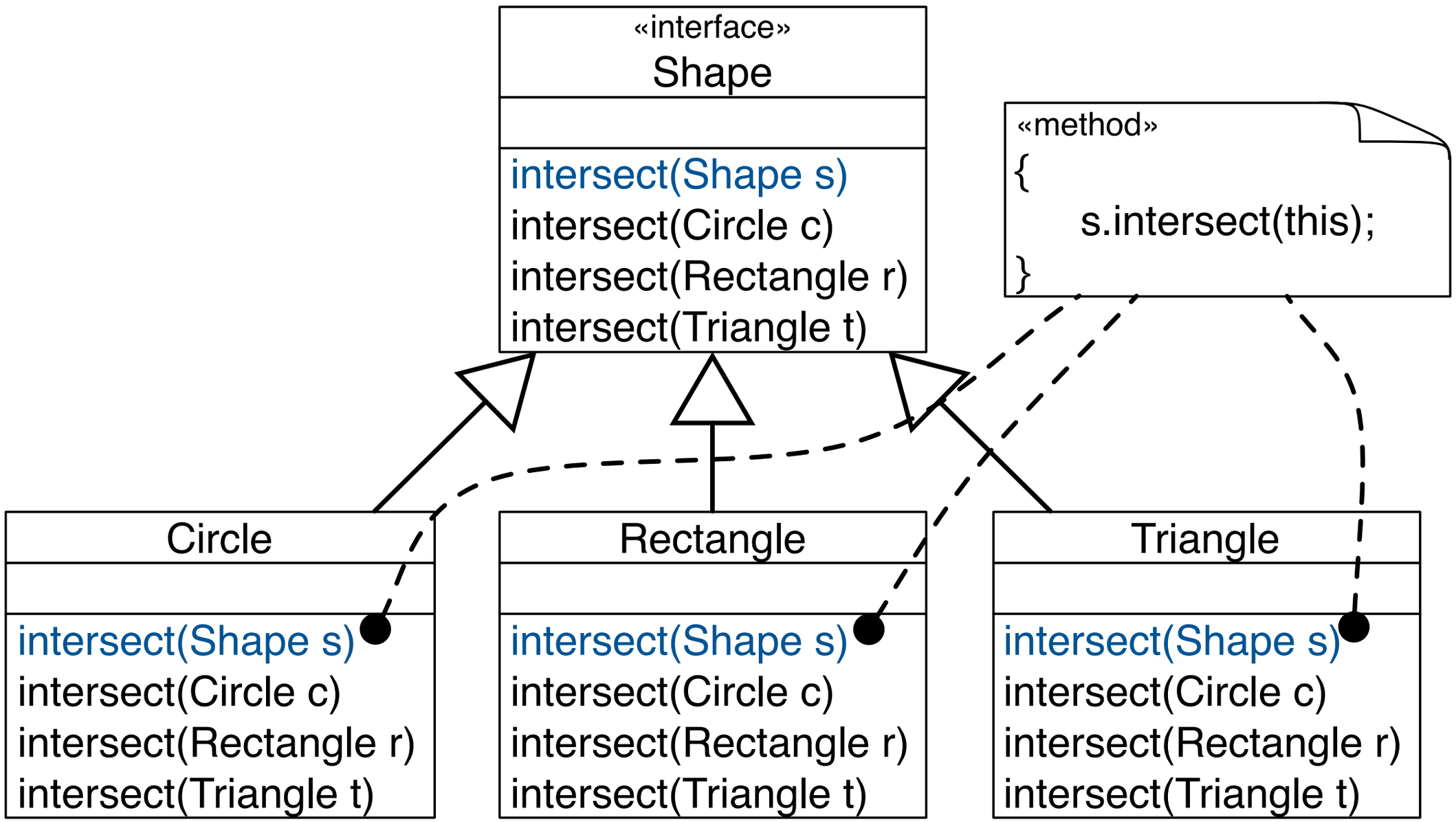



```
Shape t = new Triangle(…);
Shape r = new Rectangle(…);
if (t.intersect(r)) {…}
```

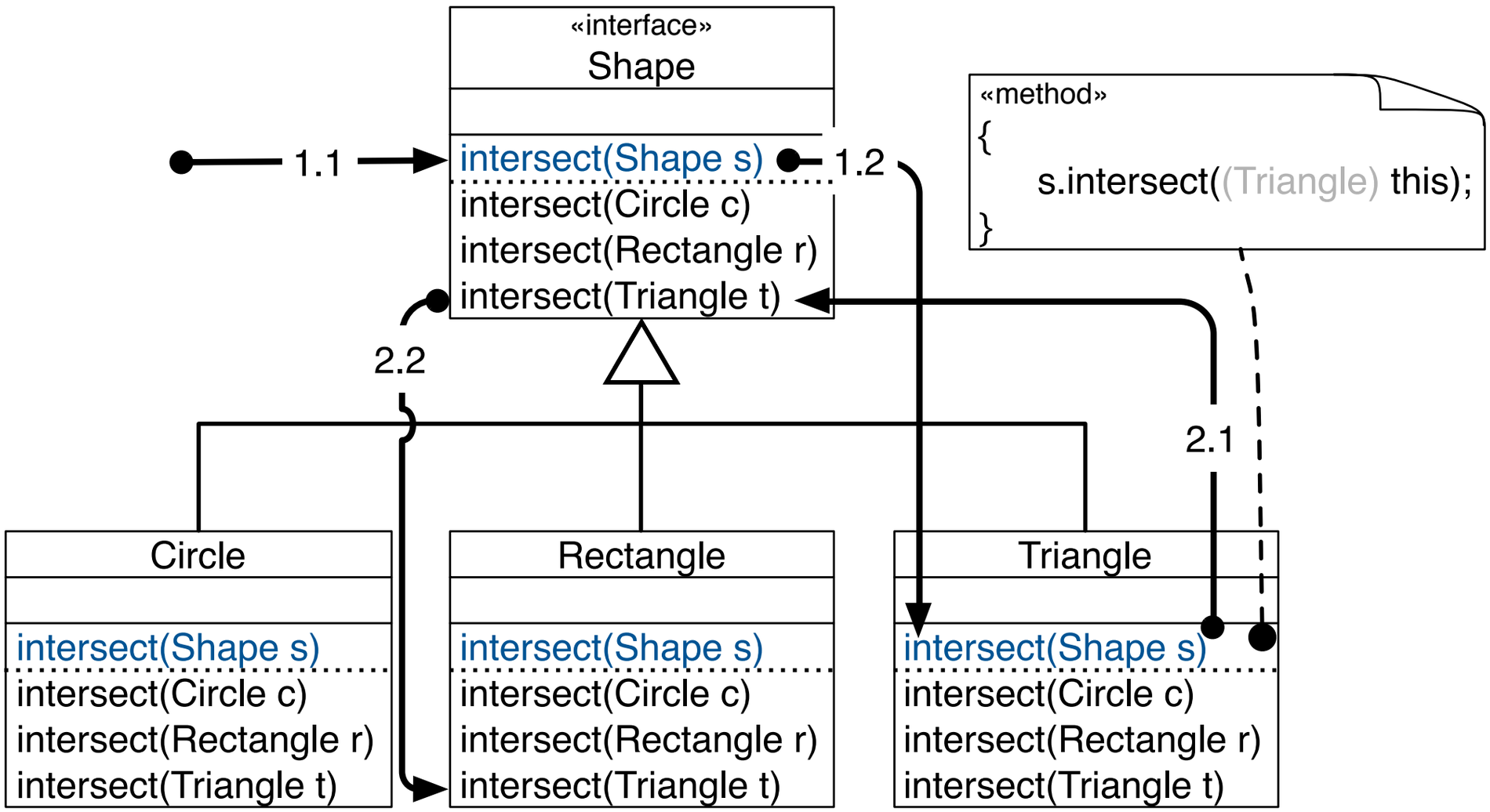
Case-Study: Calculating Shape Intersection

Simulating Double Dispatch



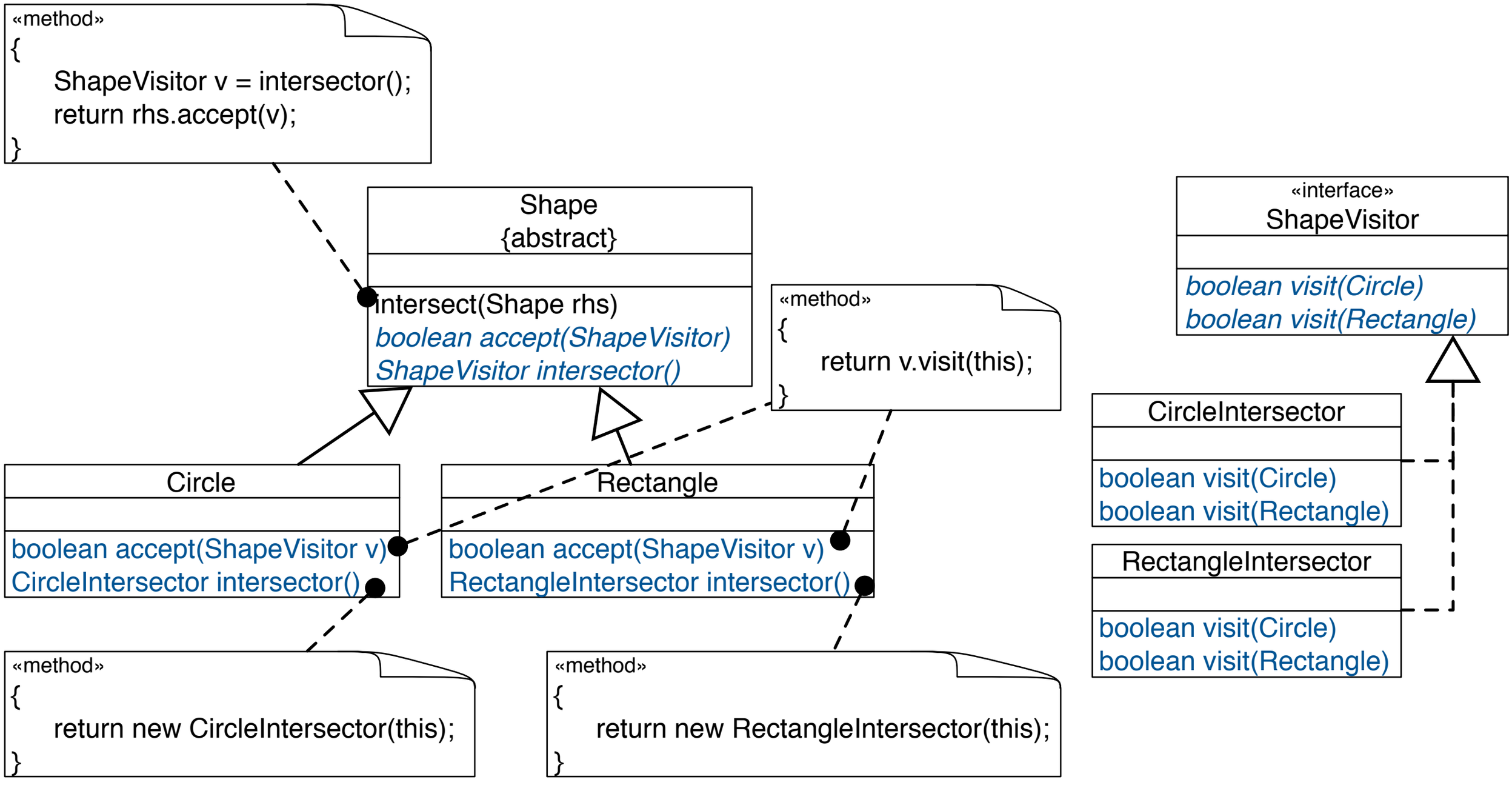
Case-Study: Calculating Shape Intersection

Simulating Double Dispatch

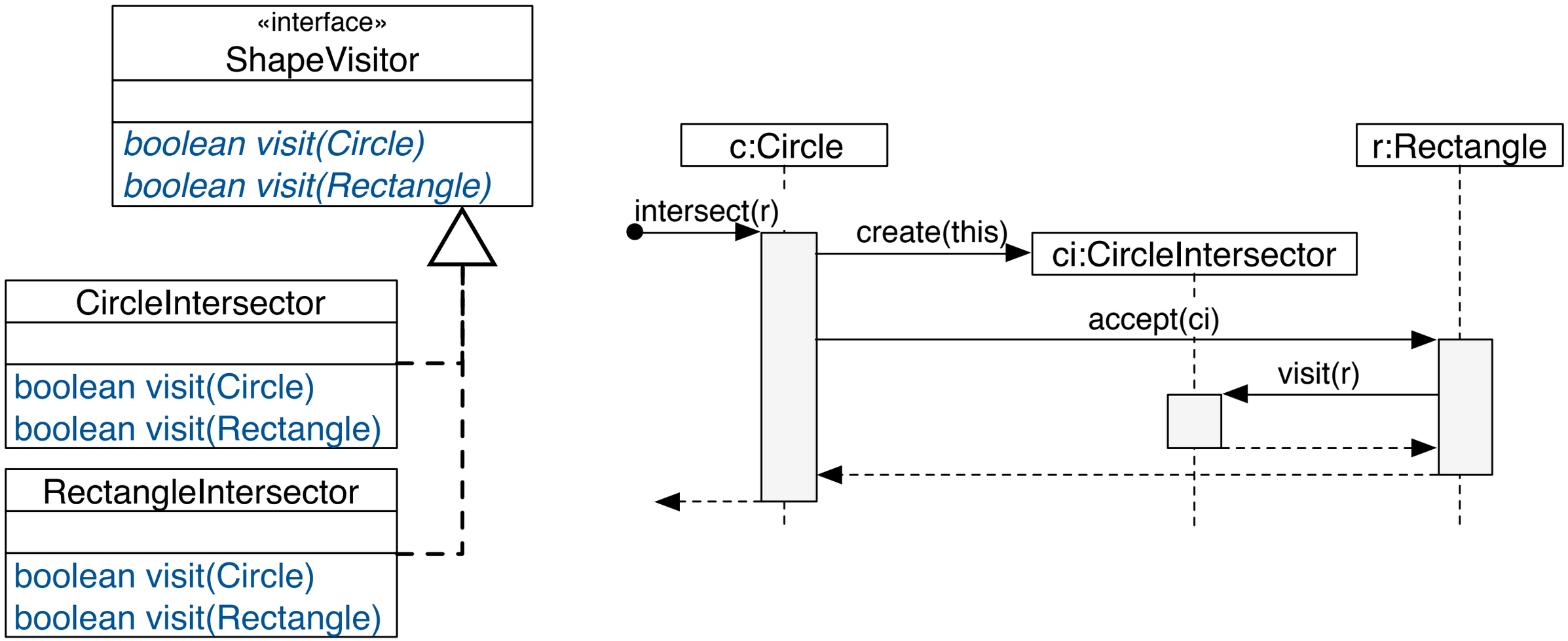



```
Shape t = new Triangle(…);
Shape r = new Rectangle(…);
if (t.intersect(r)) {…}
```

Case-Study: Shape Intersection Using Visitor



Case-Study: Shape Intersection Using Visitor




```
Shape c = new Circle(…);
Shape r = new Rectangle(…);
if (c.intersect(r)) {…}
```

Advantages of the Visitor Design Pattern

- **New operations are easy to add** without changing element classes (add a new concrete visitor).
  Different concrete elements do not have to implement their part of a particular algorithm.

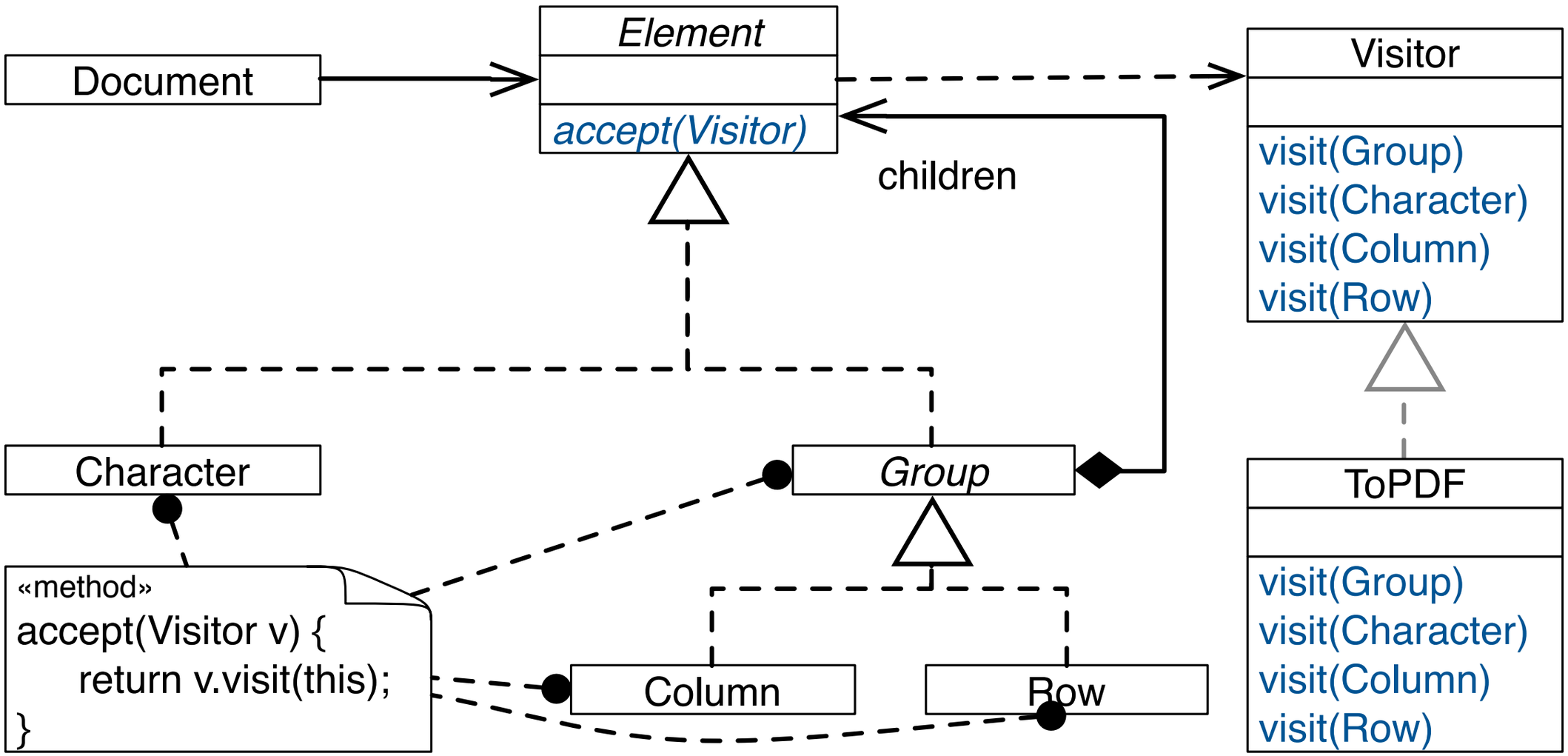
- Related behavior focused in a single concrete visitor.

- **Visiting across hierarchies**: Visited classes are not forced to share a common base class.

- **Accumulating state**: Visitors can accumulate state as they visit each element, thus, encapsulating the algorithm and all its data.

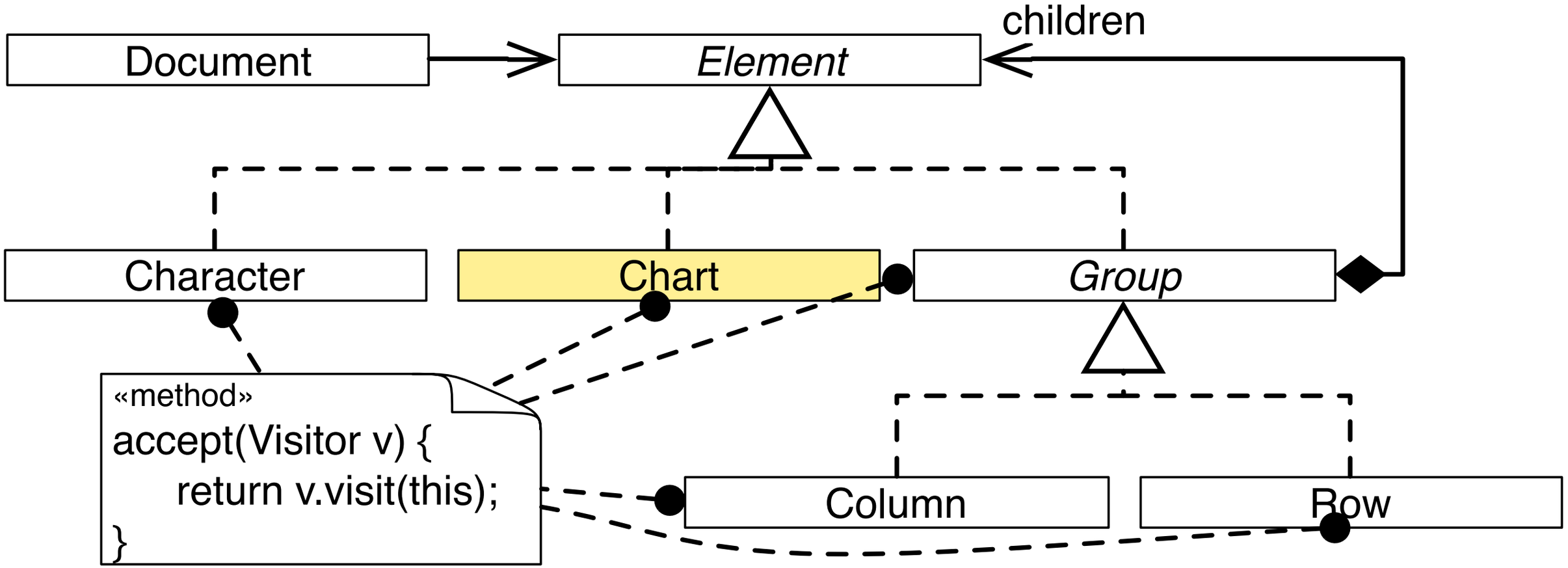
Issues of the Visitor-Based Design

What happens if we want to add a new element?



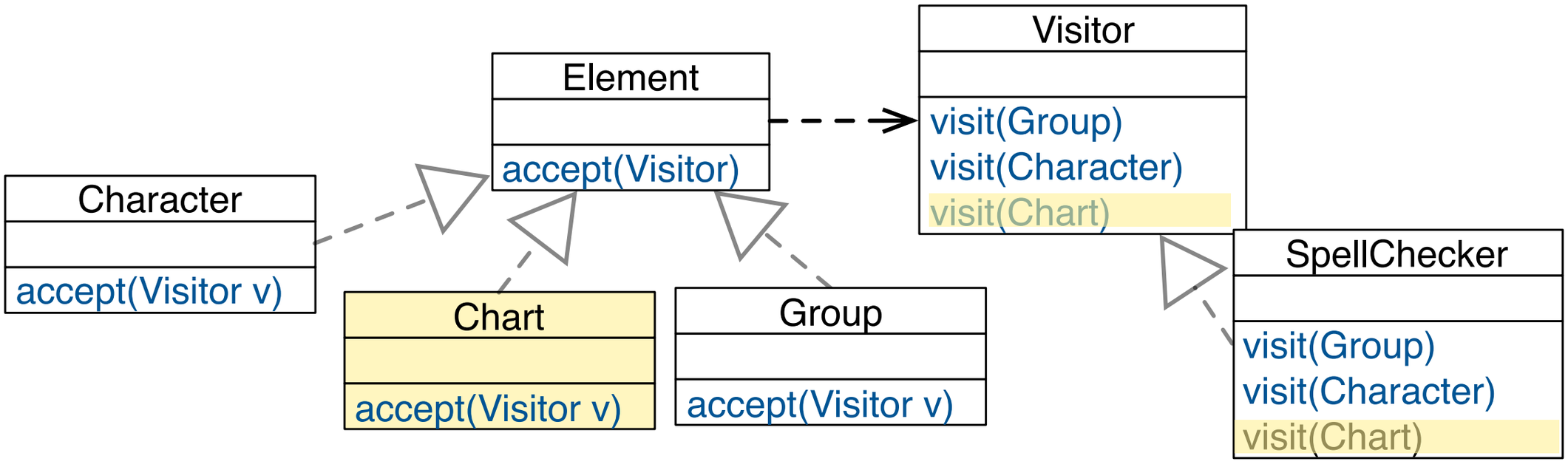
Issues of the Visitor-Based Design

E.g., adding `Chart` *(adding new kinds of Elements)*



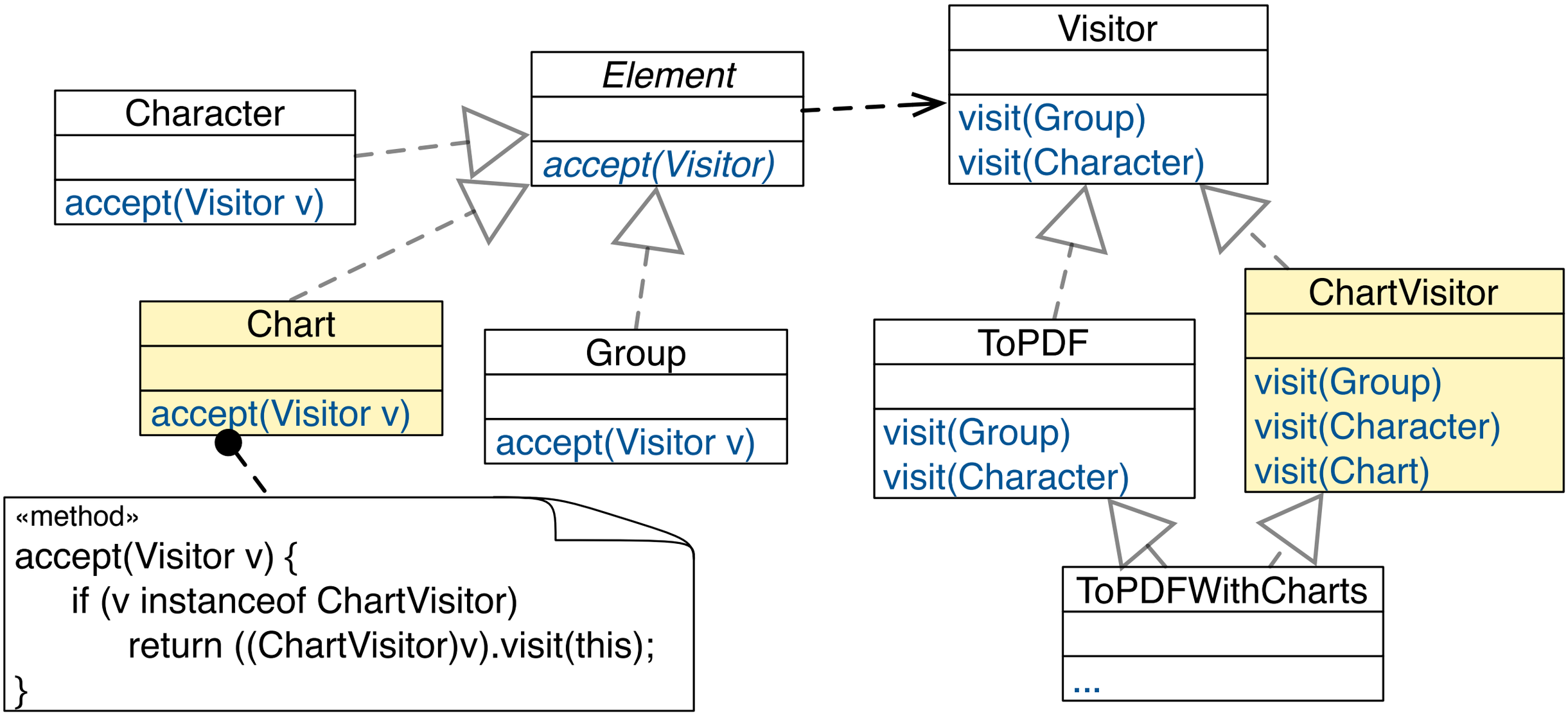
Issues of the Visitor-Based Design

E.g., adding `Chart` and updating `Visitor`



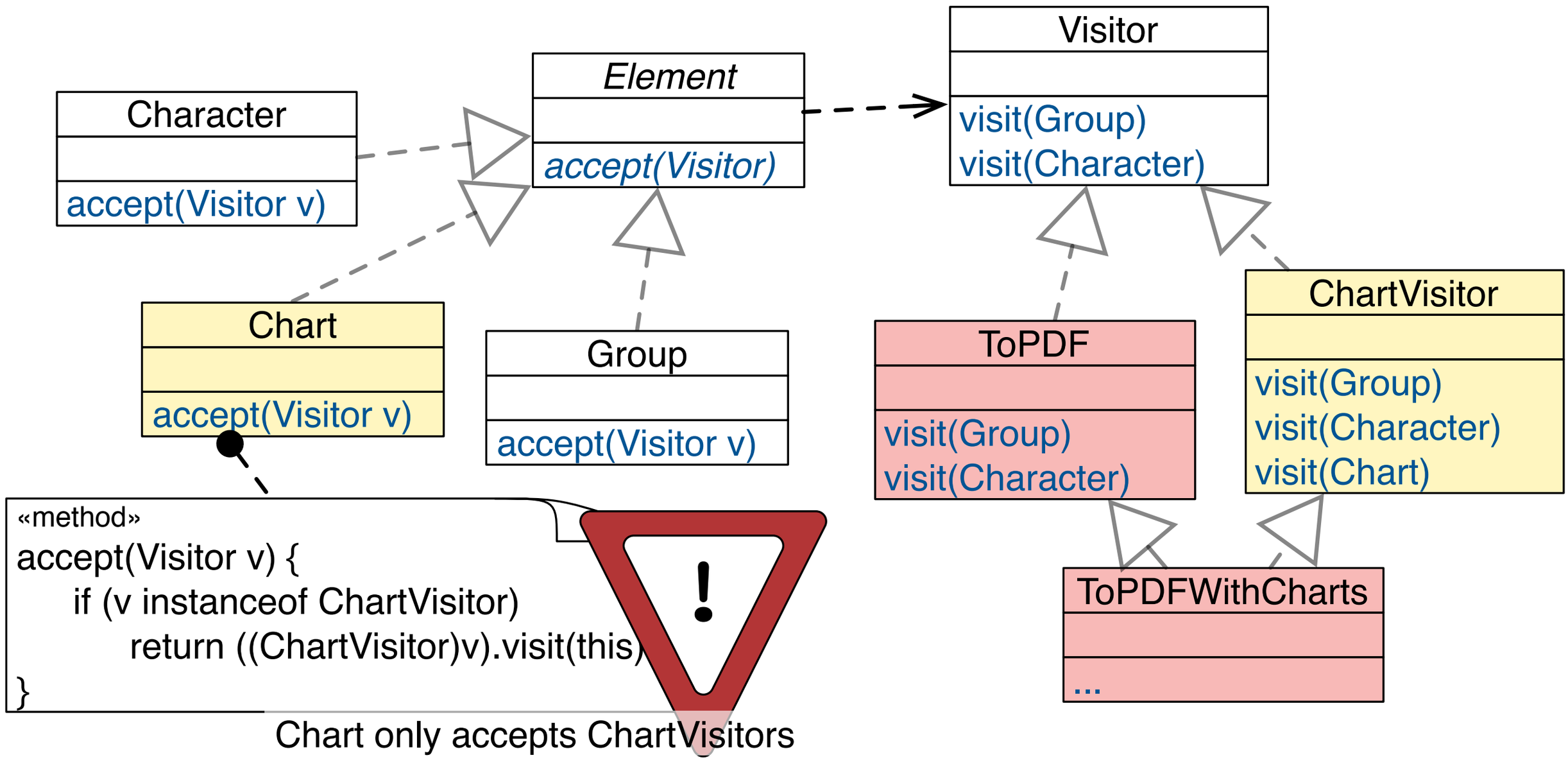
Issues of the Visitor-Based Design

E.g., adding `Chart` and keeping `Visitor` unchanged



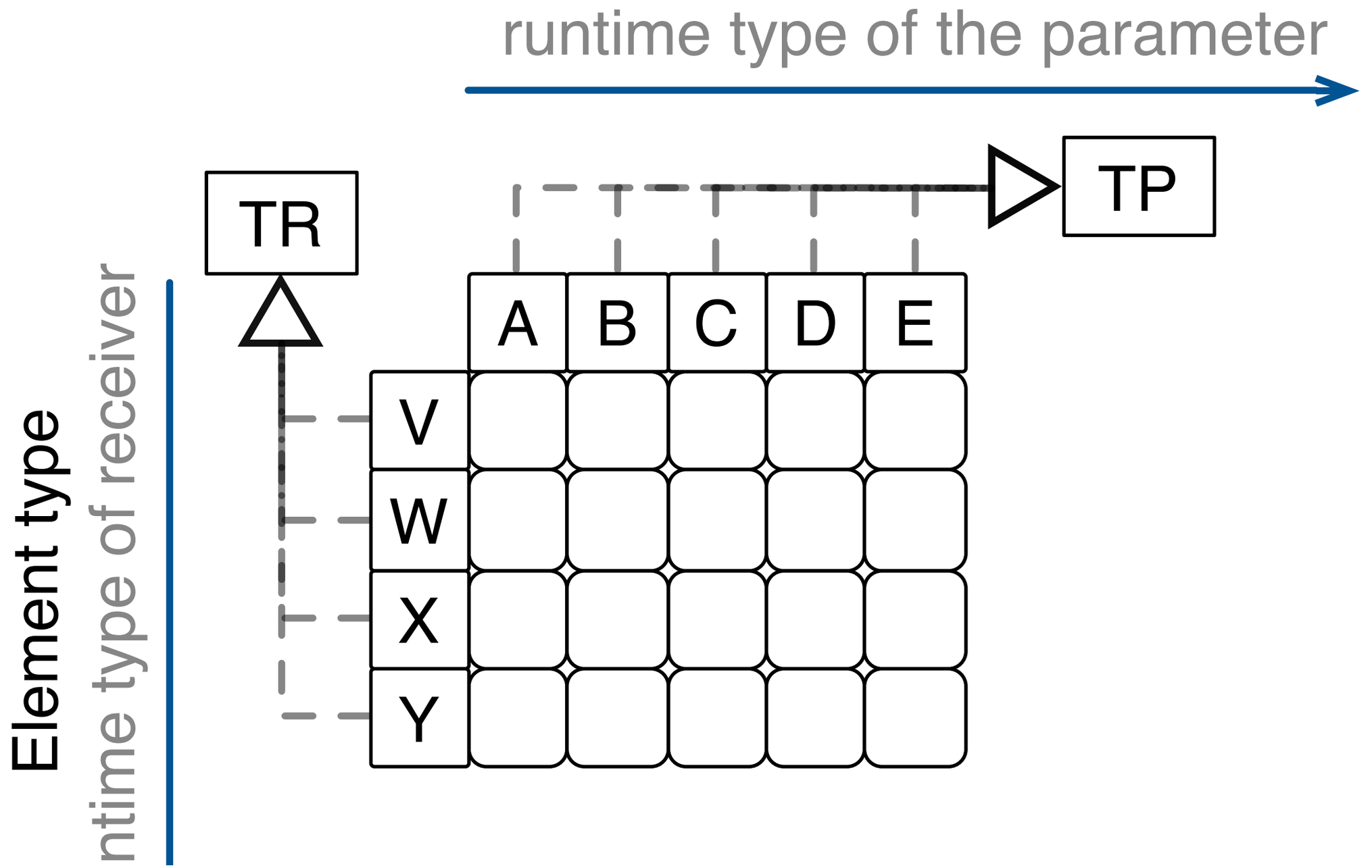
Issues of the Visitor-Based Design

E.g., adding `Chart` and keeping `Visitor` unchanged



Issues of the Visitor-Based Design

Partial Visiting Is Not Supported



Takeaway

- Visitor brings functional-style decomposition to OO designs.
- **Use Visitor for stable element hierarchies.**
  Visitor works well in data hierarchies where new elements are never or at least not very often added.
- **Do not use it, if new elements are a likely change.**
- Visitor only makes sense if we have to add new operations often! In this case Visitor closes our design against these changes.

Solving the Expression Problem in Scala

The base trait.

```
trait Expressions {

    type Expression <: TExpression
    trait TExpression {
        def eval: Double
    }

    trait Constant extends TExpression {
        val v: Double
        def eval = v
    }
}
```

Resembles the solution that we have studied as part of the implementation of the SmartHome Scenario.

Without Visitors

Solving the Expression Problem in Scala

Adding a new data-type.

```
trait AddExpressions extends Expressions {
    trait Add extends TExpression {
        val l: Expression
        val r: Expression
        def eval = l.eval + r.eval
    }
}
```

Resembles the solution that we have studied as part of the implementation of the SmartHome Scenario.

Without Visitors

Solving the Expression Problem in Scala

Adding new functionality.

```
trait PrefixNotationForExpressions extends AddExpre

    type Expression <: TExpression
    trait TExpression extends super.TExpression {
        def prefixNotation: String
    }

    trait Constant extends super.Constant with TExpression {
        def prefixNotation = v.toString
    }

    trait Add extends super.Add with TExpression {
        def prefixNotation = "+"+l.prefixNotation + r.prefixNotation
    }
}
```

Resembles the solution that we have studied as part of the implementation of the SmartHome Scenario.

Without Visitors

Solving the Expression Problem in Scala

Bringing everything together.

Resembles the solution that we have studied as part of the implementation of the SmartHome Scenario.

```
object ExpressionsFramework
        extends PrefixNotationForExpressions
        with PostfixNotationForExpressions {

    type Expression = TExpression
    trait TExpression
        extends super[PrefixNotationForExpressions].TExpression
        with super[PostfixNotationForExpressions].TExpression

    case class Constant(v: Double)
        extends super[PrefixNotationForExpressions].Constant
        with super[PostfixNotationForExpressions].Constant
        with Expression

    case class Add(val l: Expression, val r: Expression)
        extends super[PrefixNotationForExpressions].Add
        with super[PostfixNotationForExpressions].Add
        with Expression
}
```


Without Visitors

Solving the Expression Problem in Scala

The base trait.

```
trait Expressions {

    trait Expression { def accept[T](visitor: Visitor[T]): T }

    class Constant(val v: Double) extends Expression {
        def accept[T](visitor: Visitor[T]): T = visitor.visitConstant(v)
    }

    type Visitor[T] <: TVisitor[T]
    trait TVisitor[T] {
        def visitConstant(v: Double): T
    }

    trait EvalVisitor extends TVisitor[Double] {
        def visitConstant(v: Double): Double = v
    }
}
```

With Visitors

Solving the Expression Problem in Scala

Adding a new data-type.

```
trait AddExpressions extends Expressions {

    class Add(val l: Expression,
              val r: Expression) extends Expression {

        def accept[T](visitor: Visitor[T]): T = visitor.visitAdd(l, r)
    }

    type Visitor[T] <: TVisitor[T]
    trait TVisitor[T] extends super.TVisitor[T] {
        def visitAdd(l: Expression, r: Expression): T
    }

    trait EvalVisitor extends super.EvalVisitor with TVisitor[Double] {
        this: Visitor[Double] ⇒
        def visitAdd(l: Expression, r: Expression): Double =
            l.accept(this) + r.accept(this)
    }
}
```

With Visitors

Solving the Expression Problem in Scala

Bringing everything together.

```
trait ExtendedExpressions extends AddExpressions with MultExpressions {

    type Visitor[T] = TVisitor[T]
    trait TVisitor[T]
        extends super[AddExpressions].TVisitor[T]
        with super[MultExpressions].TVisitor[T]

    object EvalVisitor
            extends super[AddExpressions].EvalVisitor
            with super[MultExpressions].EvalVisitor
            with TVisitor[Double] {
        this: Visitor[Double] ⇒

    }
}
```


With Visitors

Solving the Expression Problem in Scala

Adding new functionality.

```
trait PrefixNotationForExpressions extends ExtendedExpressions {

    object PrefixNotationVisitor extends super.TVisitor[String] {
        this: Visitor[String] ⇒

        def visitConstant(v: Double): String = v.toString+" "

        def visitAdd(l: Expression, r: Expression): String =
            "+ "+l.accept(this) + r.accept(this)

        def visitMult(l: Expression, r: Expression): String =
            "* "+l.accept(this) + r.accept(this)

    }
}
```

With Visitors