Advanced Object-Oriented Design

Visitor

Modular and extensible first class actions

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http://www.pharo.org

Goals

- Studying examples
- Understanding the Visitor design pattern
- Discussions on pros and cons

Example: basic arithmetic expressions

Imagine a simple mathematical system

```
Plus
  left: (Number value: 1)
  right: (Times left: (Number value: 3) right: (Number value: 2))
```

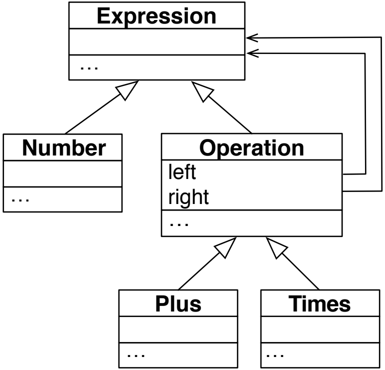
Remarks:

- In this example, we reify everything
- In Pharo, no need to wrap numbers with our own `Number` because can extend the Pharo core `Number`

```
Plus
  left: 1
  right: (Times left: 3 right: 2)
```

Basic arithmetic expressions as Composite

An expression is represented by a Composite with numbers and operations (see Lecture on Composite)



Some expressions

1

```
Number value: 1
```

(3 * 2)

```
Times left: (Number value: 3) right: (Number value: 2)
```

1 + (3 * 2)

```
Plus
  left: (Number value: 1)
  right: (Times left: (Number value: 3) right: (Number value: 2))
```

Operations on the expressions

We want two operations on expressions:

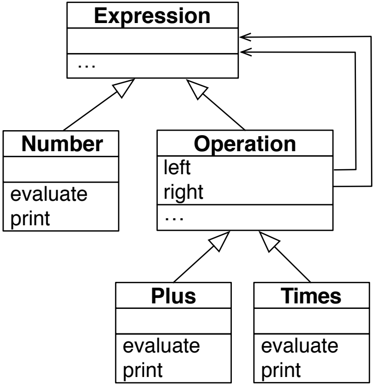
- Evaluate

```
1 + (3 * 2)
> 7
```

- Print (in Polish notation)

```
1 + (3 * 2)
> +1*32
```

First design: behavior defined in the domain



First design: behavior defined in the domain

```
Number >> evaluate
  ^ value
```

```
Plus >> evaluate
  ^  left evaluate + right evaluate
```

```
Number >> print
  stream nextPutAll: value asString
```

```
Plus >> print
...
```

First design: analysis

- Some operations require some state
  - e.g. a stack is needed to print expressions in infix notation
- Where should we define such state?
  - **in** the expression classes?
  - even if this is **only** related to print?

Should we **mix** the state of operations on items with the items themselves?

Overview of a real system

The Pillar Pharo library:

- a core hierarchy of 50 classes (document model)
- export to LaTeX (two versions)
- export to HTML
- export to Beamer
- export to ASCIIdoc, Markdown, Microdown
- transform trees for expansion
- code checkers
- ...

First design: conclusion

Putting all the behavior inside domain objects:

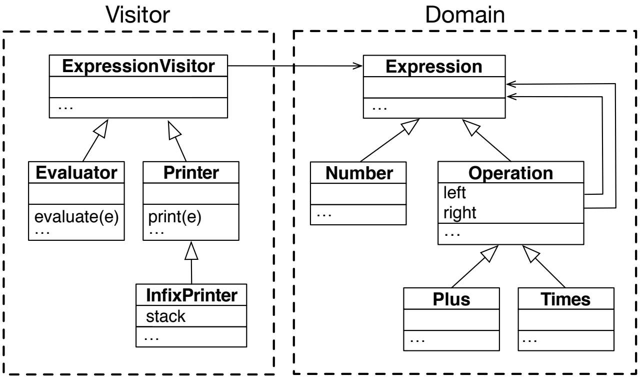
- **Blows up** the class API / state / methods
- **Mixes** concerns
- Is **not modular**: we cannot have **one** operation only
- **Prevents extension**: adding a new behavior requires changing the domain

Essence of the Visitor design pattern

A Visitor:

- **Represents** an operation
- **Decouples** this operation from the domain objects it applies to (separate class)
- Supports **modularity** (separate package)
- Supports **extension**
  - We define **once** a set of messages (**e.g.**, visitX) in domain objects
  - Then, new visitors (operations) are easy to define **without changing domain objects** it operates on

Overview of a Visitor-based design

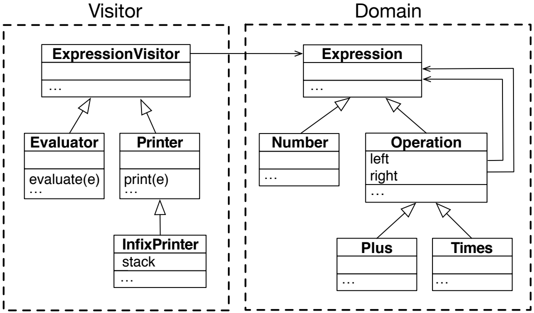


Visitor: key points

A Visitor:

- requires a structure to operate on
- performs different actions based on the kind of the elements
  - **knows** what operation to do for a Number, a Plus, and a Times
- manages its **own specific** state
- is **independent** of other ones

Visitor + Composite: a **perfect** match



Using Visitors

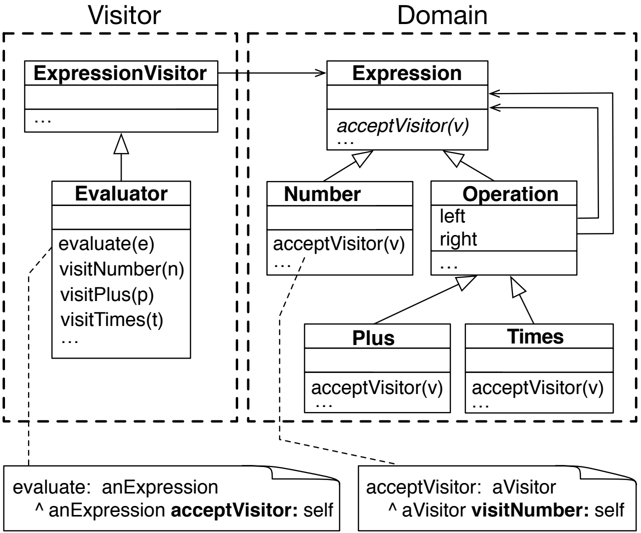
```
"1+(3*2)"
expr := (Plus
        left: (Number value: 1)
        right: (Times
                left: (Number value: 3)
                right: (Number value: 2))).

Evaluator new evaluate: expr.
> 7

Printer new print: expr.
> +1*32

InfixPrinter new print: expr.
> 1+(3*2)
```

Visitor implemention: Domain instrumentation

Prepare the domain to accept Visitors:

- add acceptVisitor: on each composite element
- tells the visitor passed in parameter how to visit it

only once for all Visitors



```
evaluate: anExpression
    ^ anExpression acceptVisitor: self
```

```
acceptVisitor: aVisitor
    ^ aVisitor visitNumber: self
```

Visitor implemention: Domain instrumentation

```
Number >> acceptVisitor: aVisitor
  ^ aVisitor visitNumber: self
```

```
Plus >> acceptVisitor: aVisitor
  ^ aVisitor visitPlus: self
```

```
Times >> acceptVisitor: aVisitor
  ^ aVisitor visitTimes: self
```

- **only once for all Visitors**
- Domain objets tell to the Visitor how they want to be visited
  - visitNumber:, visitPlus:, visitTimes:, visitXXX:

Visitor implemention

A Visitor:

- executes the right operation for an element
- propagates recursively on composite elements
    - acceptVisitor:

```
Evaluator >> visitNumber: aNumber
  ^ aNumber value
```

```
Evaluator >> visitPlus: anExpression
  | l r |
  l := anExpression left acceptVisitor: self.
  r := anExpression right acceptVisitor: self.
  ^ l + r
```

```
Evaluator >> visitTimes: anExpression
  | l r |
  l := anExpression left acceptVisitor: self.
  r := anExpression right acceptVisitor: self.
  ^ l * r
```

Visitor: an extensible design

Supporting a new operation is simple:

- Define a new Visitor class
  - e.g, Printer
- Implement the expected API
  - i.e., visitNumber, visitPlus and visitTimes
- Use it

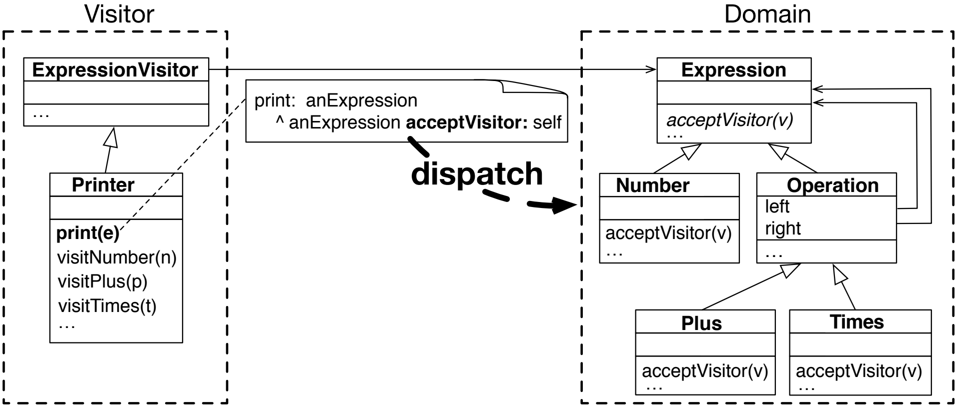
```
anExpression acceptVisitor: Printer new
```

```
Printer new print: anExpression
```

Visitor: step back

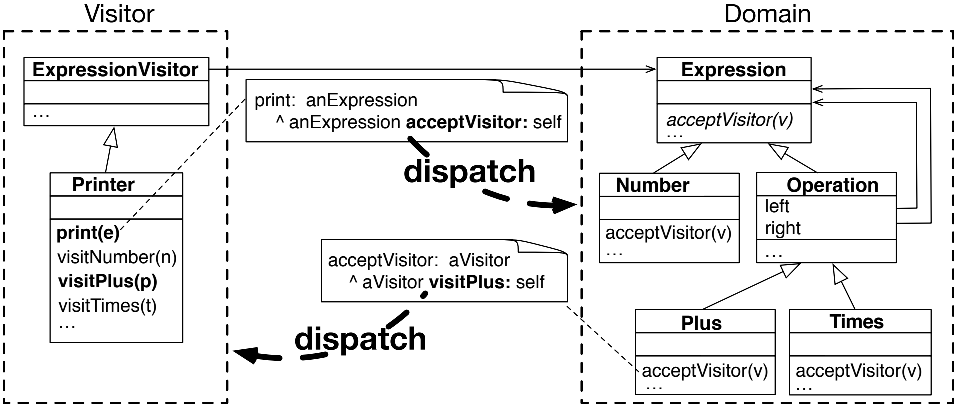
Did you really understood the subtle interaction between acceptVisitor and visitXXX methods?

Double dispatch



```
print:  anExpression
    ^ anExpression acceptVisitor: self
```

Double dispatch



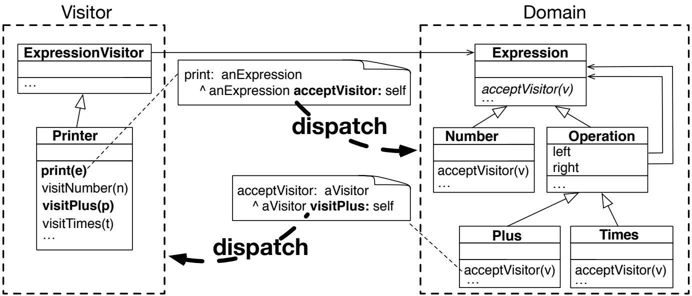
```
print:  anExpression
    ^ anExpression acceptVisitor: self
```

```
acceptVisitor:  aVisitor
    ^ aVisitor visitPlus: self
```

Visitor core: Double dispatch

Double dispatch:

- Core mechanism of Visitor
- No conditional checks
- Provides decoupling between:
  - Visitors and domain objects
  - Different visitors



```
print:  anExpression
   ^ anExpression acceptVisitor: self
```

```
acceptVisitor:  aVisitor
   ^ aVisitor visitPlus: self
```

When to use a Visitor

Whenever you have to perform multiple operations on structured object graphs
Examples:

- Parse tree (ProgramNode) uses a Visitor for
  - the compilation (emitting code on CodeStream),
  - pretty printing, syntax hilighting
  - different analysis pass, rotten green test analysis
- Rendering documents (Document) in different formats
  - nodes expansion, HTML, LaTeX, ...

When using a Visitor is challenging

- If the elements of the composite **change**
  - It requires to change **all** Visitors
- Related to the *expression problem* in statically-typed languages

Conclusion

Pros:

- Visitor is a very nice pattern
- It provides a modular and extensible design
- Double dispatch makes it plug and play

Cons:

- Can look complex
- Not well adapted to changing structures

Produced as part of the course on http://www.fun-mooc.fr

Advanced Object-Oriented Design and Development with Pharo

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2023