The Visitor Design Pattern

EECS3311 A & E: Software Design
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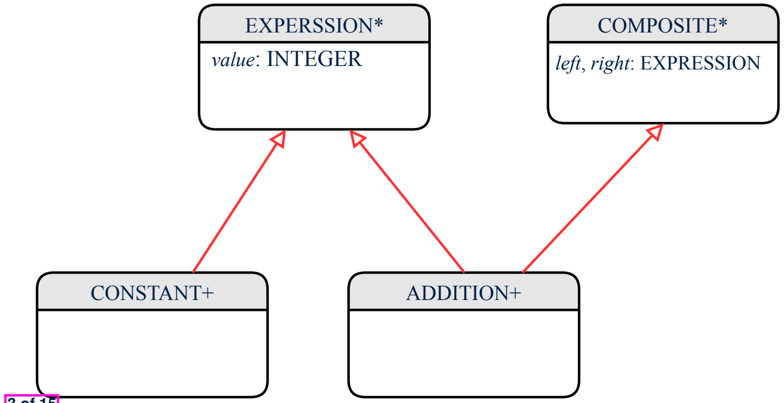
Learning Objectives

1. Motivating Problem: ***Processing*** Recursive Systems
2. First Design Attempt: Cohesion & Single-Choice Principle?
3. Open-Closed Principle
4. Second Design Attempt: ***Visitor Design Pattern***
5. Implementing and Testing the Visitor Design Pattern

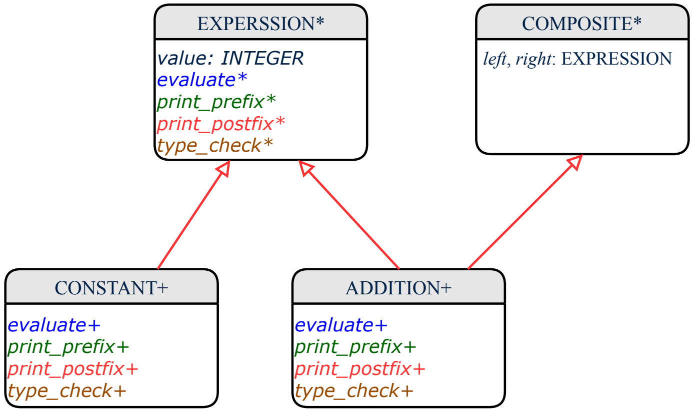
Motivating Problem (1)

Based on the *composite pattern* you learned, design classes to model *structures* of arithmetic expressions (e.g., `341`, `2`, `341 + 2`).



Motivating Problem (2)

Extend the *composite pattern* to support *operations* such as `evaluate`, pretty printing (`print_prefix`, `print_postfix`), and `type_check`.



Problems of Extended Composite Pattern

- Distributing the various **unrelated** ***operations*** across nodes of the ***abstract syntax tree*** violates the *single-choice principle*:

  To add/delete/modify an operation
  ⇒ Change of all descendants of `EXPRESSION`

- Each node class lacks in *cohesion*:

  A *class* is supposed to group *relevant* concepts in a *single* place.
  ⇒ Confusing to mix codes for evaluation, pretty printing, and type checking.
  ⇒ We want to avoid "polluting" the classes with these various unrelated operations.

Open/Closed Principle

Software entities (classes, features, etc.) should be ***open*** for *extension*, but ***closed*** for *modification*.

⇒ When *extending* the behaviour of a system, we:

- May add/modify the ***open*** (unstable) part of system.
- May not add/modify the ***closed*** (stable) part of system.

e.g., In designing the application of an expression language:

- **ALTERNATIVE 1**:
  Syntactic constructs of the language may be ***open***, whereas operations on the language may be ***closed***.
- **ALTERNATIVE 2**:
  Syntactic constructs of the language may be ***closed***, whereas operations on the language may be ***open***.

Visitor Pattern

- *Separation of concerns*:
  - Set of language constructs
  - Set of operations

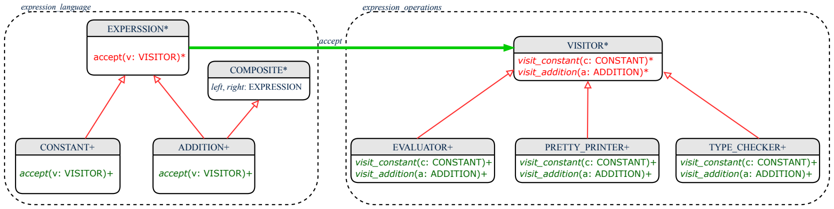
  ⇒ Classes from these two sets are *decoupled* and organized into two separate clusters.

- *Open-Closed Principle (OCP)*: [**ALTERNATIVE 2**]
  - ***Closed***, staple part of system: set of language constructs
  - ***Open***, unstable part of system: set of operations

  ⇒ *OCP* helps us determine if Visitor Pattern is *applicable*.

  ⇒ If it was decided that language constructs are ***open*** and operations are ***closed***, then do **not** use Visitor Pattern.

Visitor Pattern: Architecture


expression_language
EXPERSSION*
accept(v: VISITOR)*
COMPOSITE*
left, right: EXPRESSION
CONSTANT+
accept(v: VISITOR)+
ADDITION+
accept(v: VISITOR)+
accept
expression_operations
VISITOR*
visit_constant(c: CONSTANT)*
visit_addition(a: ADDITION)*
EVALUATOR+
visit_constant(c: CONSTANT)+
visit_addition(a: ADDITION)+
PRETTY_PRINTER+
visit_constant(c: CONSTANT)+
visit_addition(a: ADDITION)+
TYPE_CHECKER+
visit_constant(c: CONSTANT)+
visit_addition(a: ADDITION)+

Visitor Pattern Implementation: Structures

Cluster ***expression_language***

- Declare *deferred* feature `accept(v: VISITOR)` in `EXPRSSION`.
- Implement `accept` feature in each of the descendant classes.

```
class CONSTANT inherit EXPRESSION
...
  accept(v: VISITOR)
    do
      v.visit_constant(Current)
    end
end
```

```
class ADDITION
inherit EXPRESSION COMPOSITE
...
  accept(v: VISITOR)
    do
      v.visit_addition(Current)
    end
end
```

Visitor Pattern Implementation: Operations

Cluster ***expression_operations***

- For each descendant class `C` of `EXPRESSION`, declare a *deferred* feature `visit_c (e: C)` in the *deferred* class `VISITOR`.

```
deferred class VISITOR
  visit_constant(c: CONSTANT) deferred end
  visit_addition(a: ADDITION) deferred end
end
```

- Each descendant of `VISITOR` denotes a kind of operation.

```
class EVALUATOR inherit VISITOR
  value : INTEGER
  visit_constant(c: CONSTANT)  do value := c.value end
  visit_addition(a: ADDITION)
    local eval_left, eval_right: EVALUATOR
    do a.left.accept(eval_left)
       a.right.accept(eval_right)
       value := eval_left.value + eval_right.value
    end
end
```

Testing the Visitor Pattern

```
1   test_expression_evaluation: BOOLEAN
2    local add, c1, c2: EXPRESSION ; v: VISITOR
3    do
4     create {CONSTANT} c1.make (1) ; create {CONSTANT} c2.make (2)
5     create {ADDITION} add.make (c1, c2)
6     create {EVALUATOR} v.make
7     add.accept(v)
8     check attached {EVALUATOR} v as eval then
9      Result := eval.value = 3
10    end
11   end
```

Double Dispatch in **Line 7**:

1. ***DT*** of `add` is *ADDITION* ⇒ Call `accept` in *ADDITION*

   `v.visit_addition(add)`

2. ***DT*** of `v` is *EVALUATOR* ⇒ Call `visit_addition` in *EVALUATOR*

   visiting result of `add.left` + visiting result of `add.right`

To Use or Not to Use the Visitor Pattern

- In the architecture of visitor pattern, what kind of *extensions* is easy and hard? Language structure? Language Operation?
  - Adding a new kind of ***operation*** element is easy.

    To introduce a new operation for generating C code, we only need to introduce a new descendant class `C_CODE_GENERATOR` of `VISITOR`, then implement how to handle each language element in that class.

    ⇒ *Single Choice Principle* is *obeyed*.
  - Adding a new kind of ***structure*** element is hard.

    After adding a descendant class `MULTIPLICATION` of `EXPRESSION`, every concrete visitor (i.e., descendant of `VISITOR`) must be amended to provide a new `visit_multiplication` operation.

    ⇒ *Single Choice Principle* is *violated*.
- The applicability of the visitor pattern depends on to what extent the ***structure*** will change.

  ⇒ Use visitor if ***operations*** applied to ***structure*** change often.

  ⇒ Do not use visitor if the ***structure*** changes often.

Beyond this Lecture. . .

- Learn about implementing the Composite and Visitor Patterns, from scratch, in this tutorial series:

  https://www.youtube.com/playlist?list=PL5dxAmCmjv_4z5eXGW-ZBgsS2WZTyBHY2

- The Visitor Pattern can be used to facilitate the development of a language compiler:

  https://www.youtube.com/playlist?list=PL5dxAmCmjv_4FGYtGzcvBeoS-BobRTJLq

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