Design patterns

Design Patterns

Elements of Reusable Object-Oriented Software

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What are design patterns

- Solutions to specific problems in OO software design
- 23 patterns in 3 categories
  - Creational
  - Structural
    - Composite
    - …
  - Behaviorial
    - Observer
    - Interpreter
    - …

Why are we studying them?

Observer

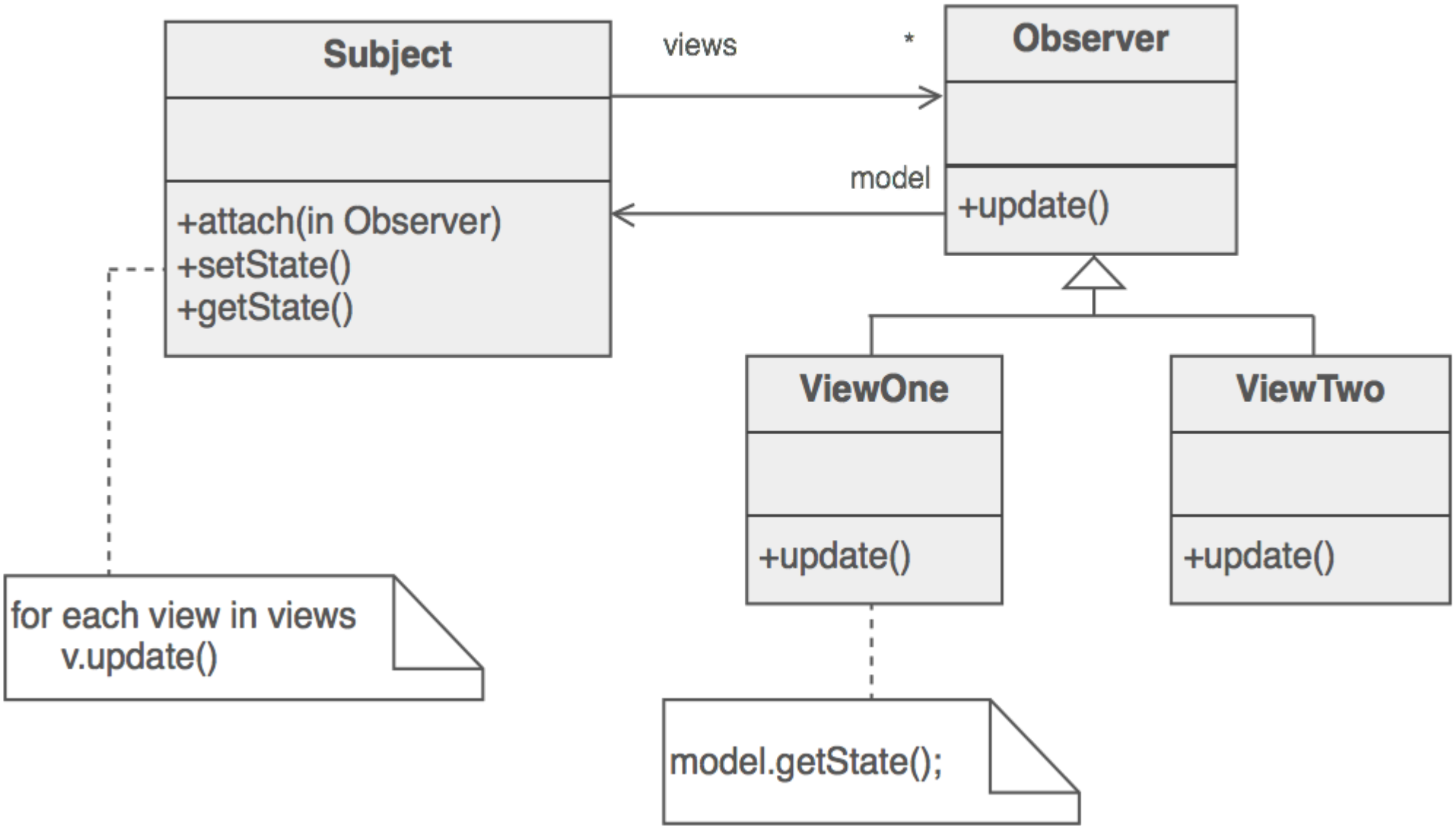
- One to many relationship
  - The many need to know changes in “one” immediately

- Example
  - Points & Shapes
  - Map & location-based services
  - A game character & other game components
  - …

Example

- If a person/subject changes its status, how to let all his “subscriber” knows?
  - What to do when there is only one subscriber?
  - What to do when there are multiple subscribers of different types?
  - What if new subscribers are added?
  - How to make the code easy to maintain and extend?

Class diagram



Example (location, location-related service)

- “location” would be the *Subject* in previous slide
- “*observer”* would be the superclass of all the sub-classes that try to update themselves based on the location information

The benefit of observer pattern

- When new types of observers are added, the prototype and implementation of the subject class doesn’t need any changes.

Other things to pay attention

- Don’t forget the subscribing and unsubscribing methods
- Pull notification vs push notification
- What if I want to delete a subject
- Can an observer subscribe multiple subjects?

Composite pattern

- Tree hierarchy
- How do you build a tree?

How to build a tree and traverse it?

```
struct node{
   struct node* left;
   struct node* right;
   int val;
   int sum(){
        …
   }
}
```

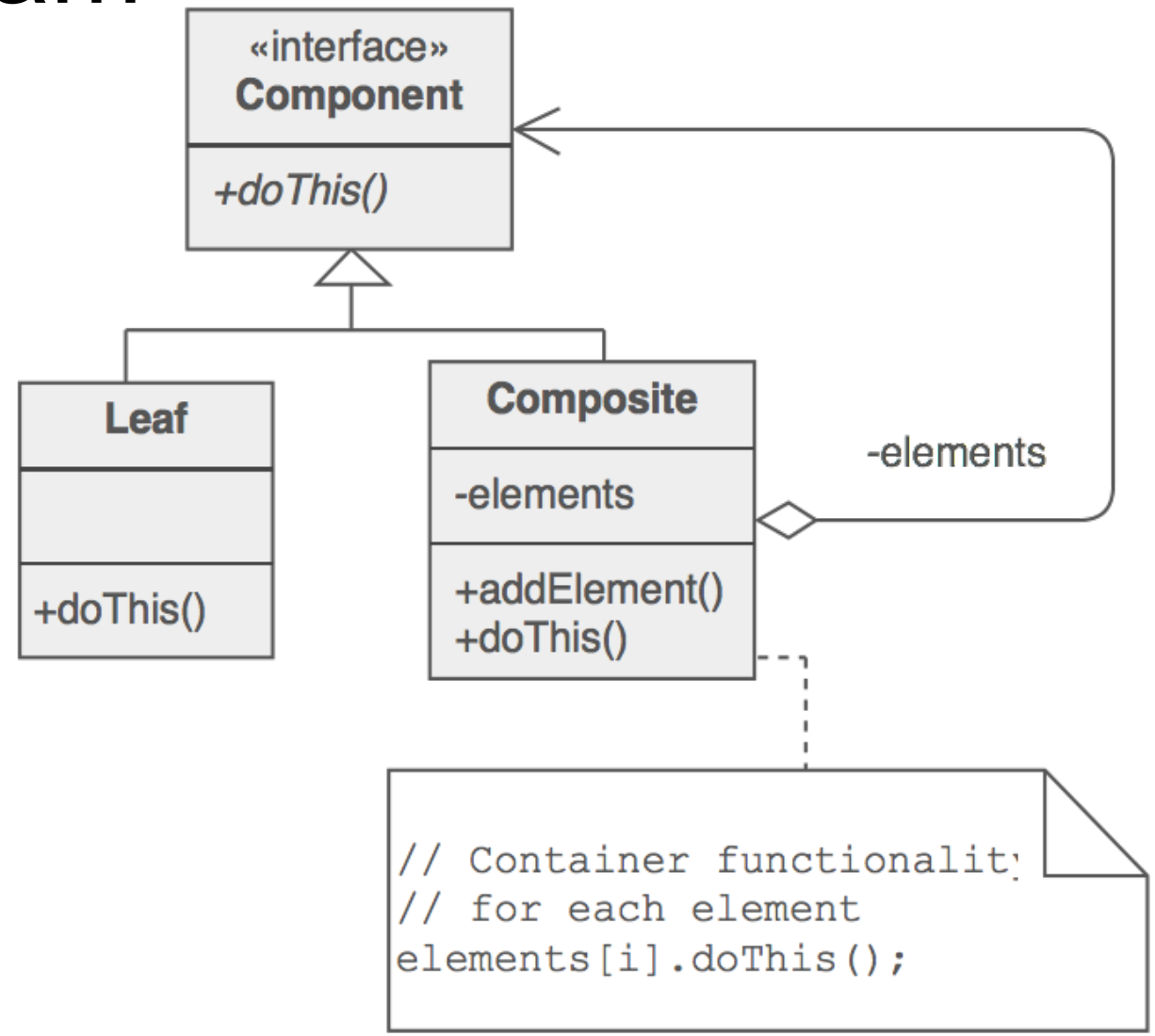
How to differentiate leaves and others?

```
struct leaf{
   int val;
   int sum(){ return val;}
}
```

How to accommodate different types of internal nodes?

- Examples
  - struct node or struct leaf?
  - Book
  - Graphics

Class diagram



Apply composite pattern to tree

- “Leaf” in previous slide is tree leaf
- “Composite” in previous slide is non-leaf nodes in a tree

Interpreter

- What is an interpreter
  - Language, compiler

- Example
  - Boolean expression
    - Abstract syntax tree

    a && b || !c

    a parser will turn this into an abstract syntax tree, and then an interpreter will evaluate the tree. How to write a program to do the tree-based evaluation?

How to do addition & subtraction

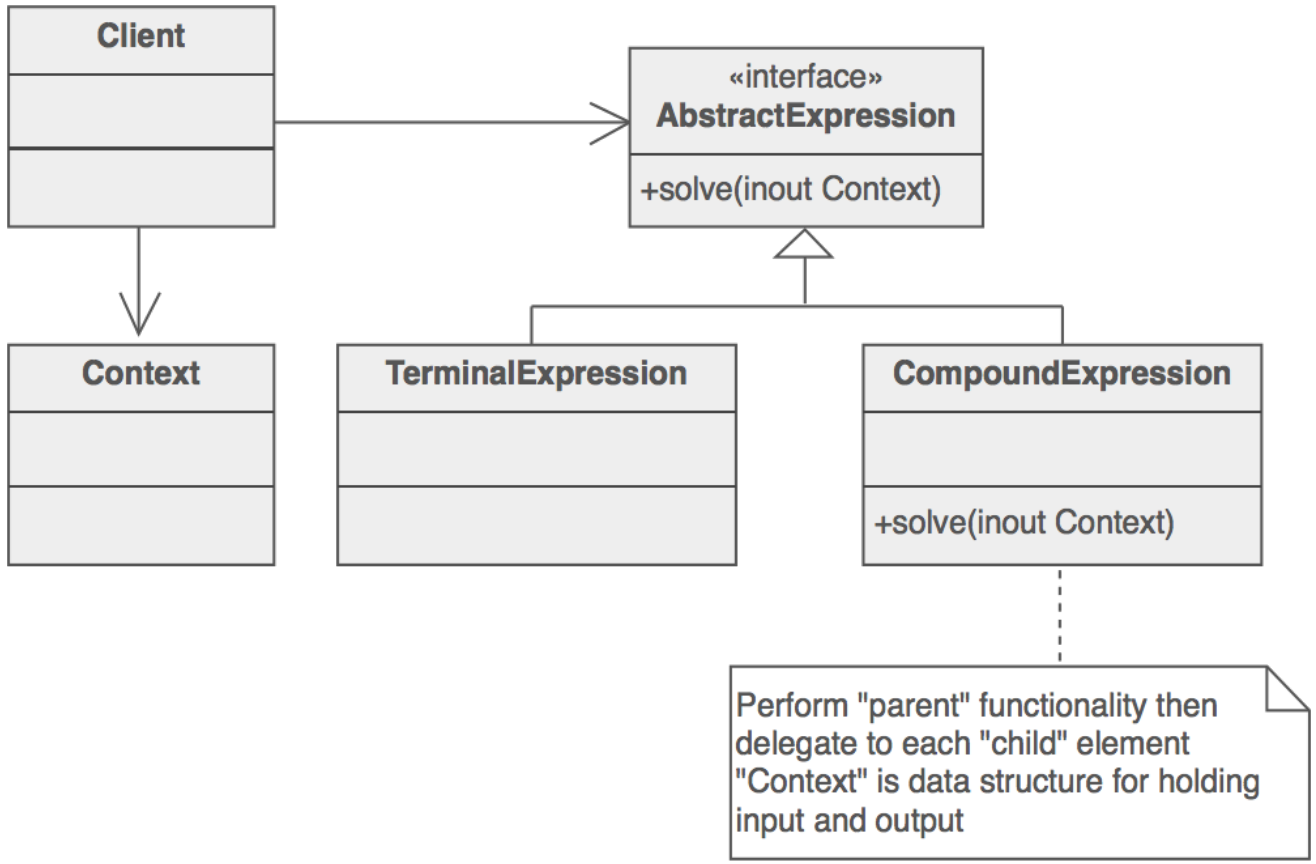
- How to represent an addition expression?
  - Constant + Constant
  - Constant + Constant + Constant
- How to represent a subtraction expression?

How to do addition & subtraction

- How to represent an addition expression?
  - Tree is a good form
- How to represent a subtraction expression?
  - Tree

- The challenge:
  - Any node in the above tree could be a constant, an addition expression, or a subtraction expression, etc.

Class diagram



Strategy Design Pattern

Classes centered on operations, instead of data

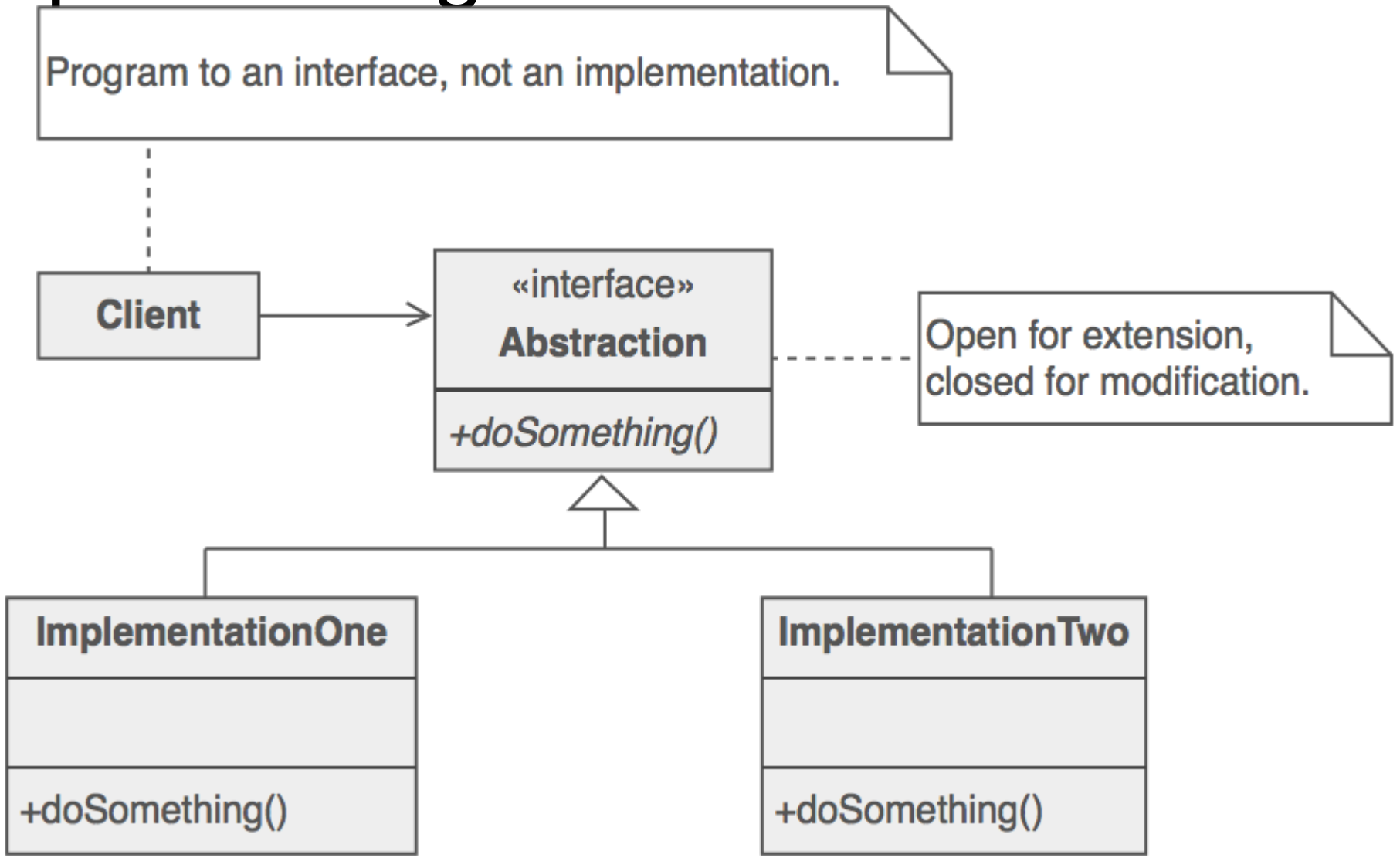
Strategy

- Multiple variants of one algorithm
- Different types of objects only differing in behavior
- **The key part of a class is its method, NOT its data**
  - Example: printer, sorter, comparator
  - The method works for multiple data types

Example

- Printers
  - Various font size, indentation, capitalization

Class diagram
-- encapsulate algorithms into class



Alternative solutions

- If in C
- Super-class on the data side
- Template in C++

Other examples

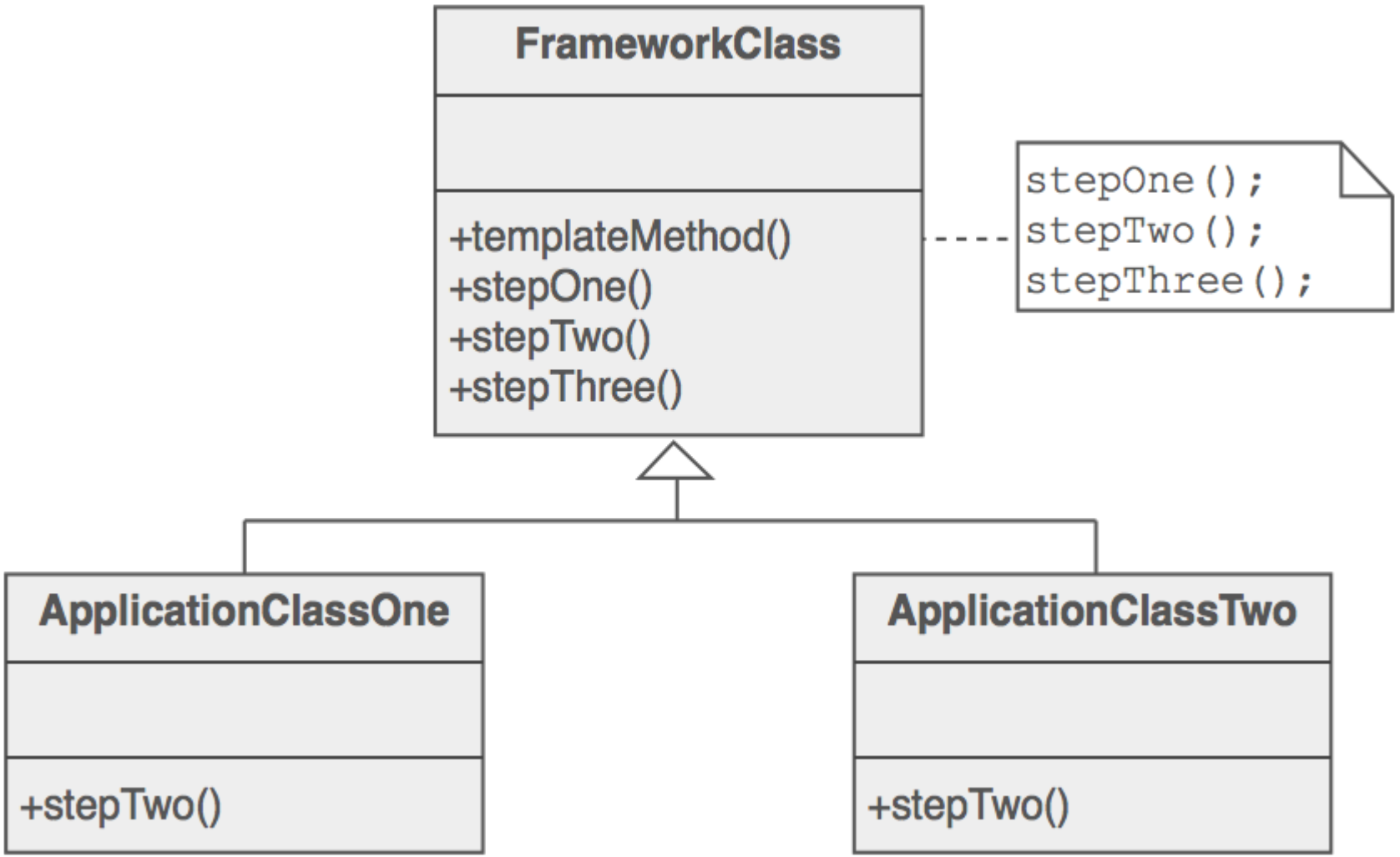
- Different sorting
- Different rendering
- …

Template

- Provide a skeleton for similar algorithms
  - The key of the class is still operation, not data

- Example

Class diagram

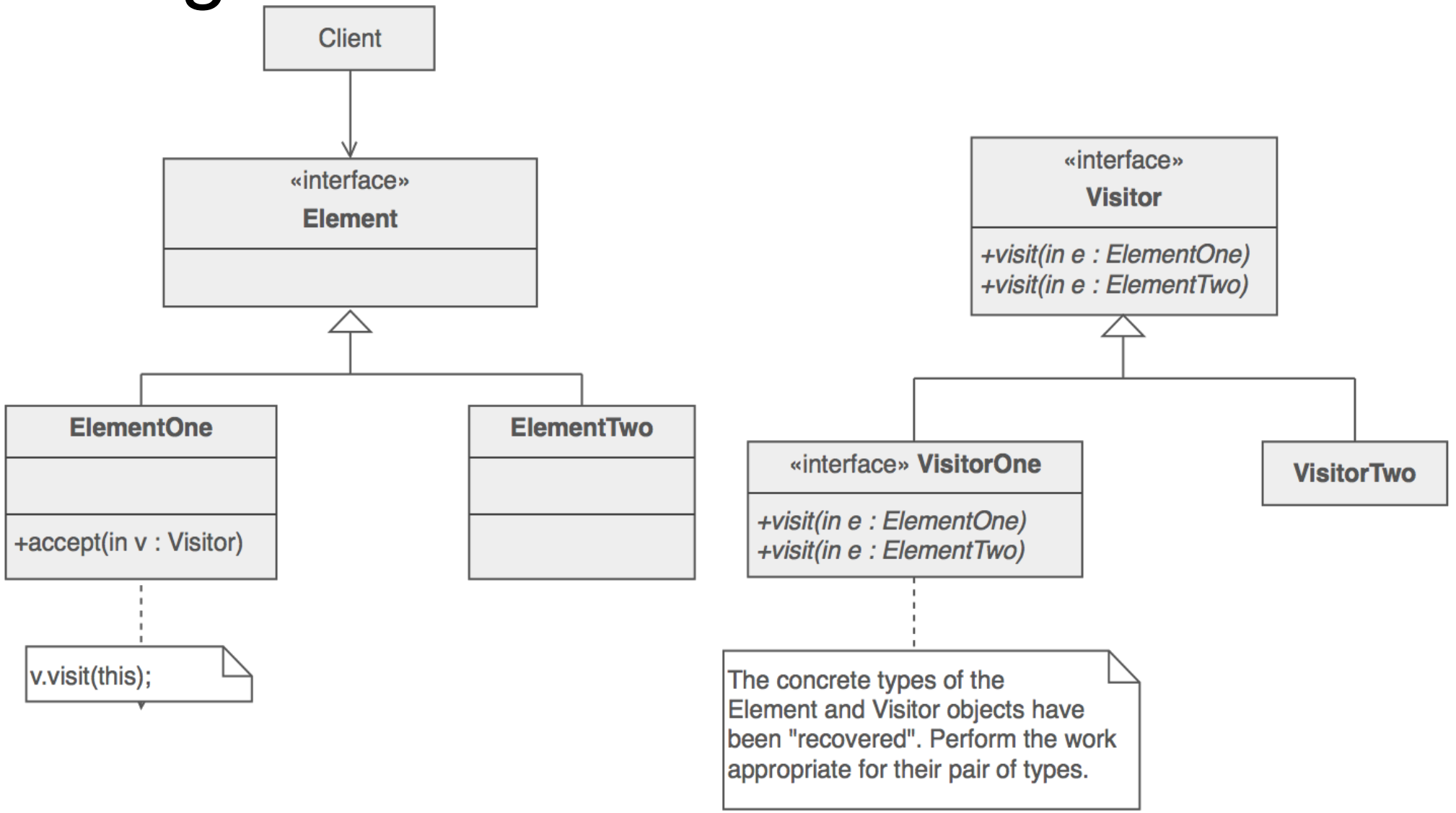


Visitor

- How to add a class of operations for a variety of data classes?

- Example
  - Different operations for AST nodes
  - Different operations for Person (Female, Male)

Class diagram



Visitor

- Two class hierarchies: data & operations
- What is it good at?
  - If you add operations (Visitor classes), the interface of the Element classes remains unchanged
- What is it bad at?
  - If you add new Element sub-class, significant changes are needed for the Visitor side
- Double-dispatch
  - Imagine two dimensions of a function call
    - The exact algorithm
    - The type of data this algorithm works on
  - You will get chance to make choice along both dimensions dynamically, using visitor pattern

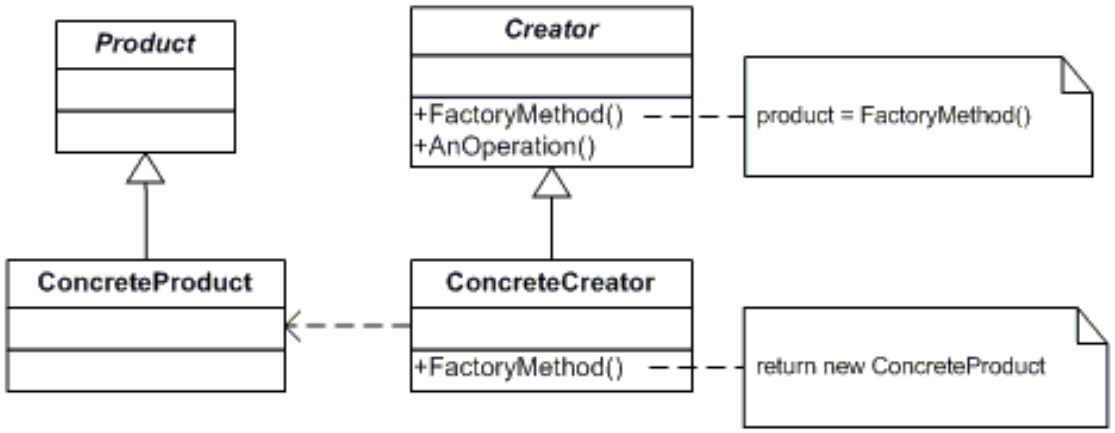
Creational design patterns

Factory Method

- Lets a class defer instantiation to subclasses
  - No need to decide which subclass I want to use statically

- Example
  - Date (US style, Europe style, Chinese style, …)
  - Window

Class diagram



Factory design pattern is somewhat similar with Strategy design pattern

When to use factory design pattern?

- The type of the sub-class is determined at run time
- The type changes very infrequently once set

Abstract Factory

- For creating families of related or dependent objects without specifying their concrete classes

- Examples
  - Date, currency, data
  - Window, mouse, scroll bar, …

Abstract factory design pattern is somewhat similar with Visitor design pattern

Class diagram