CSE 403: Software Engineering, Fall 2016

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Design Patterns

Emina Torlak

emina@cs.washington.edu

Outline

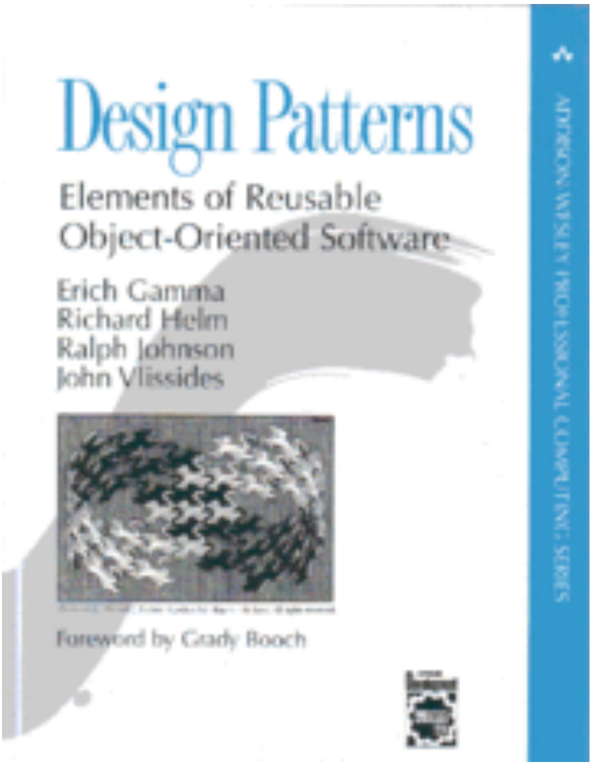
- Overview of design patterns
- Creational patterns
- Structural patterns
- Behavioral patterns

intro

overview of design patterns

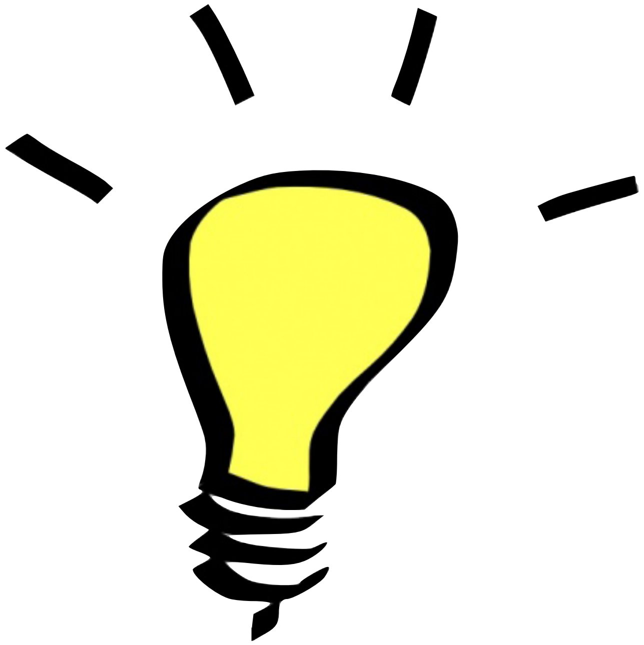
What is a design pattern?

- A **standard** solution to a common programming problem
  - a design or implementation structure that achieves a particular purpose
  - a high-level programming idiom
- A technique for making code **more flexible** or **efficient**
  - reduce coupling among program components
  - reduce memory overhead
- **Shorthand** for describing program design
  - a description of connections among program components
  - the shape of a heap snapshot or object model


Design Patterns
Elements of Reusable Object-Oriented Software
Erich Gamma
Richard Helm
Ralph Johnson
John Vlissides
Foreword by Grady Booch
ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES

Why should you care?

- You could come up with these solutions on your own …
- But you shouldn't have to!
- A design pattern is a **known solution** to a **known problem**.



Types of design patterns

- **Creational patterns**
  - how objects are instantiated
- **Structural patterns**
  - how objects / classes can be combined
- **Behavioral patterns**
  - how objects communicate
- **Concurrency patterns**
  - how computations are parallelized / distributed

When (not) to use design patterns

- **Rule 1: delay**
  - Understand the problem & solution first, then improve it
- Design patterns can increase or decrease understandability of code
  - Add indirection, increase code size
  - Improve modularity, separate concerns, ease description
- If your design or implementation has a problem, consider design patterns that address that problem
- References:
  - Design Patterns: Elements of Reusable Object-Oriented Software, by Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides, 1995.
  - Effective Java: Programming Language Guide, by Joshua Bloch, 2001.

create

creational patterns

Kinds of creational patterns

- Factory (method)
- Abstract factory
- Builder
- Prototype
- Flyweight
- Singleton

Creational patterns address inflexibility of constructors in Java:

1. Can't return a subtype of the class they belong to
2. Always return a fresh new object, never re-use one

Factory patterns (problem)

```
interface Matrix { ... }
   class SparseMatrix implements Matrix { ... }
   class DenseMatrix implements Matrix { ... }
```

- Clients use the supertype (Matrix)
  - But still need to use a SparseMatrix or DenseMatrix **constructor**
  - Must decide concrete implementation somewhere
- Don't want to change code to use a different constructor

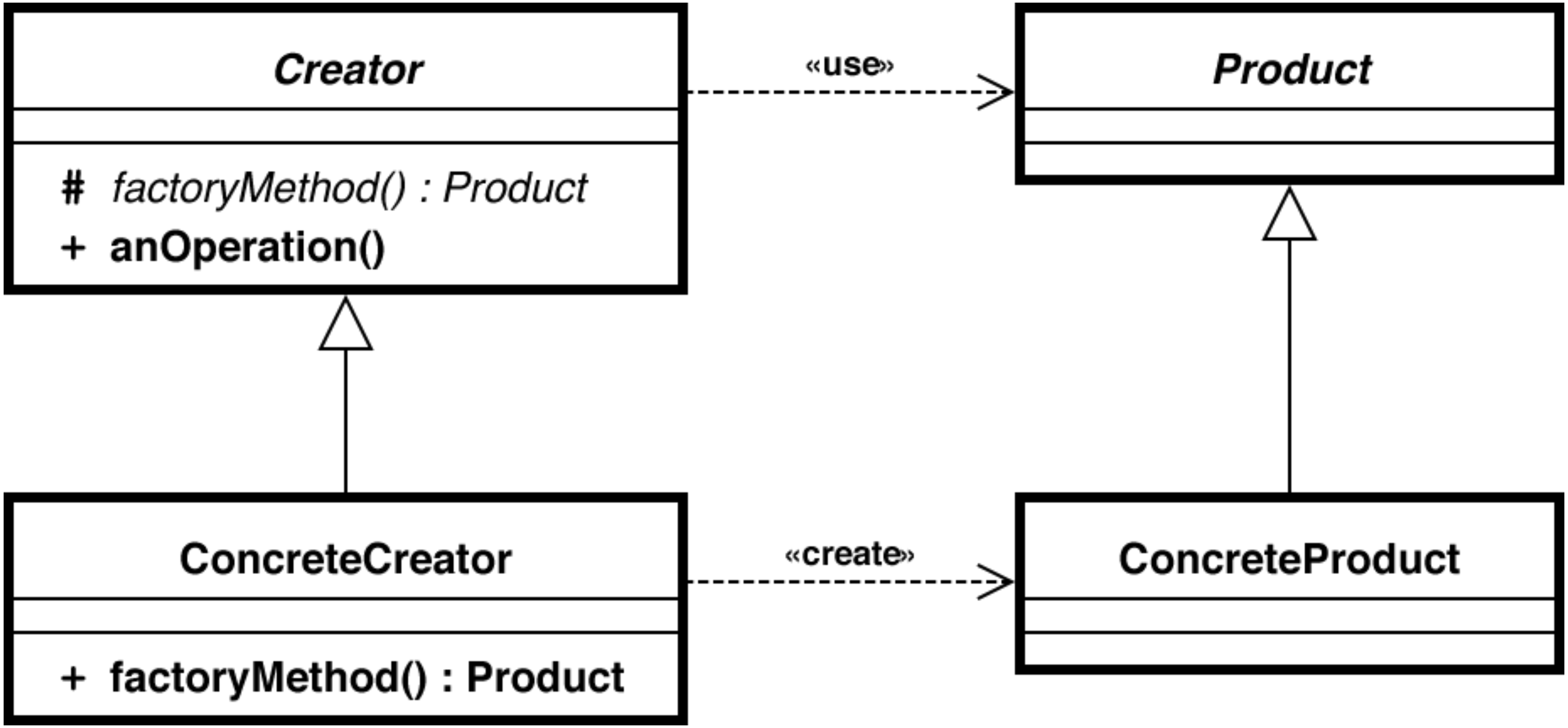
Factory method pattern (one solution)

```
class MatrixFactory {
     public static Matrix createMatrix() {
       return new SparseMatrix();
     }
}
```

- Clients call createMatrix instead of a particular constructor
- Advantages:
  - To switch the implementation, change only one place
  - createMatrix can do arbitrary computations to decide what kind of matrix to make
- Frequently used in frameworks (e.g., Java swing)
  - BorderFactory.createRaisedBevelBorder()

Abstract factory pattern (another solution)

A factory class that can be subclassed (to make new kinds of factories) and that has an overridable method to create its objects



shape

structural patterns

Kinds of structural patterns

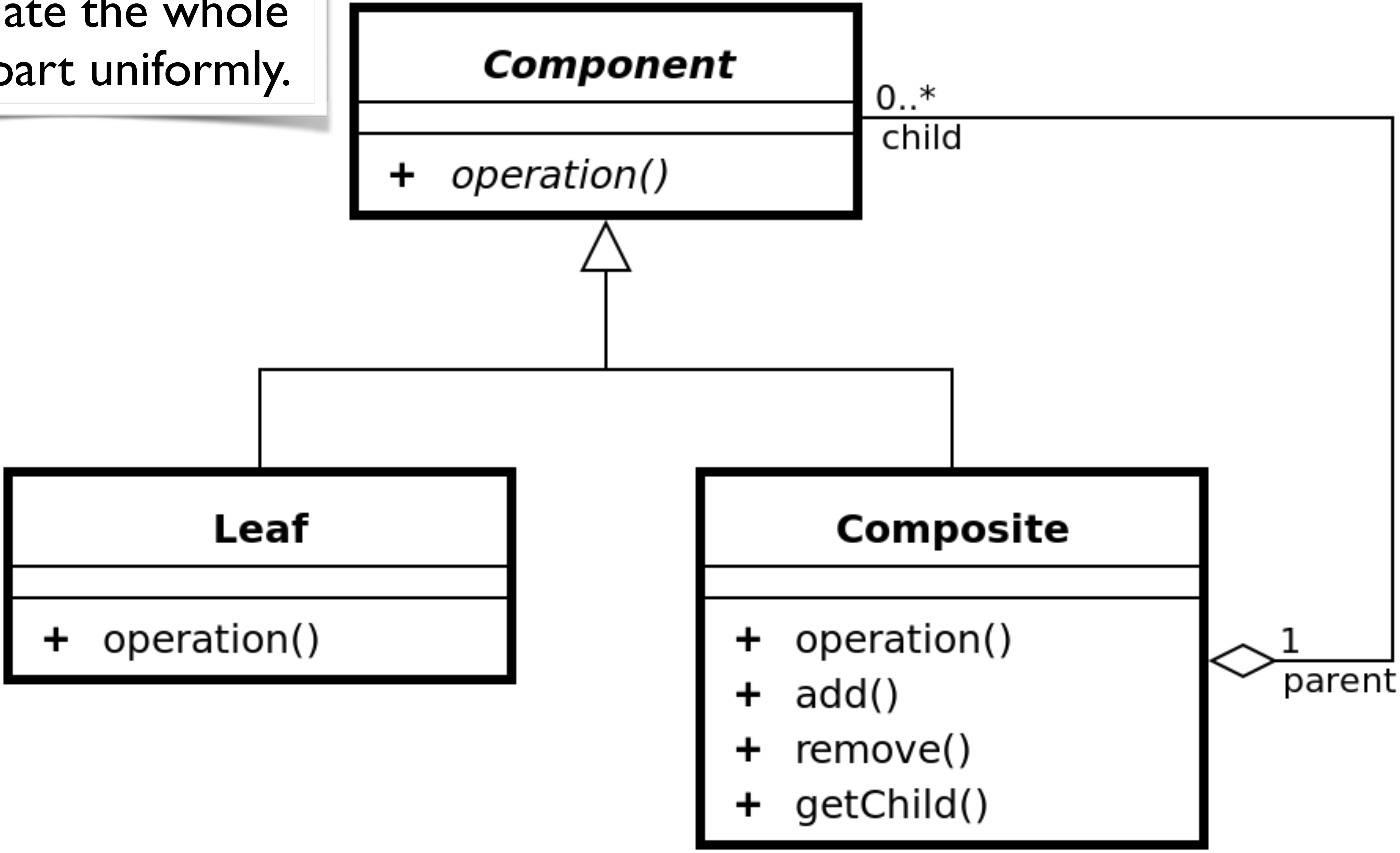
- Composite
- Decorator
- Adapter
- Proxy
- …

Structural patterns enable client code to

1. modify the interface
2. extend behavior
3. restrict access
4. unify access

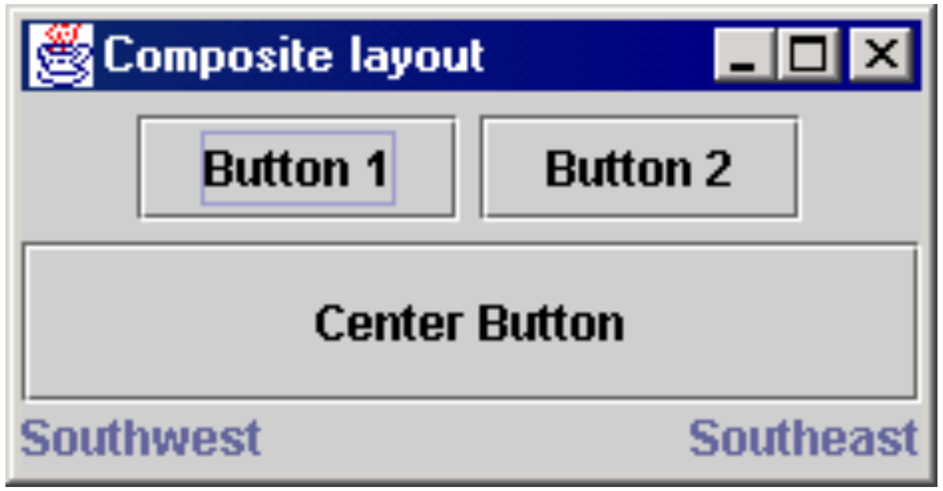
Composite pattern

A client can manipulate the whole or any part uniformly.



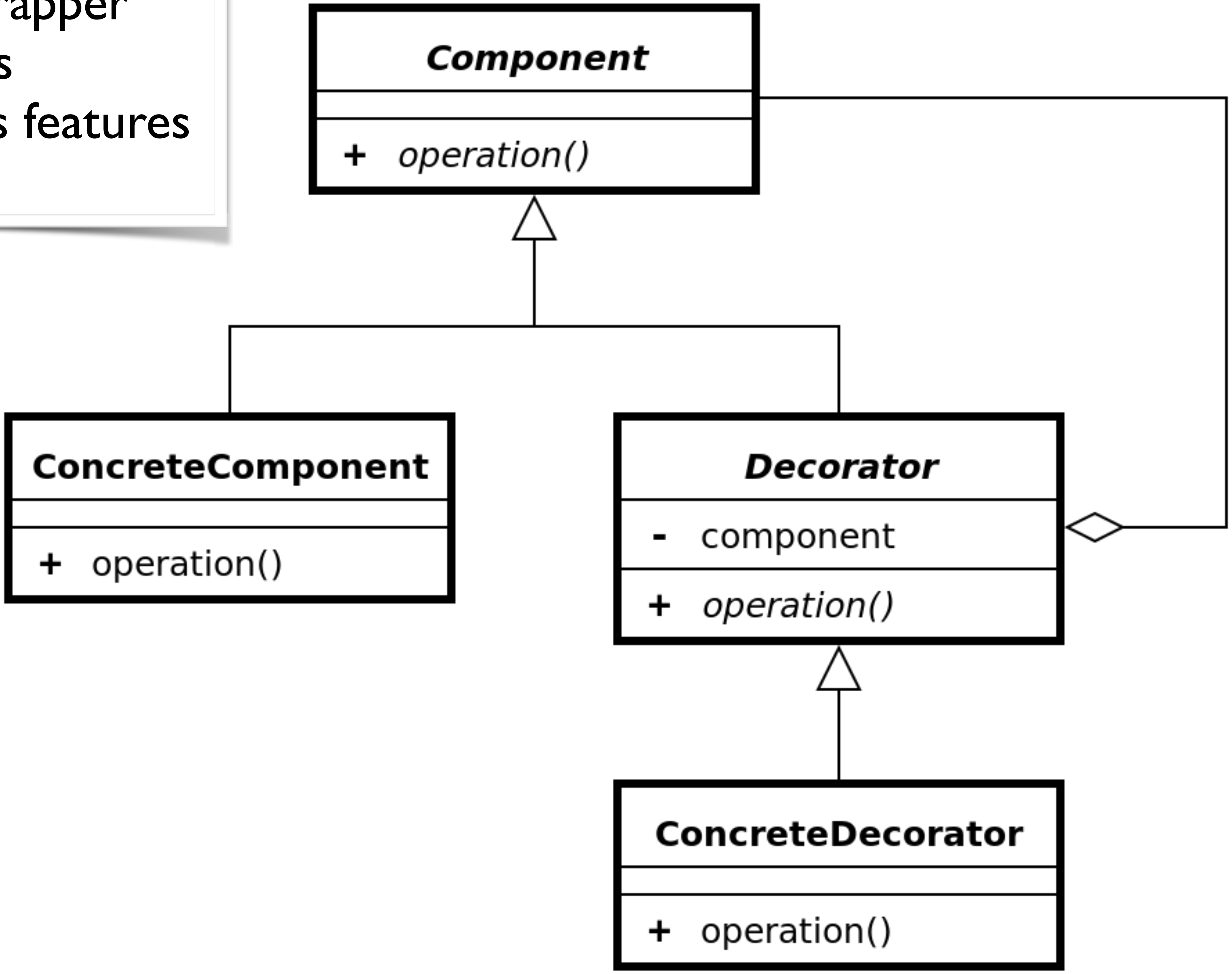
Composite pattern example: Java GUI

```
Container north = new JPanel(new FlowLayout());
north.add(new JButton("Button 1"));
north.add(new JButton("Button 2"));

Container south = new JPanel(new BorderLayout());
south.add(new JLabel("Southwest"), BorderLayout.WEST);
south.add(new JLabel("Southeast"), BorderLayout.EAST);

Container overall = new JPanel(new BorderLayout());
overall.add(north, BorderLayout.NORTH);
overall.add(new JButton("Center Button”), BorderLayout.CENTER);
overall.add(south, BorderLayout.SOUTH);

frame.add(overall);
```



Decorator pattern

A decorator is a wrapper object that modifies behavior of, or adds features to, another object.



Decorator pattern example: Java IO

- InputStream class has only public int read() method to read one letter at a time.
- Decorators such as BufferedReader add functionality to read the stream more easily.

```
// InputStreamReader/BufferedReader decorate InputStream
InputStream in = new FileInputStream("hardcode.txt");
InputStreamReader isr = new InputStreamReader(in);
BufferedReader br = new BufferedReader(isr);

// With a BufferedReader decorator, read an
// entire line from the file in one call
// (InputStream only provides public int read() )
String wholeLine = br.readLine();
```

behave

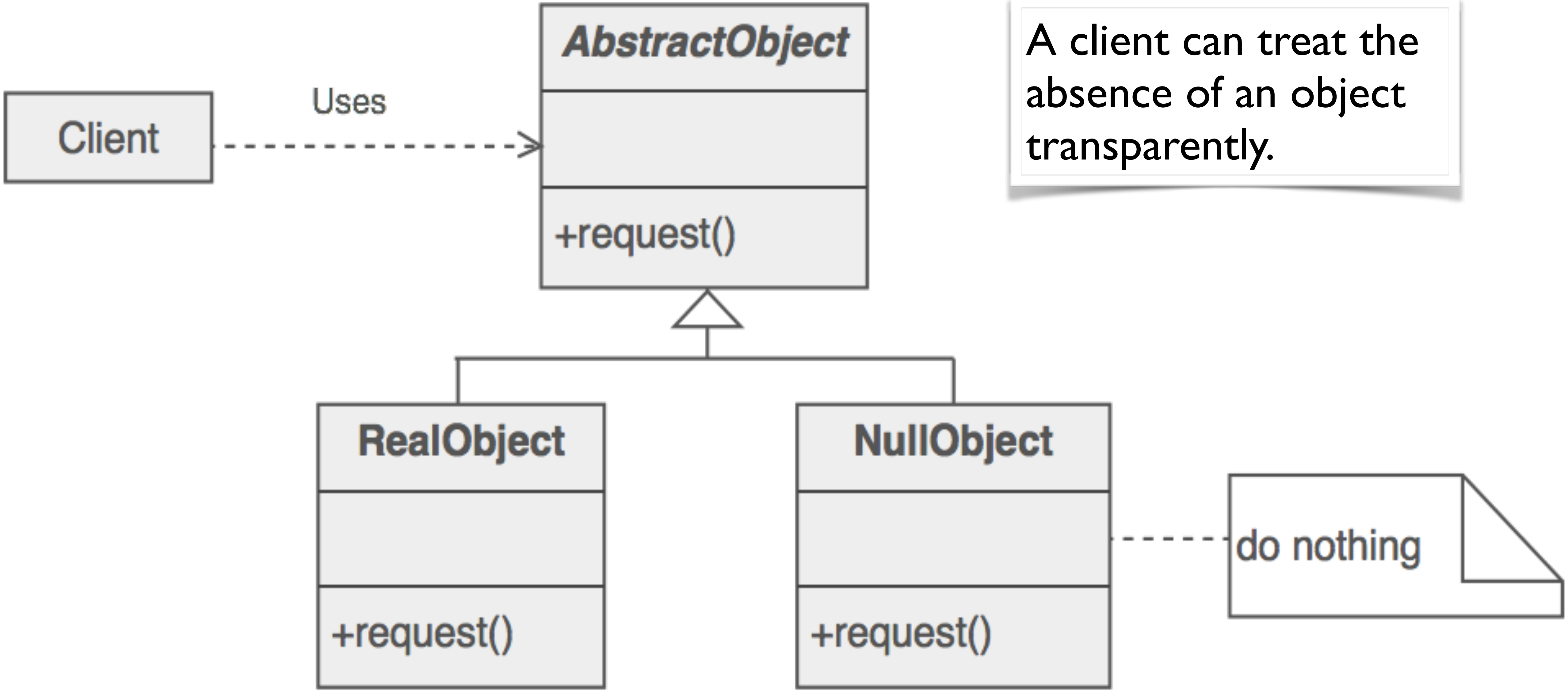
behavioral patterns

Kinds of behavioral patterns

- Null object
- Template method
- Iterator
- Strategy
- …

Behavioral patterns identify and capture common patterns of communication between objects.

Null object pattern



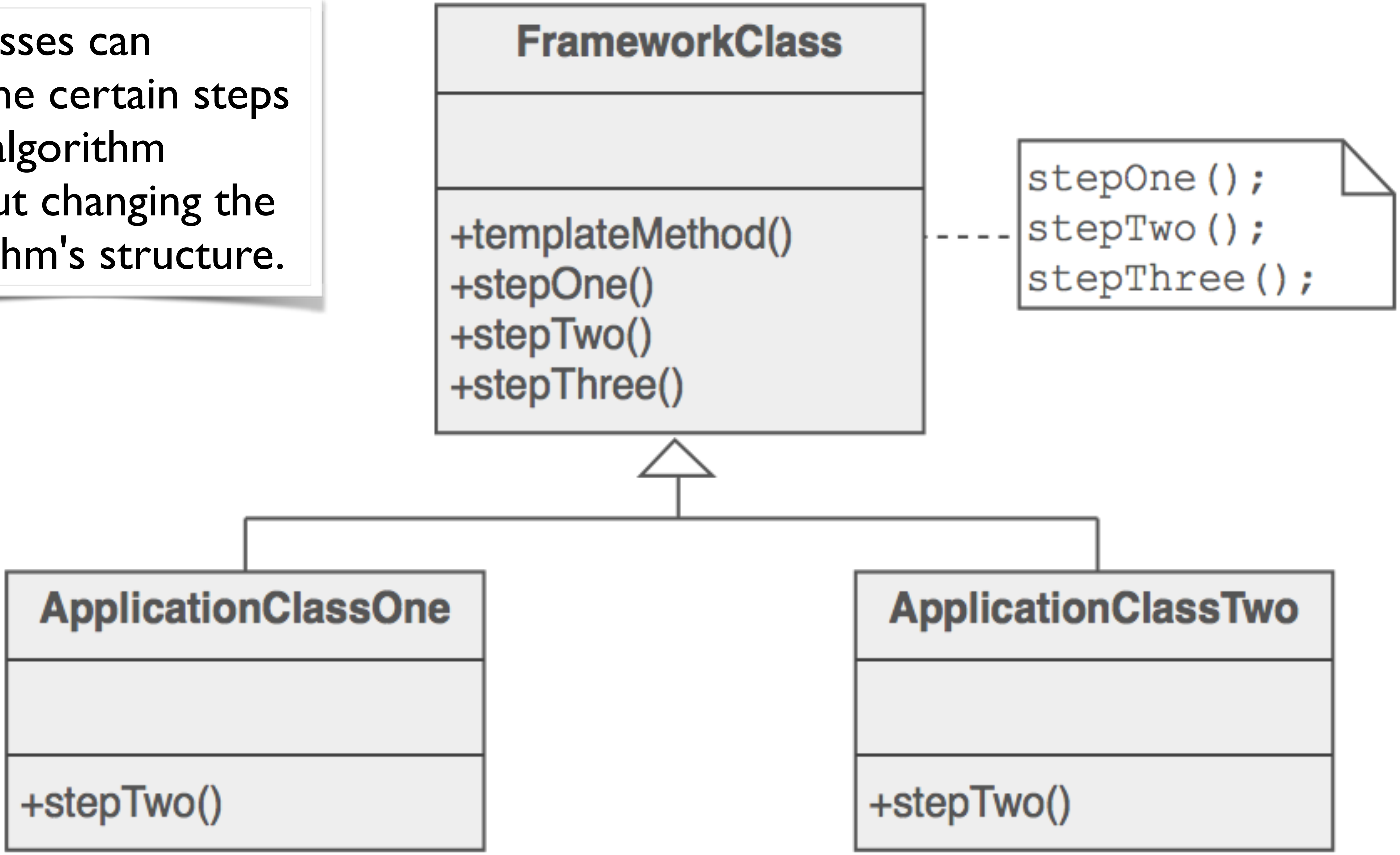
A client can treat the absence of an object transparently.

Null object pattern example: empty list

```
List<Object> search(String value) {
    if (“”.equal(value))
      return Collections.emptyList(); // null object (empty list)
    else
      return …;
}

if (search(userInput).isEmpty())     // no NullPointerException
    …
else
    …
```

Template method pattern

Subclasses can redefine certain steps of an algorithm without changing the algorithm's structure.



```
stepOne();
stepTwo();
stepThree();
```

Template method example: games

```
abstract class Game {

    protected int playersCount;
    abstract void initializeGame();
    abstract void makePlay(int player);
    abstract boolean endOfGame();
    abstract void printWinner();

    // template method
   public final void playOneGame(int playersCount) {
        this.playersCount = playersCount;
        initializeGame();
        int j = 0;
        while (!endOfGame()) {
            makePlay(j);
            j = (j + 1) % playersCount;
        }
        printWinner();
    }
}

class Monopoly extends Game { … }
class Chess extends Game { … }
```

Summary

- A design pattern is a known solution to a known problem.
    - Creational, structural, behavioral
- If your design or implementation has a problem, then (and only then) consider design patterns that address that problem.