Reuse at Design Level: Design Patterns

CS 617- Lecture 17

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3:30-5:00 pm

Rushikesh K. Joshi

Department of Computer Sc. & Engg.

Indian Institute of Technology, Bombay

Mumbai - 400 076

Reuse in Software Engineering

- Reuse at code level is common in software development
- e.g. C standard libraries such as math.h and stdio.h;
- user defined libraries such as “serverutils”, “library.h”
- What about reusing old design solutions and not just the code ?

Christopher Alexander's Work

Two books for building architects

The timeless way of building: Alexander 1977

A Pattern language: Alexander et al. 1977

- He classified the problems that occurred again and again and described core solutions to them that could be used again and again
- Examples: main entrance, sequence of sitting spaces, public outdoor room, interior windows

Patterns in Software Engineering

- Studies in other disciplines is helpful in software engineering other than computer science, its basic discipline
- Researchers in Object Oriented Software Engineering now find that design patterns can be formulated to represent commonly occurring problems in design and also the solutions to them

Framework Cookbooks

- Frameworks such as Smalltalk's MVC were available in 80's
- But using a framework for a specific application needed the knowledge of classes and class interactions in the framework
- e.g Krasner and Pope's cookbook on MVC framework (1988)
- e.g. Ralph Johnson's cookbook: HotDraw for implementing graphical editor (1992)

The Growth of Pattern Community

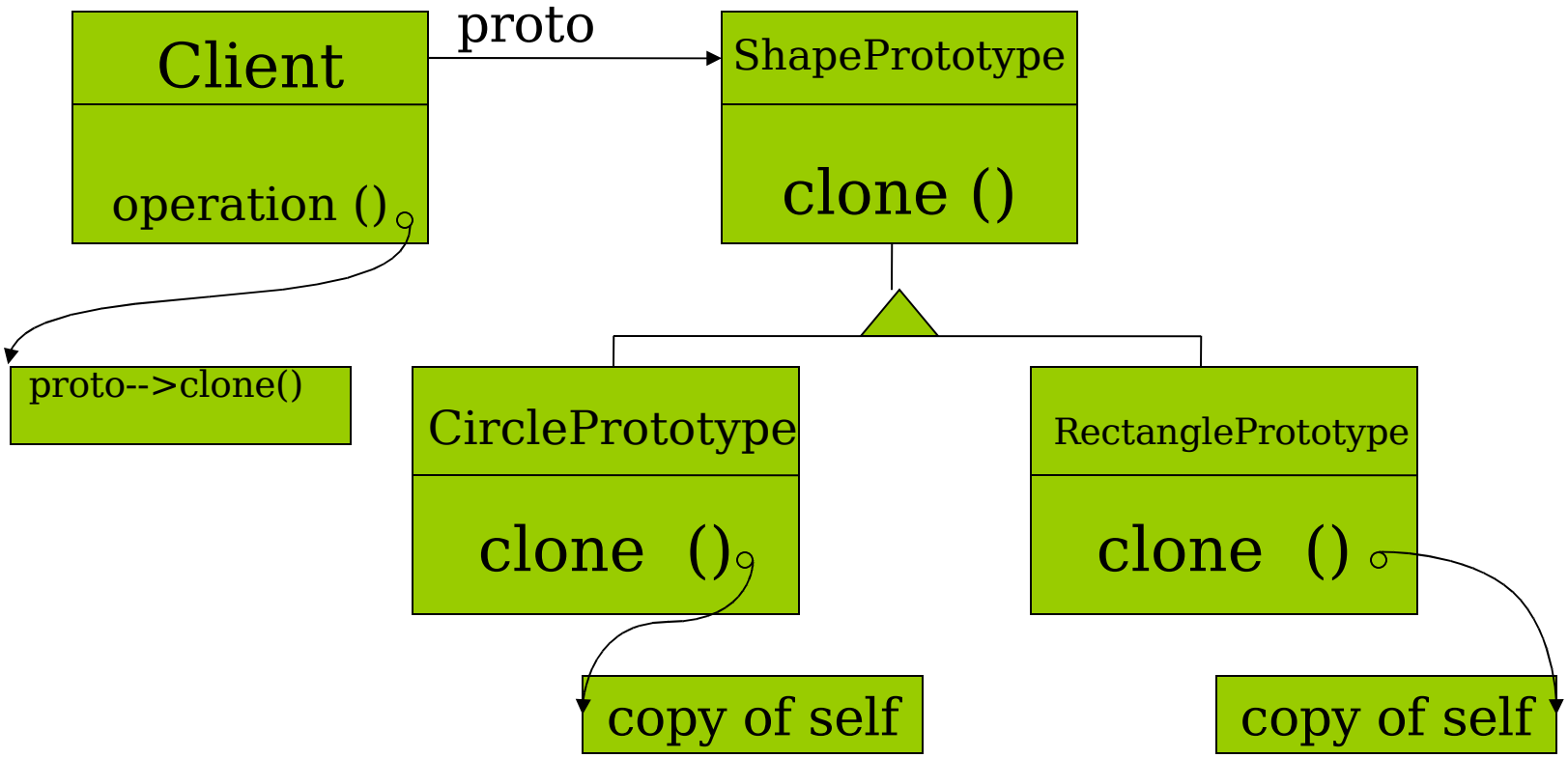
- Gamma described patterns in ET++ framework in his Ph.D. thesis in 1992
- Peter Code published an article on design patterns in an issue of CACM in 1992
- Code organized OOPSLA workshops on patterns in 1992 and 1993
- The pioneering book on design patterns by the *gang of four*
- Since then patterns have been discussed widely in the OO Software community

A Problem

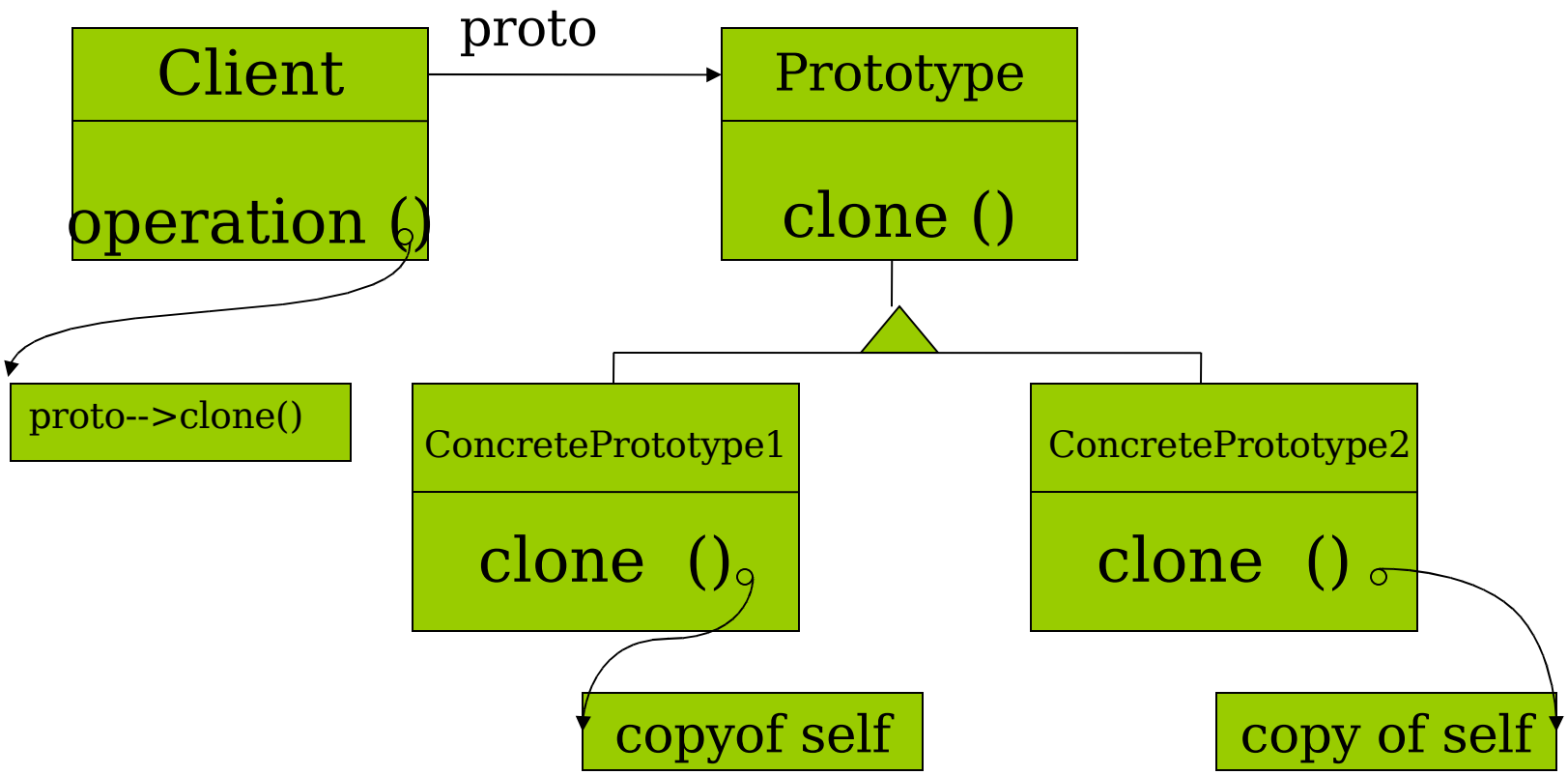
In a graphical editor, by clicking on an object, one can obtain a copy of the original object. Obtaining a copy of an existing object is a common design problem in on-line compositions.

We can provide a design solution to solve this problem, and reuse this design whenever similar situation arises.

The Solution



The Design Pattern: Prototype



Describing a Design Pattern

- Specify the generic problem that is solved
- Motivate the design pattern solution with the help of an example
- Provide the structure for the pattern
- Discuss collaborations between classes
- Discuss other issues related to the pattern such as trade-offs, implementation techniques etc.

Template provided by Erich Gamma et. al

- *Pattern name, its classification*
- *Intent, Motivation, Applicability*
- *Structure, Participants, Collaborations*
- *Consequences, Implementation, Sample code,*
- *Known uses*
- *Related patterns*

Classification of Patterns

- Creational Patterns
  - concerned about ways to create new objects
- Structural Patterns
  - concerned about the composition of objects and classes
- Behavioral Patterns
  - concerned about ways in which objects interact

Creational Patterns

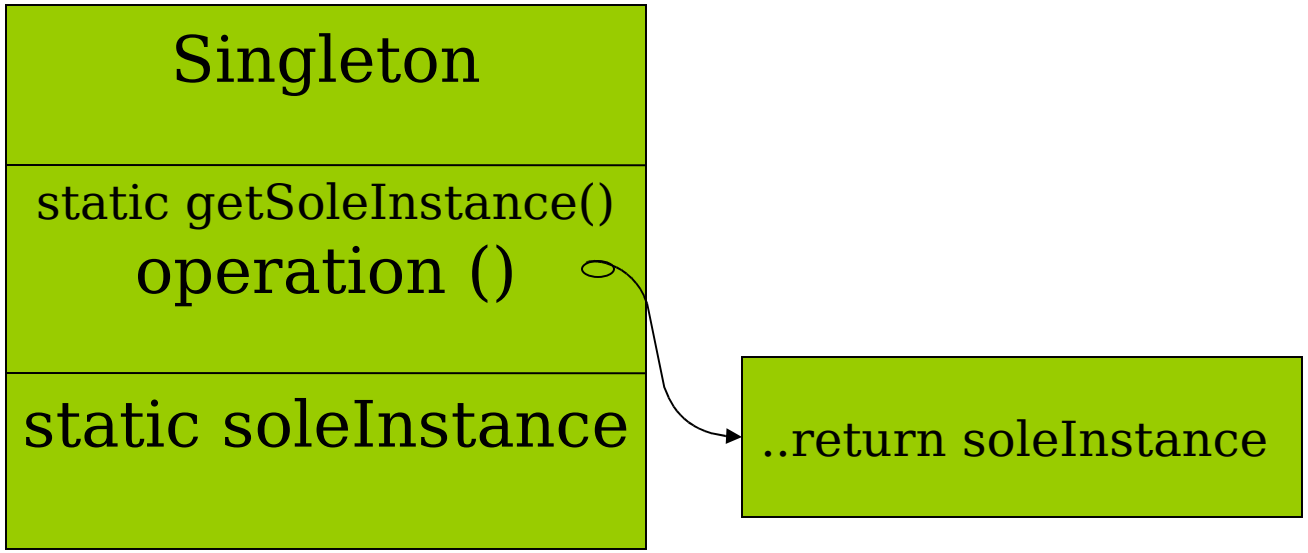
- Singleton
  - To create a sole instance of a class
- Prototype
  - To create objects by cloning existing objects
- Builder
  - build an object from existing representation

Creational Patterns

- Factory Method
  - defer instantiation to subclasses
- Abstract Factory
  - Provides interface to create families of objects without specifying the concrete classes of the objects

Singleton

A class that creates only one instance at most



Implementing Singleton

- Make the constructor protected
  - Prohibit normal creation mode
- A new instance can only be created through a class method
- The class method is the static method in our case
- Return the unique instance crated

Singleton.c

```
Class Singleton {
protected:
   Singleton () ;
public:
   static Singleton *getSoleInstance () {....};
private:
   static Singleton *soleInstance;
}
```

Factory Method

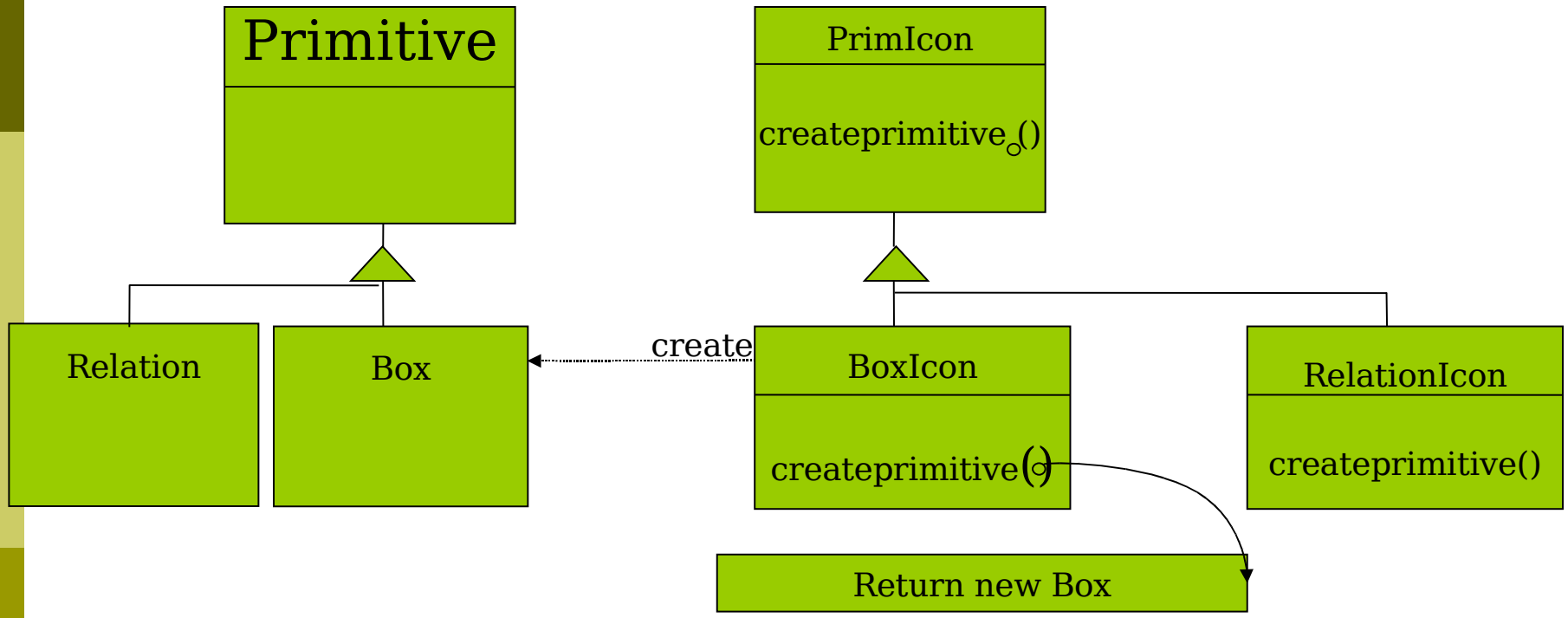
Example: In a modeling tool, you can select a type of entity or relation and then create an actual entity of the selected type. The selected icon thus acts as a factory or creator of some actual type.

An object is used to create another

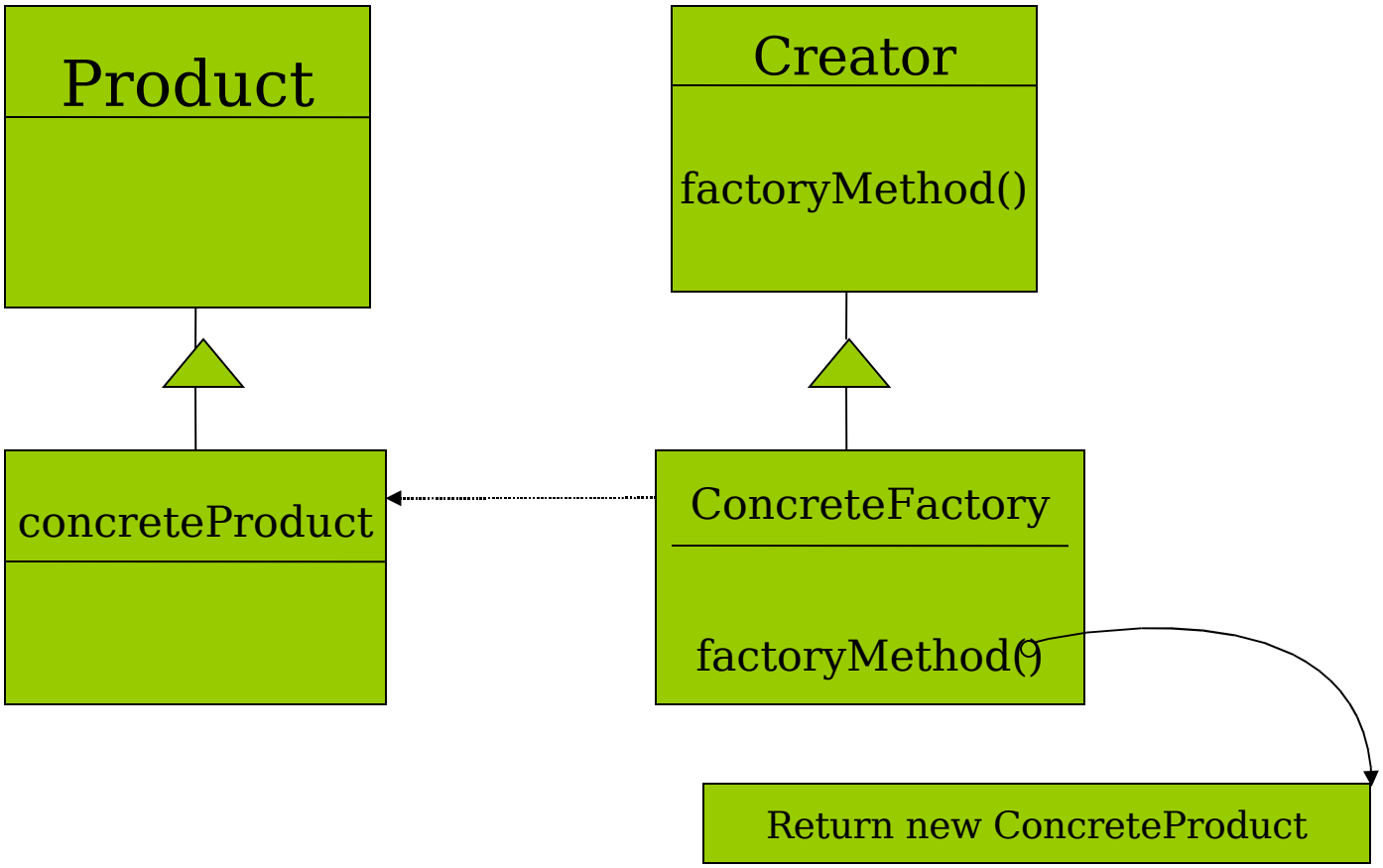
One creator object creates instances of one class

Hierarchy of creators, polymorphism on creation

An Example of Factory Method



The Factory Method Pattern



Structural Patterns

- Adapter
  - convert an interface to another
- Composite
  - Compose objects in a tree structure
- Decorator
  - Attach additional Responsibilities dynamically

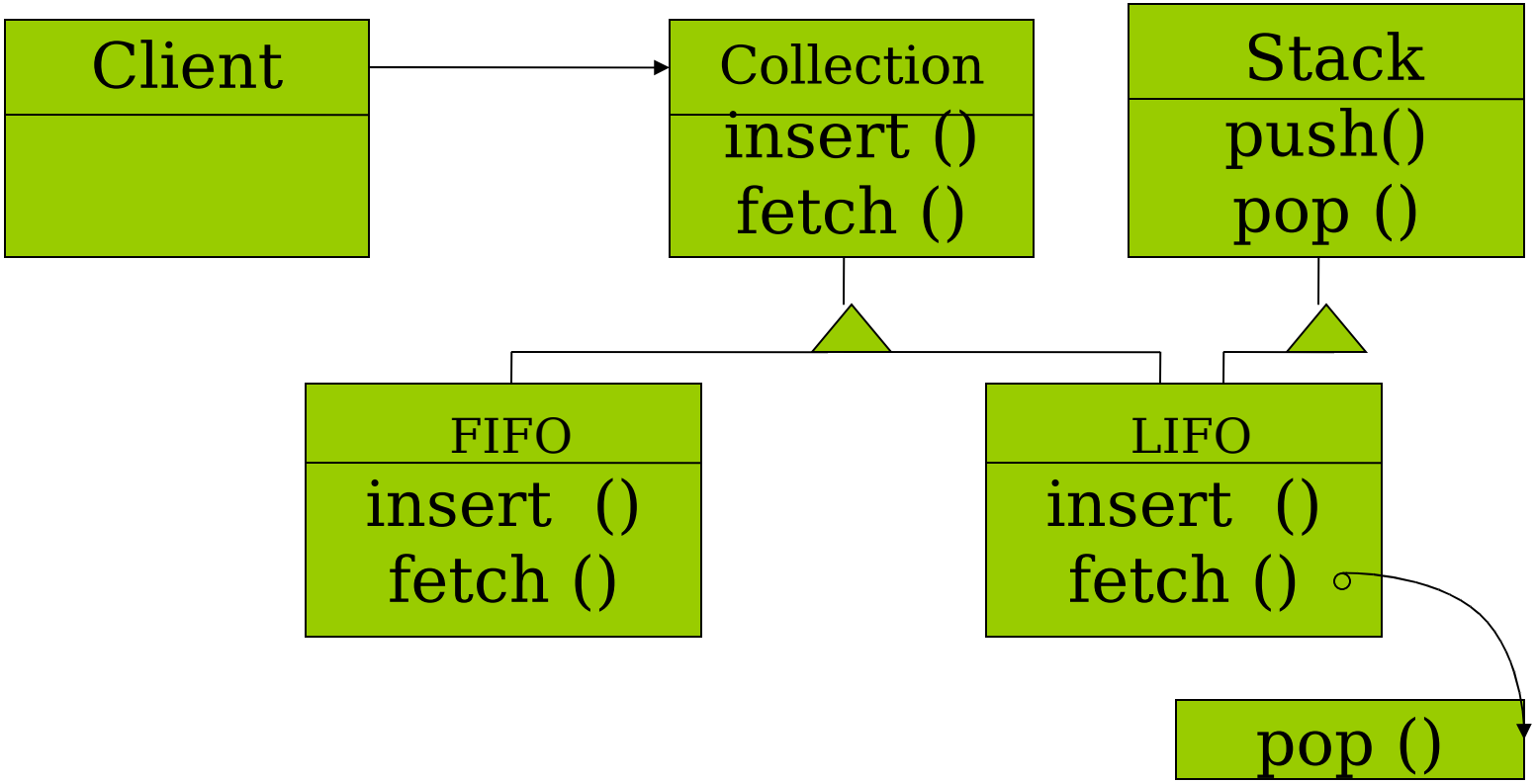
More Structural Patterns

- Proxy
  - Provide a surrogate or placeholder for another object
- Facade
  - Provide a unified interface to a set of interfaces in a subsystem
- Bridge
  - Decouple abstraction from implementation, let them vary independently

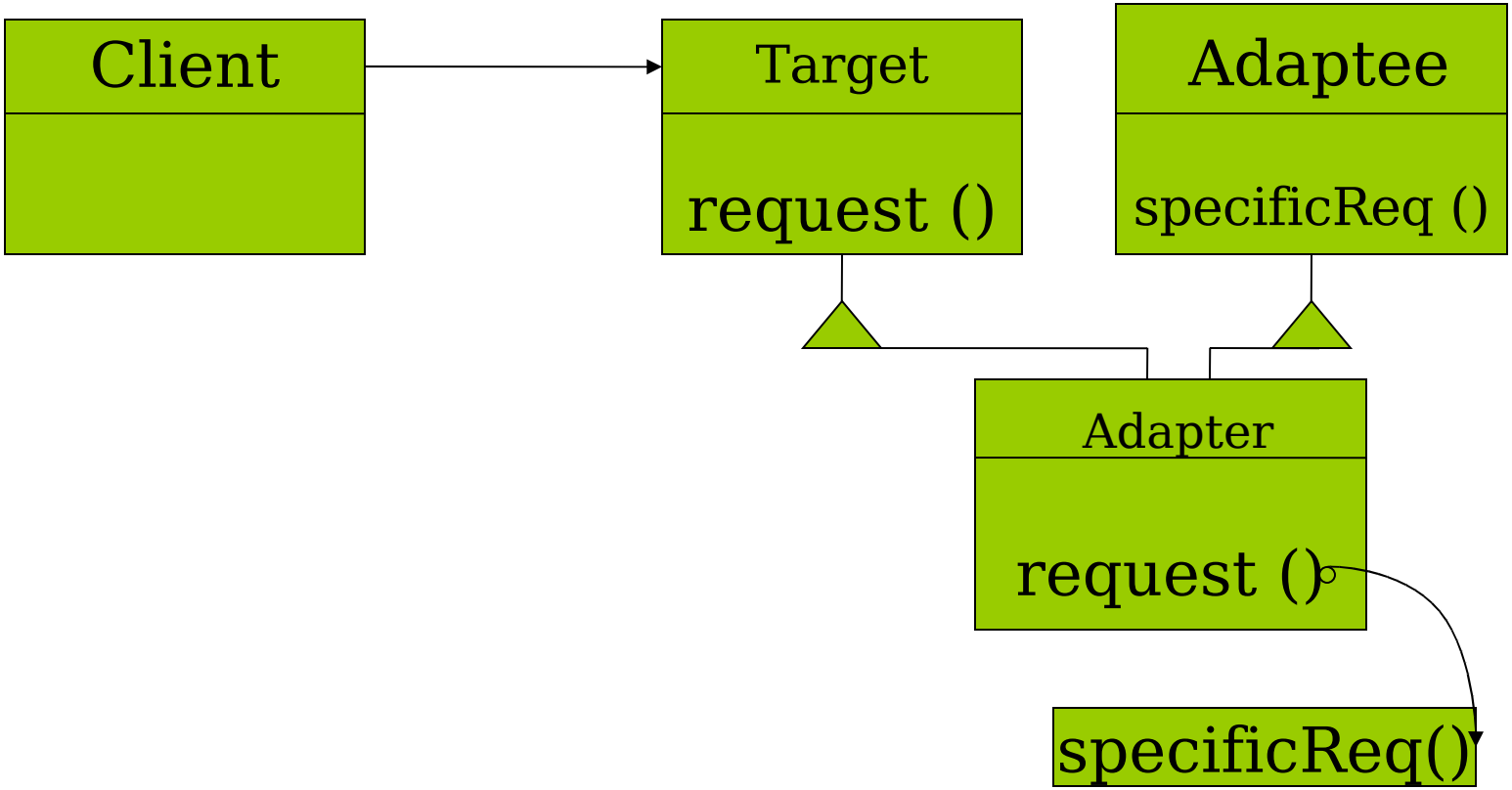
Adapter Pattern

- You are building a collection class hierarchy for collections such as FIFO, Set, LIFO
- You find that there is an existing class Stack which can be used for providing LIFO collection
- How do we adapt the existing class to the new interface of Collection classes?

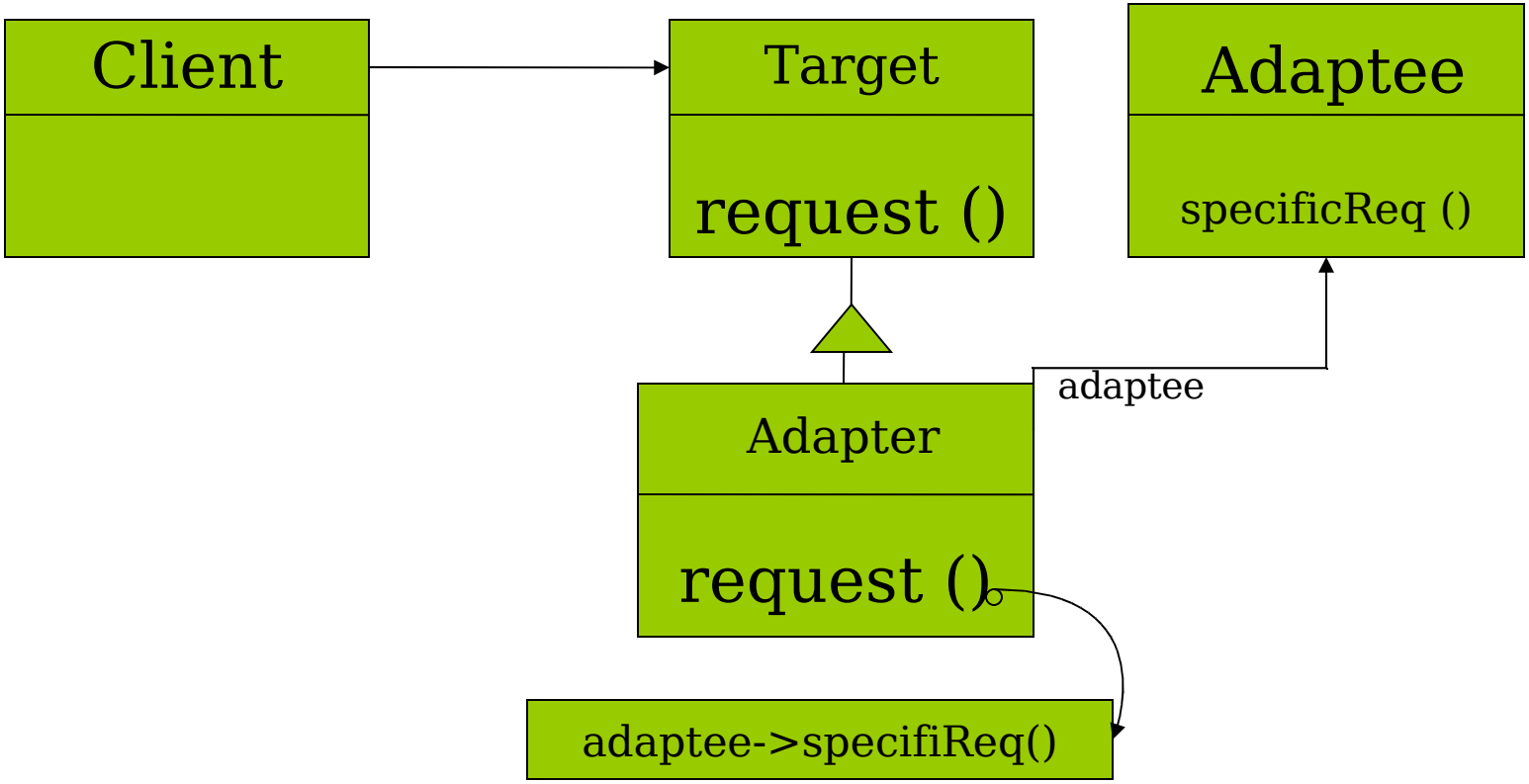
The Solution



The Adapter Pattern
Class Adapter



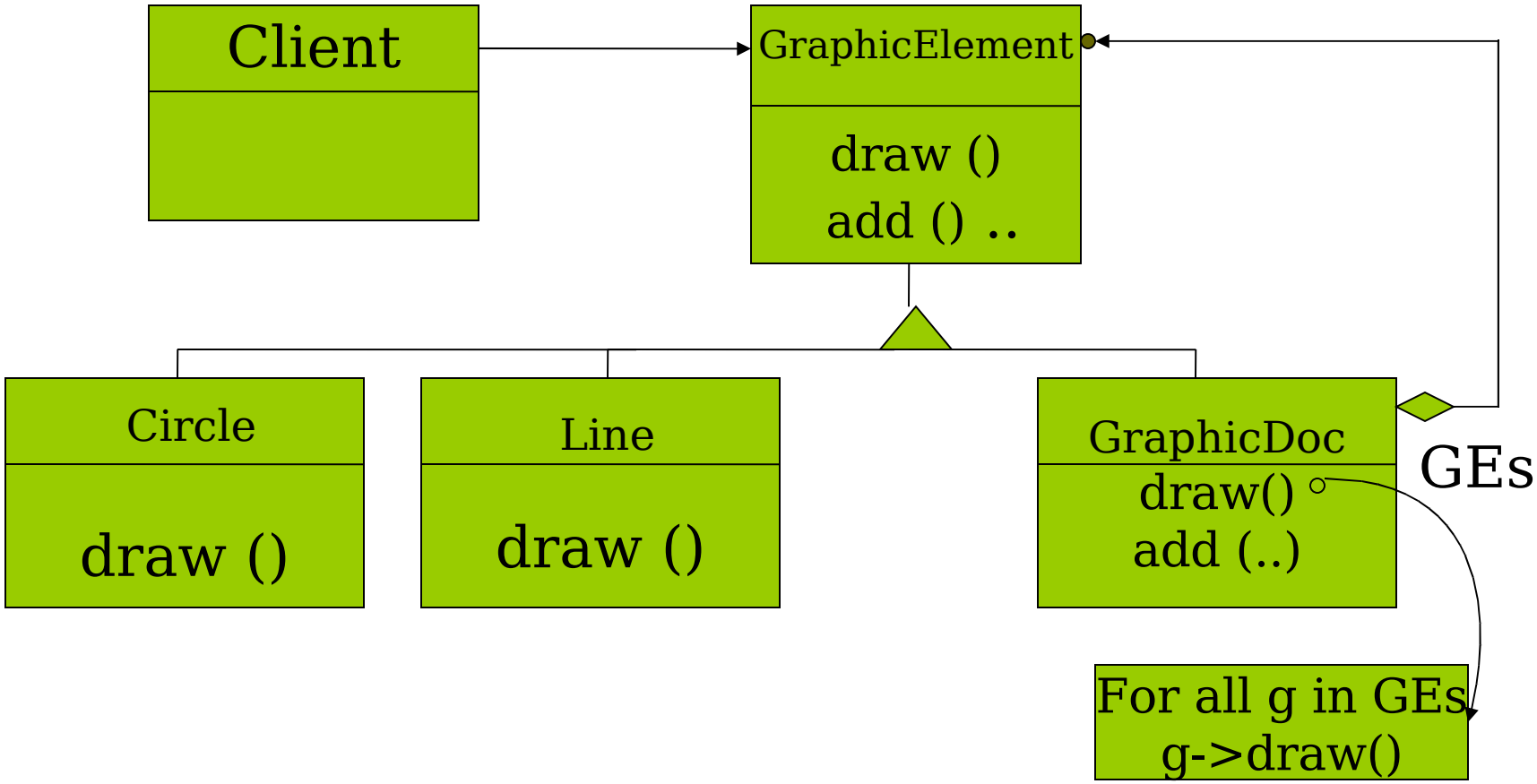
The Adapter Pattern
Object Adapter



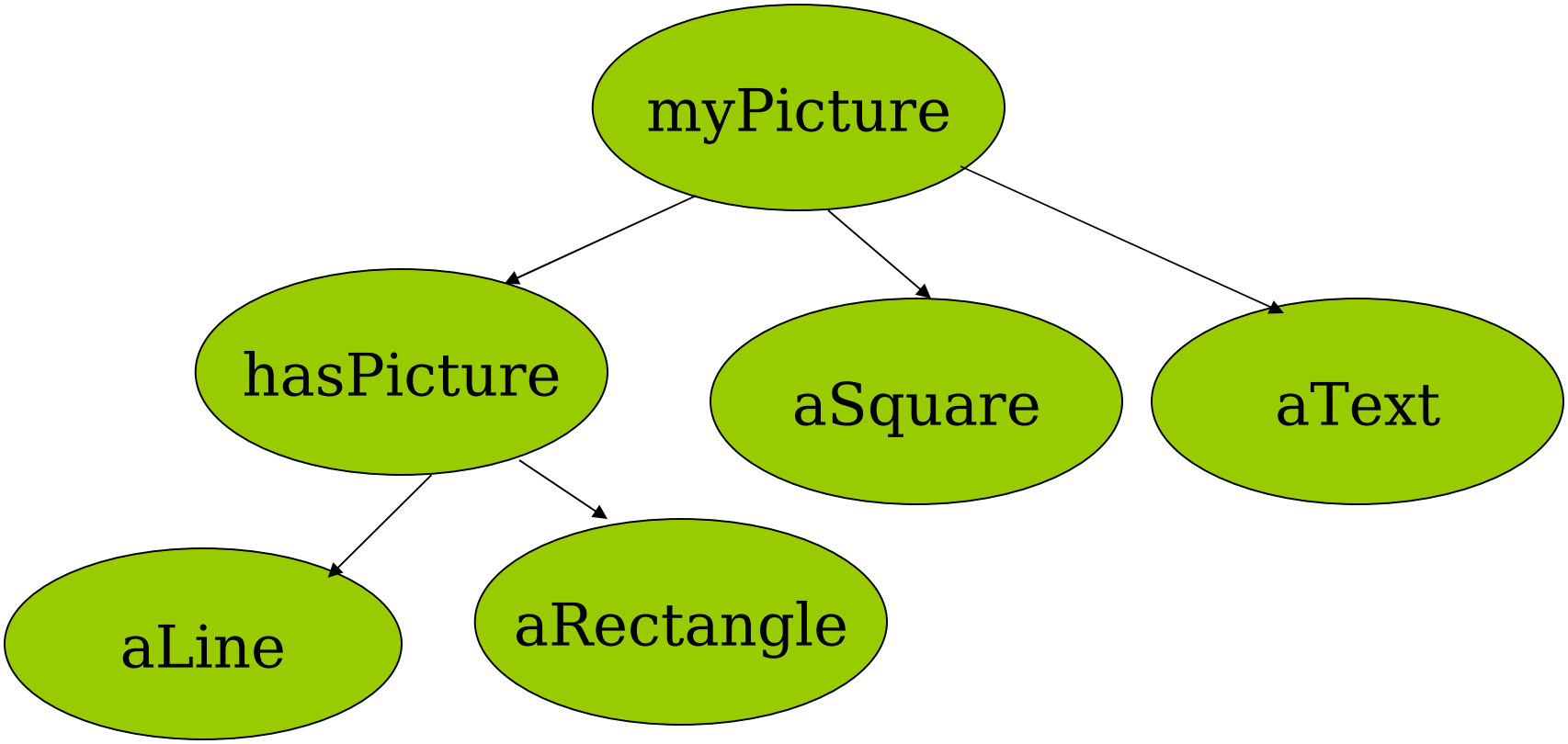
Composite Pattern

- An Example: A Graphic Document is composed of graphical objects such as Line, Rectangle, Circle, Text, Image or another Graphical Document
- Thus a graphic document is a tree structured composition

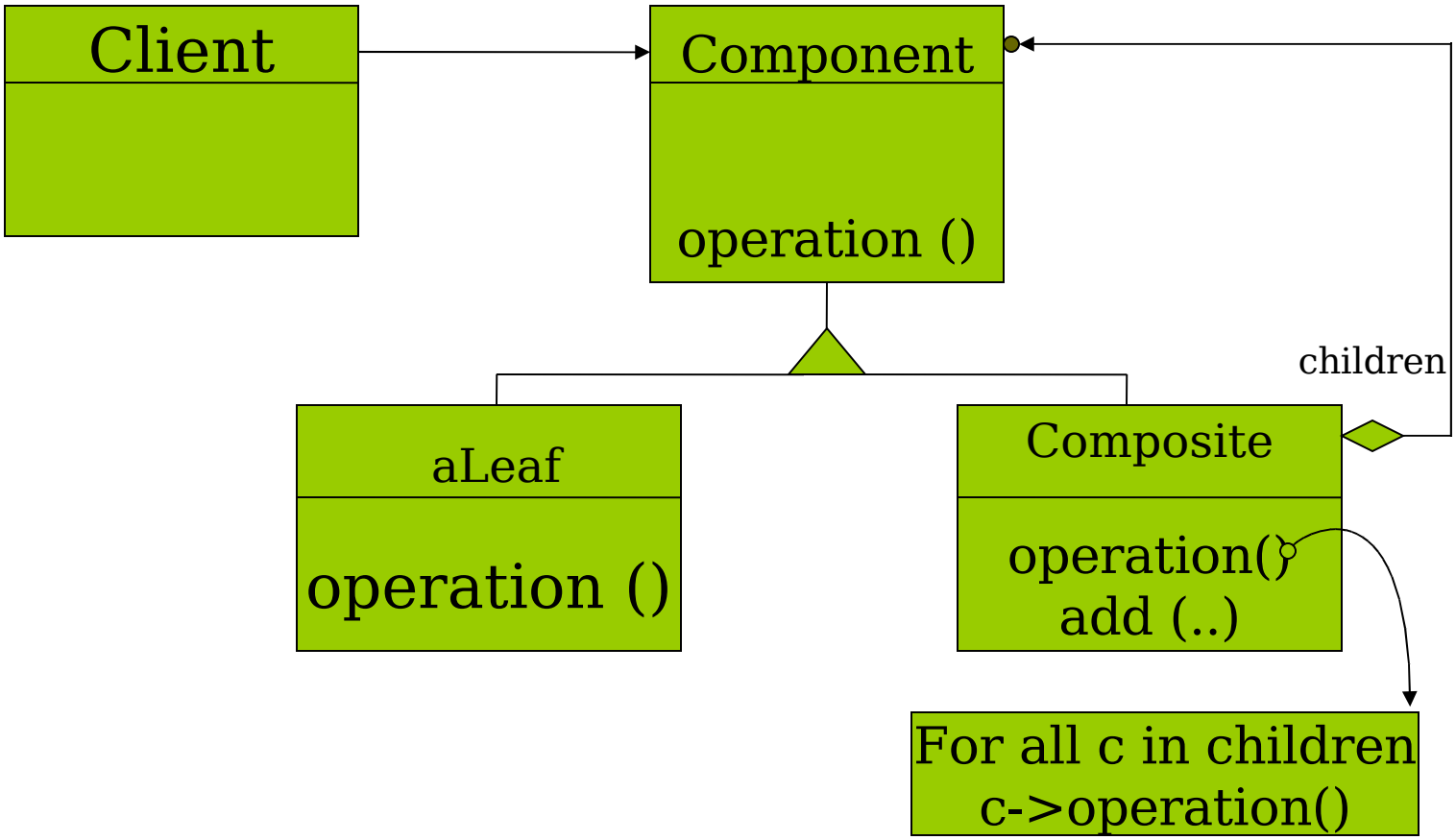
The Solution



Instance of a Composite Class

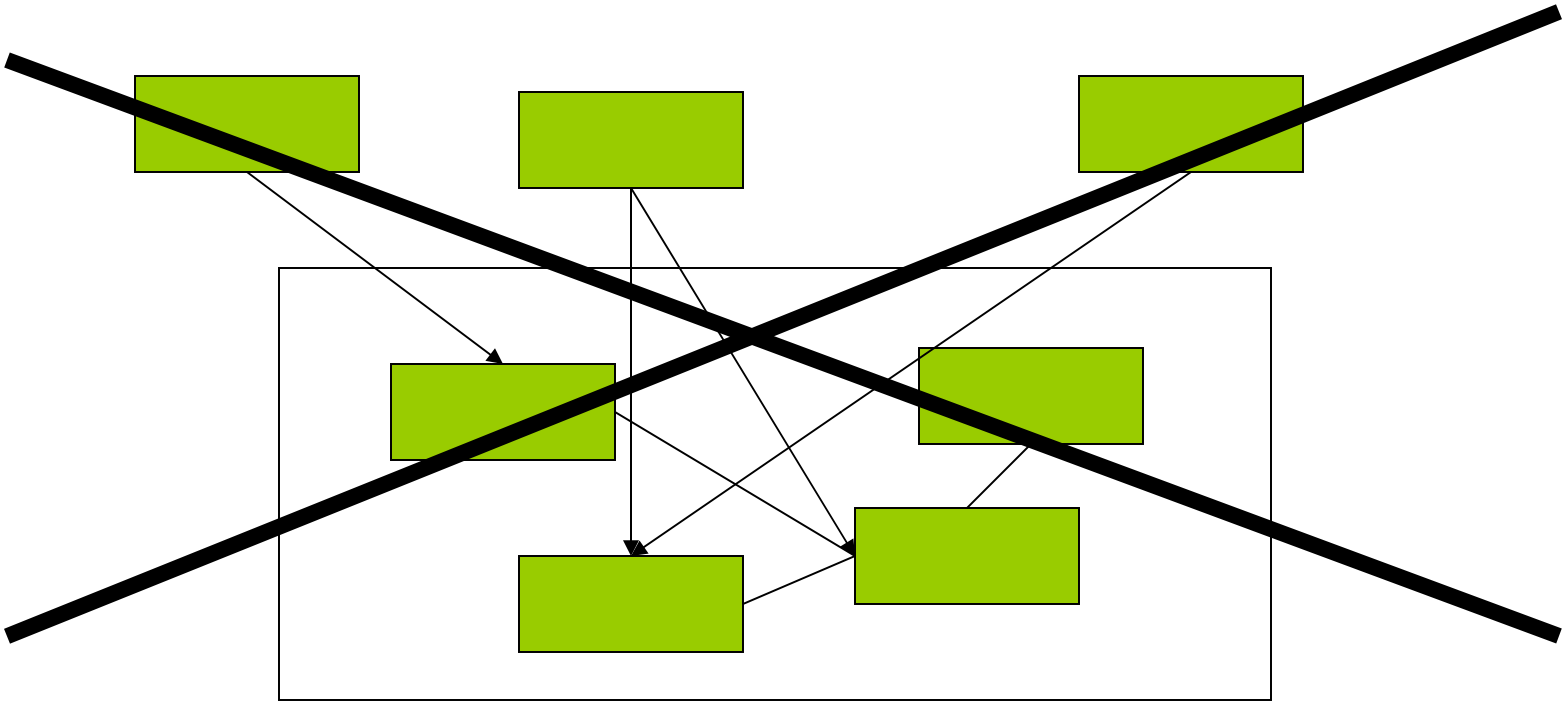


The Composite Pattern



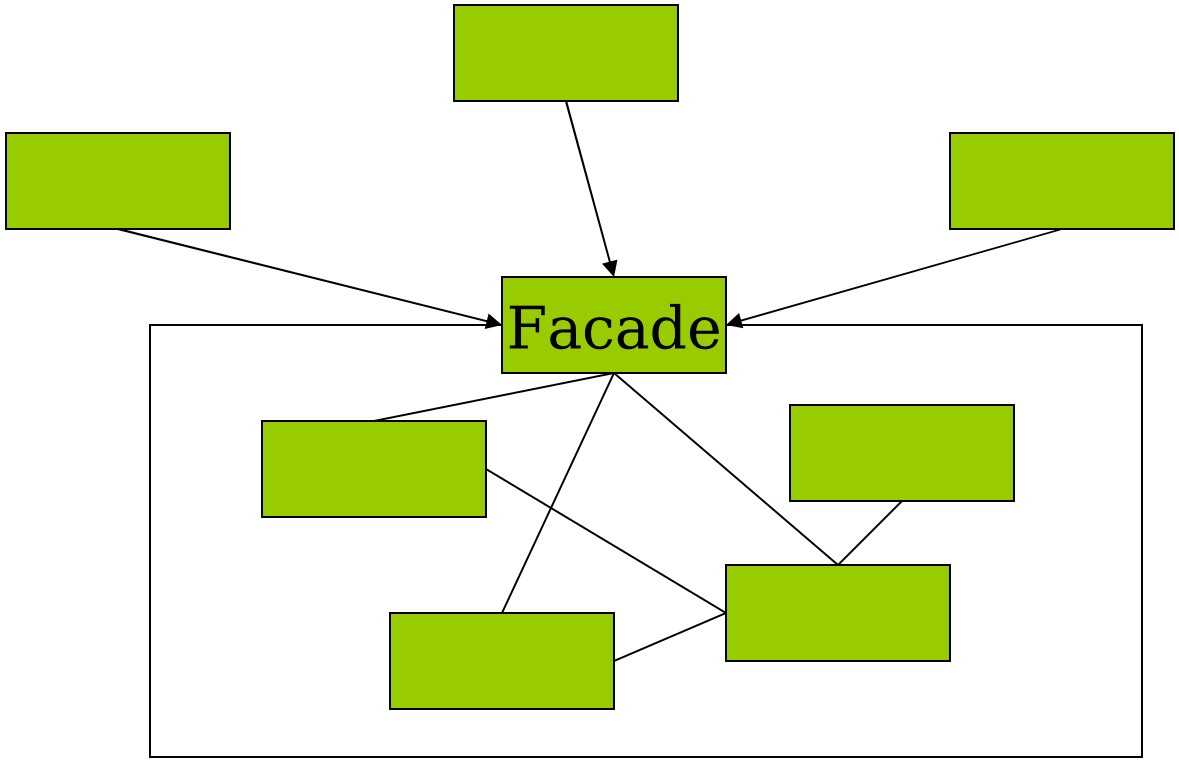
components within a subsystem?

Study the following scenario



The Facade Pattern

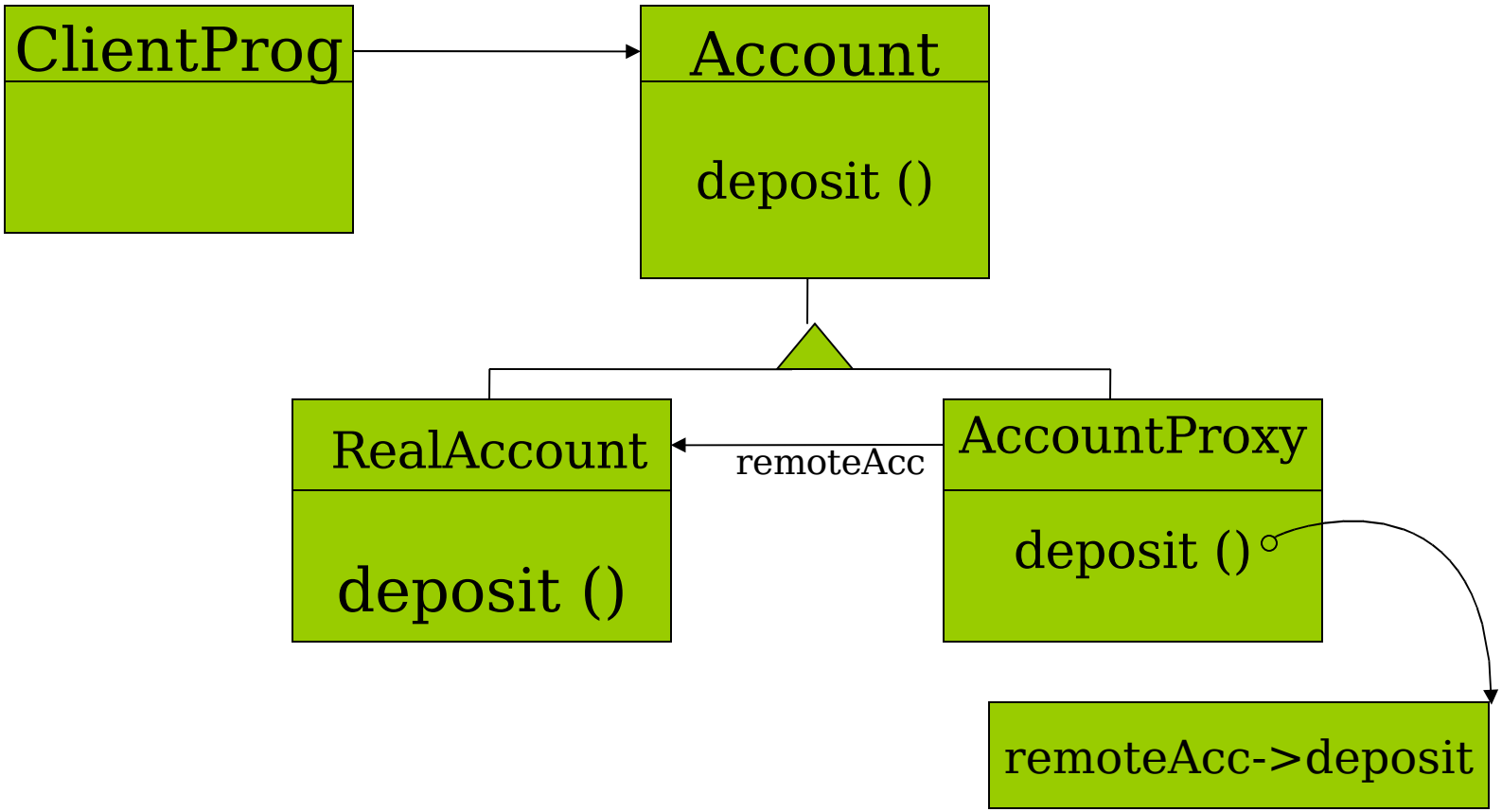
Provide a unified interface for a subsystem



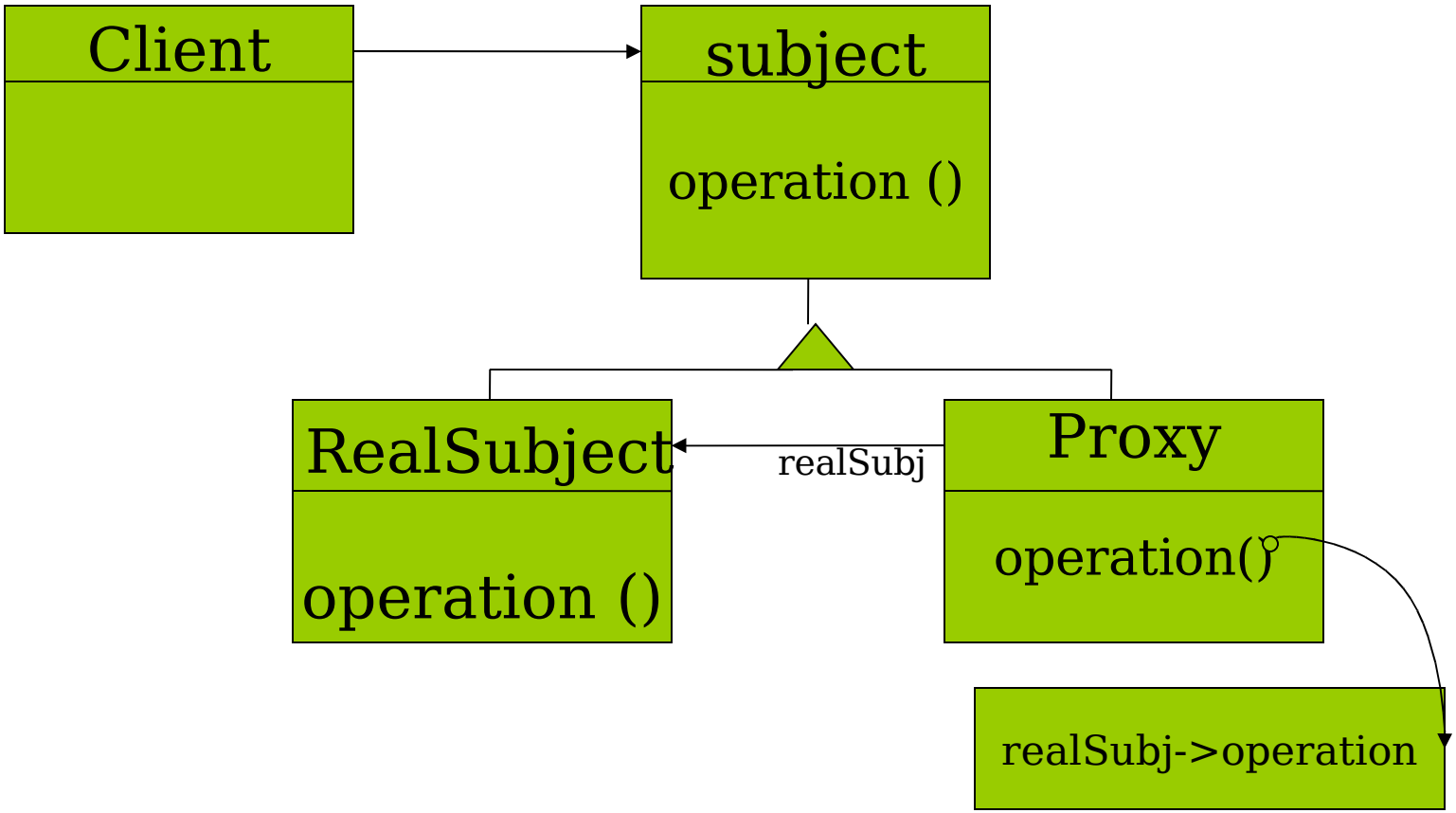
A Paradigm for Remoting

- Distribution transparency - Client unaware of the distributed nature of the server
- Location Transparency - Client unaware of the location of the server
- A client invokes methods on an object as if it is a local object
- *Proxy Handles* provide a mechanism to implement this paradigm

Designing Surrogate Objects



The Proxy Pattern



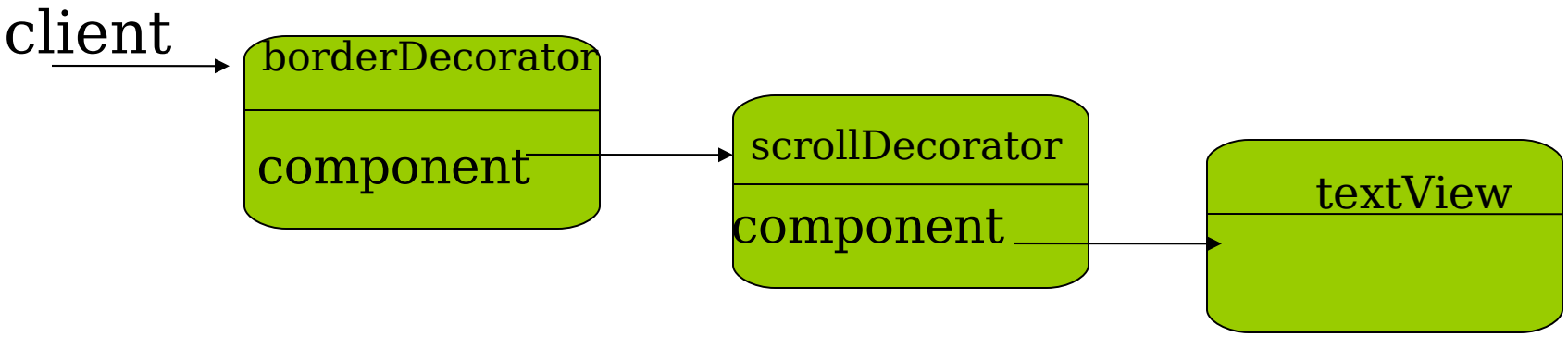
The Proxy

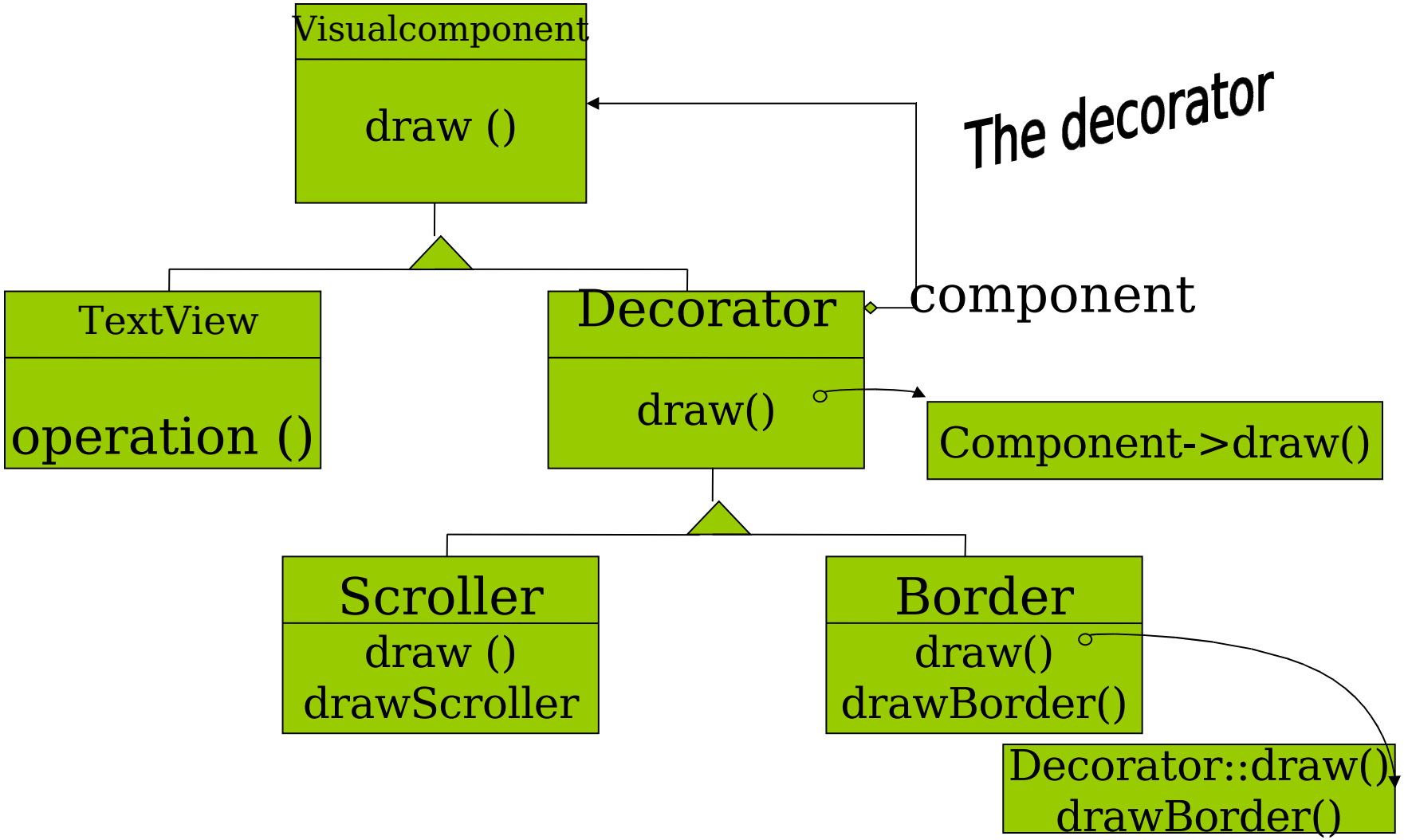
- Both real and proxy objects inherit from an abstract superclass
- Thus, they both provide the same interface
- Their implementations are different
- A client can handle anyone of them through generalization, i.e. a superclass pointer
- Internally proxy carries out the communication with the remote object

The Pattern

- Client has a pointer to the Subject
- Subject is the abstract superclass
- RealSubject is the server implementation
- Proxy is the proxy implementation available at the client process
- Proxy has a handle to RealSubject
- operation() is implementation differently by RealSubject and Proxy classes

The Decorator: Object Diagram




Visualcomponent
draw ()
The decorator
TextView
operation ()
Decorator
draw()
component
Component->draw()
Scroller
draw ()
drawScroller
Border
draw()
drawBorder()
Decorator::draw()
drawBorder()

References

[1] E. Gamma, R. Helm, R. Johnson, J. Vlissides, Design Patterns, Addison-Wesley, 1995

[2] W. Pree, Design Patterns for Object-Oriented Development, Addison-Wesley, 1995

[3] Linda Rising, The Patterns Handbook, Cambridge University Press, 1998