

Ingineria Programării

Cursul 7 – 31 Martie
adiftene@infoiasi.ro

Cuprins

- ▶ Din Cursurile trecute...
- ▶ Design Patterns
 - Elements
 - GOF
 - Creational Patterns
- ▶ Creational Patterns (not in GOF)
 - Lazy Initialization
 - Object Pool
- ▶ Structural Patterns
 - Adapter
 - Bridge
 - Composite
 - Decorator
 - Façade
 - Flyweight
 - Proxy

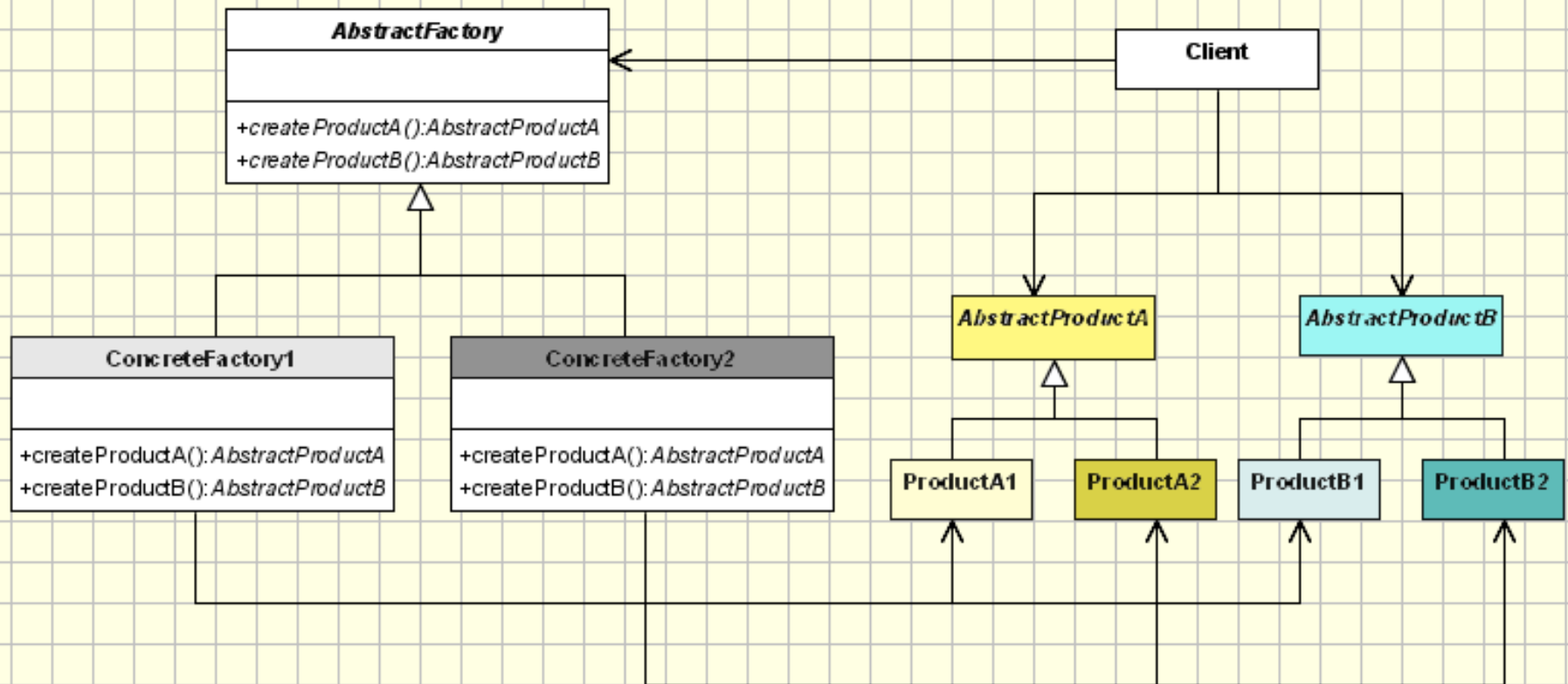
Din Cursurile Trecute

- ▶ Design Patterns: Definitions, Elements
- ▶ GOF: Creational Patterns, Structural Patterns, Behavioral Patterns
- ▶ Creational Patterns
 - Abstract Factory
 - Builder
 - Factory Method
 - Prototype
 - Singleton

CP – Abstract Factory

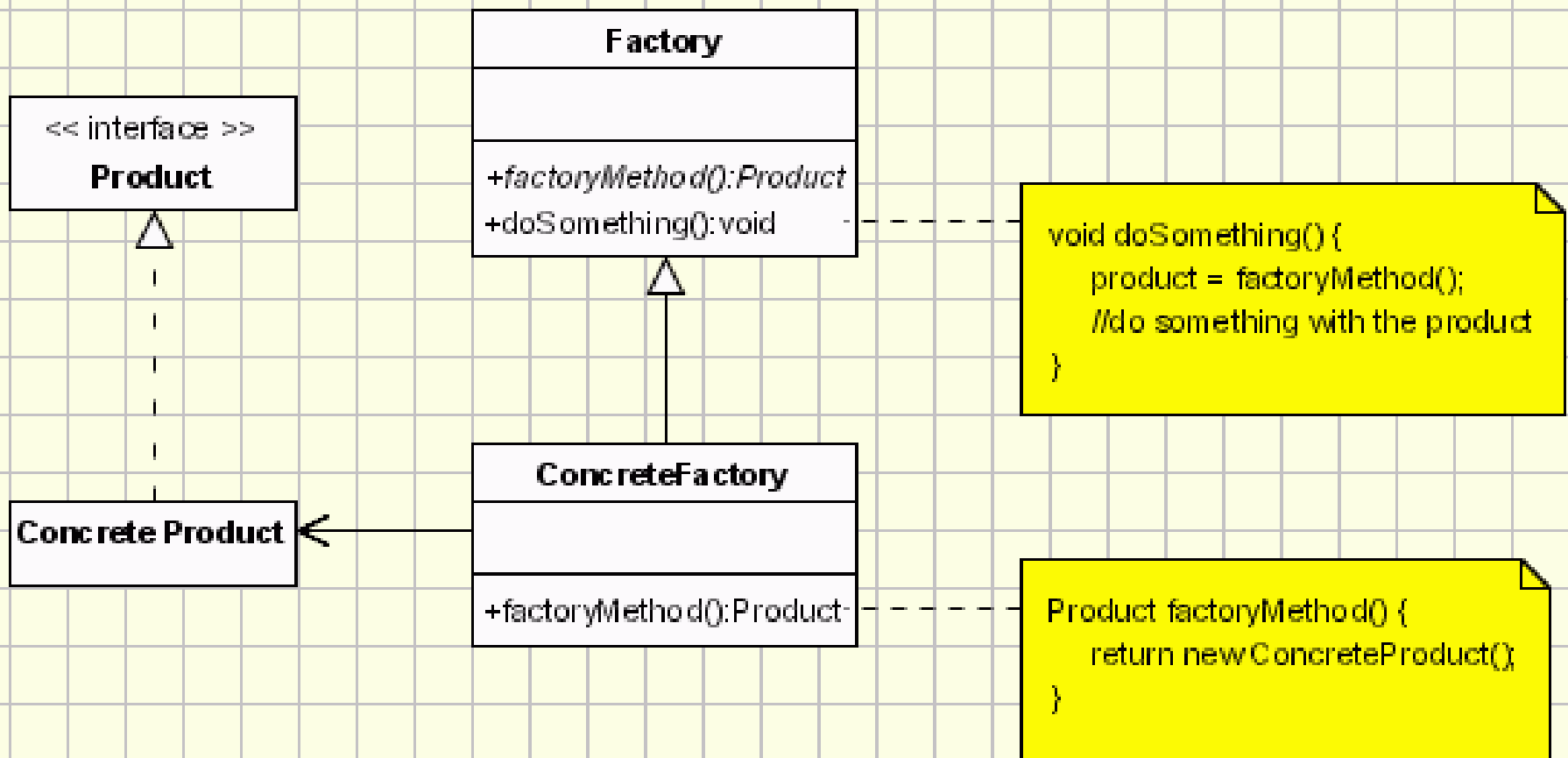
► Abstract Factory – maze, computer components

cd: Abstract Factory Implementation - UML Class Diagram



CP – Factory Method

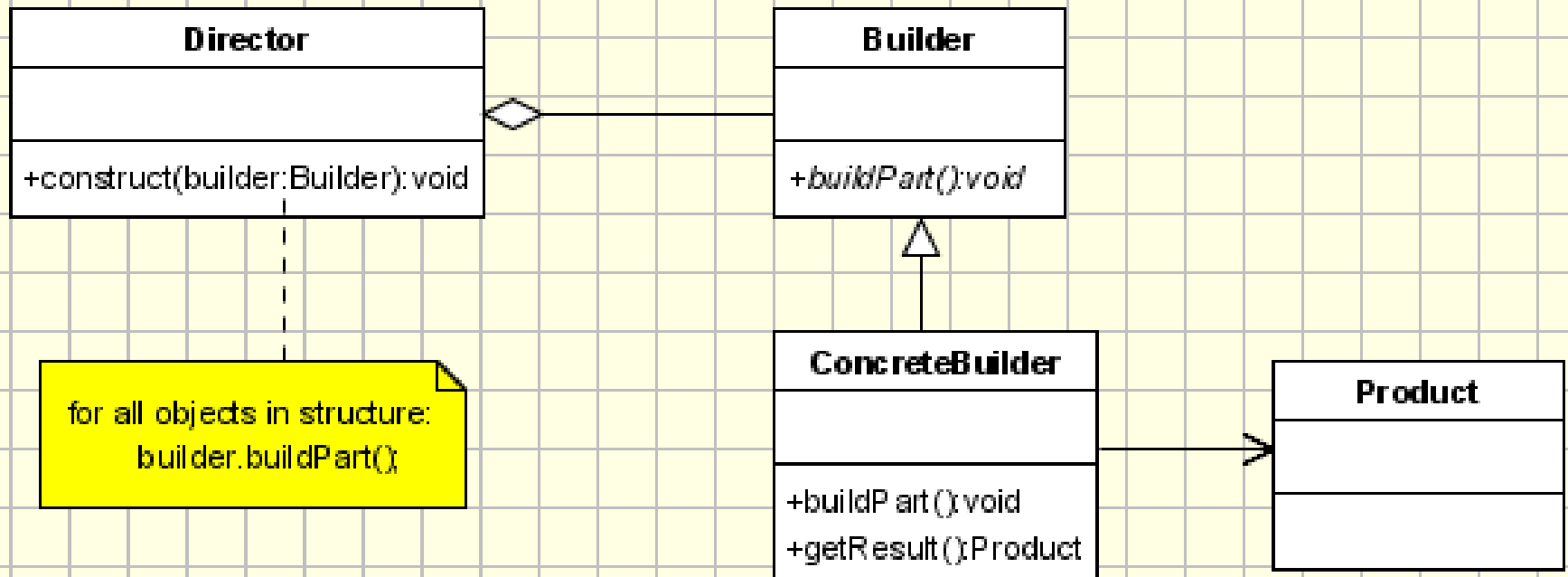
- ▶ Factory Method – Open/New Project, Hello Mr/Ms



CP – Builder

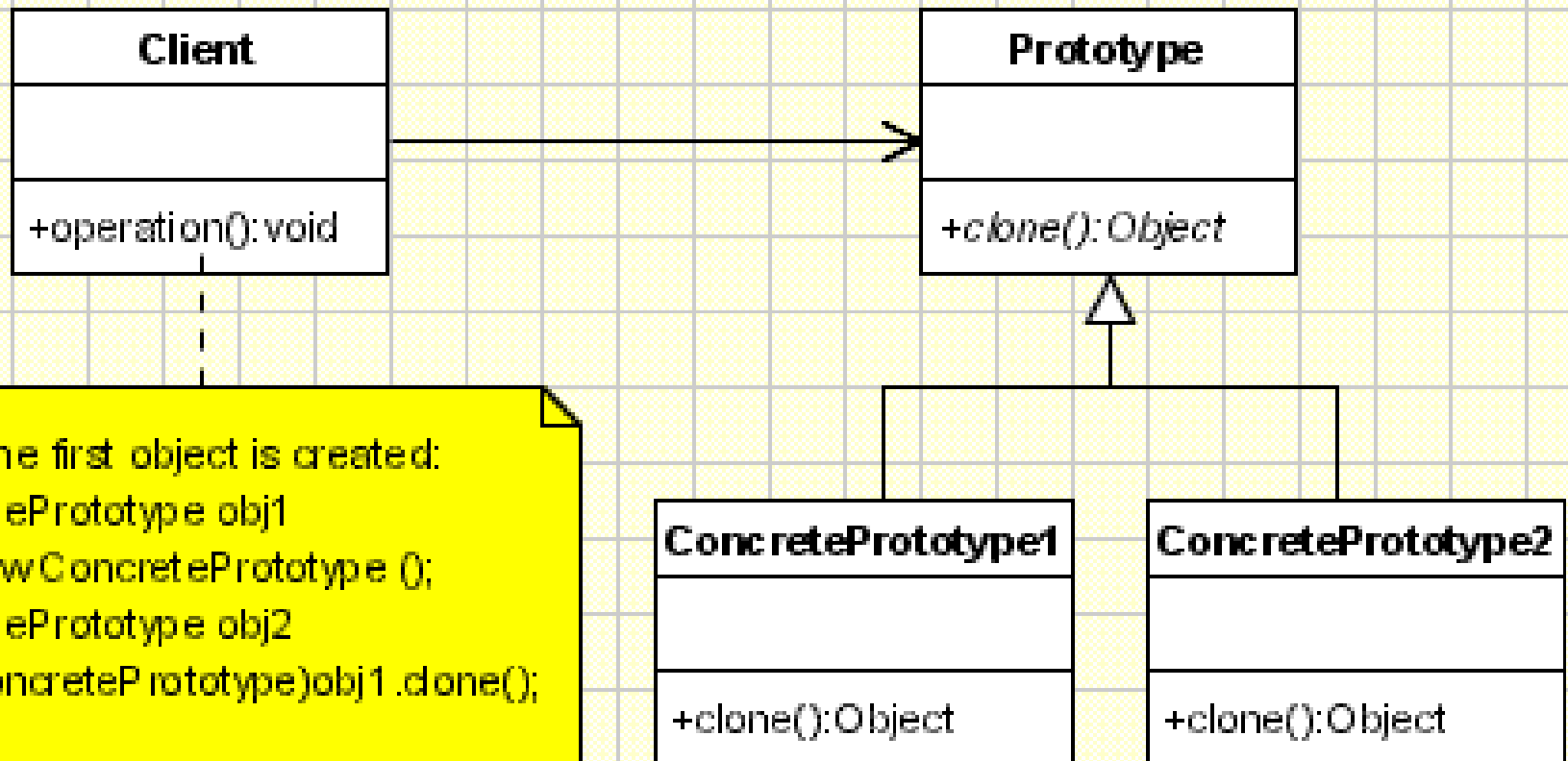
► Builder – RTF Reader, Happy Meal

cd: Builder Implementation - UML Class Diagram



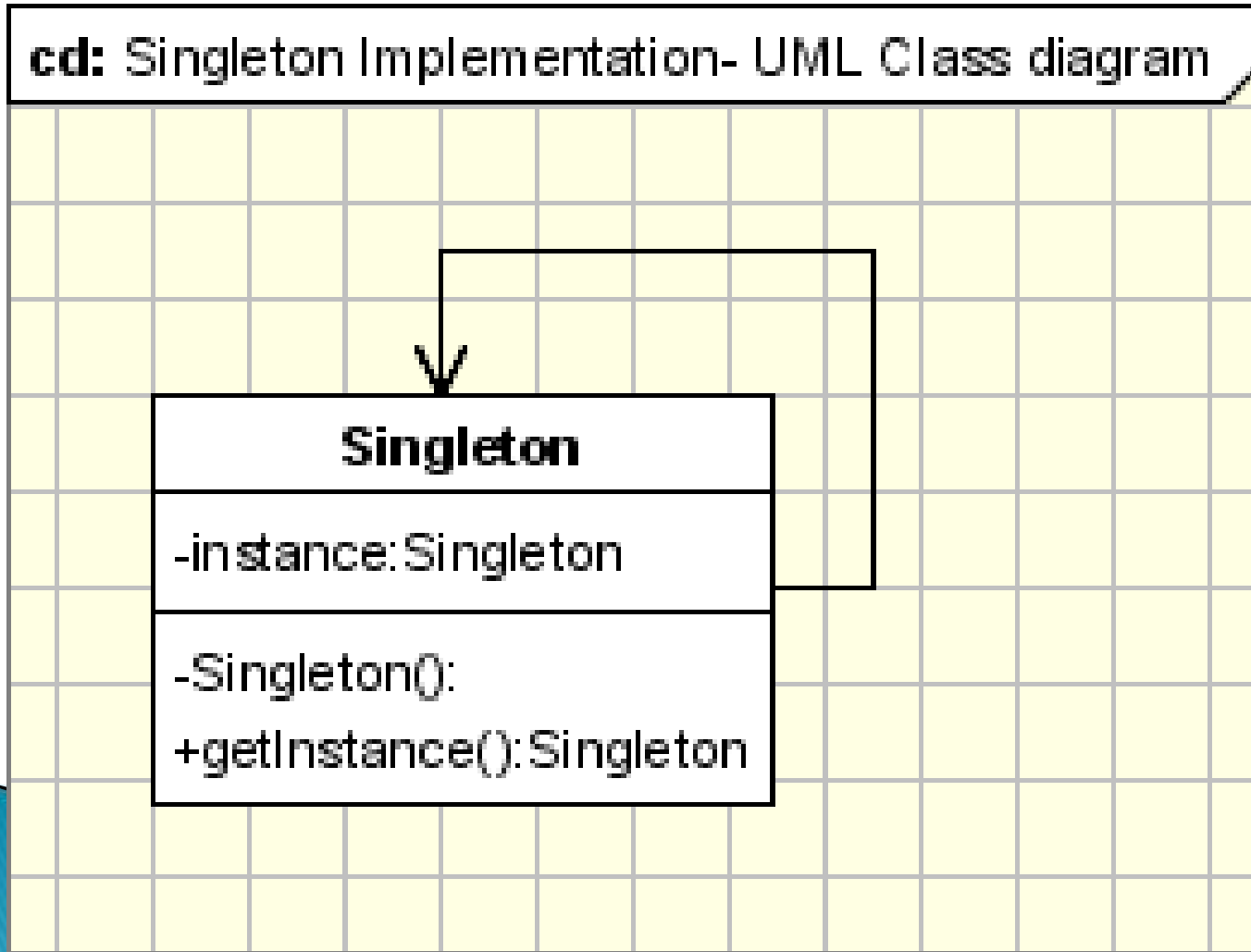
CP – Prototype

► Prototype – Music editor, Clonable



CP – Singleton

► Singleton – Logger



CP – Lazy initialization

- ▶ **Lazy initialization** is the tactic of delaying the creation of an object, the calculation of a value, or some other expensive process until the first time it is needed
- ▶ How? With a **flag**
- ▶ Each time when the object is called, the **flag** is tested:
 - If it is **ready**, it is **returned**
 - If **not**, it is **initialized**

Lazy initialization – Java 1

```
public class Fruit {  
    private static final Map<String,Fruit> types = new  
        HashMap<String, Fruit>();  
    private final String type;  
  
    //using a private constructor to force use of the factory method  
    private Fruit(String type) { this.type = type; }  
  
    public static synchronized Fruit getFruit(String type) {  
        if(!types.containsKey(type)) {  
            types.put(type, new Fruit(type)); // Lazy initialization  
        }  
        return types.get(type);  
    }  
}
```

Lazy Initialization – Java 2 (1)

```
public class Policy {  
    private SalesPerson salesperson;  
    // code missing to conserve space. . .  
    public SalesPerson getSalesPerson() {  
        return this.salesPerson; }  
}
```

Q: When we must create the SalesPerson object?

A1: You could create the SalesPerson object when the Policy is created

```
public Policy() {  
    this.salesPerson = new SalesPerson();  
}
```

Lazy Initialization – Java 2 (2)

A2: You could use lazy initialization to delay the creation until the SalesPerson object is actually needed

```
public Policy() {  
}  
public SalesPerson getSalesPerson() {  
    if ( this.salesPerson == null ) {  
        this.salesPerson = new SalesPerson();  
    }  
    return this.salesPerson;  
}
```

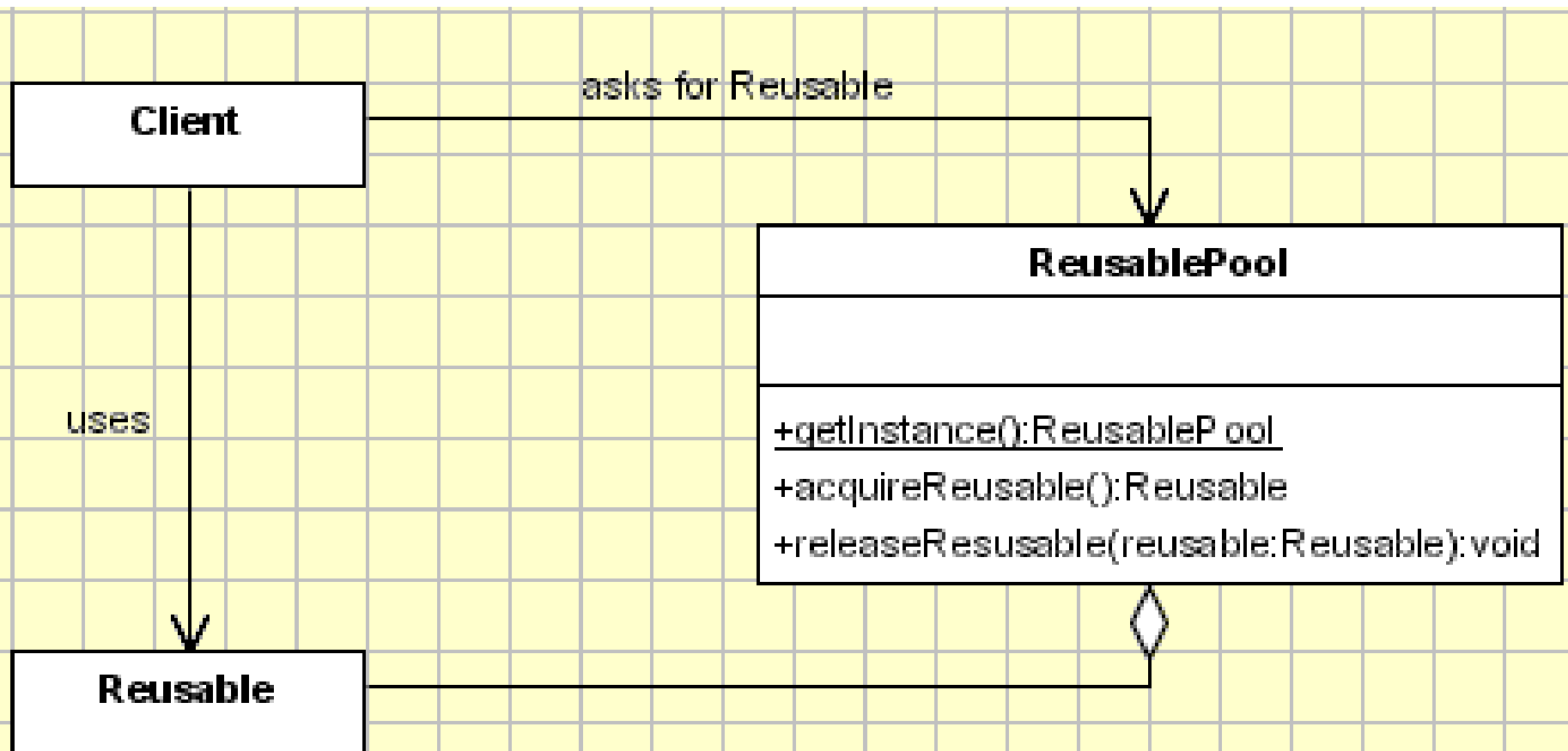
CP – Object Pool

- ▶ **Intent:** reuse and share objects that are expensive to create.
- ▶ **Motivation:** Performance can be sometimes the key issue during the software development and **the object creation (class instantiation) is a costly step.** The Object Pool pattern offer a mechanism to reuse objects that are expensive to create
- ▶ **Why use it?** Basically, we'll use an object pool whenever there are several clients who needs the same stateless resource which is expensive to create

Object Pool – Implementation (1)

- ▶ When a client asks for a Reusable object, the pool performs the following actions:
 - **Search** for an available Reusable object and if it **was found** it will be **returned** to the client.
 - **If no Reusable object was found** then it **tries to create a new one**. If this actions **succeeds** the new Reusable object will be **returned** to the client.
 - **If the pool was unable to create a new Reusable**, the pool will **wait** until a reusable object will be released.

Object Pool – Implementation (2)



Object Pool – Applicability

- ▶ Lets' take the example of the **database connections**. It's obviously that opening too many connections might affect the performance:
 - **Creating a connection is an expensive operation**
 - **When there are too many connections opened it takes longer to create a new one and the database server will become overloaded**
- ▶ Here the **object pool comes to manage the connections** and provide a way to reuse and share them. It can also limit the maximum number of objects that can be created

Structural Patterns 1

- ▶ **Structural patterns** are concerned with how classes and objects are composed to form larger structures
- ▶ **Example:** consider how **multiple inheritance** mixes two or more classes into one. The result is a class that combines the properties of its parent classes. This pattern is particularly useful for making independently developed class libraries work together.

Structural Patterns 2

- ▶ Rather than composing interfaces or implementations, structural *object patterns* describe ways to compose objects to realize new functionality
- ▶ The added flexibility of object composition comes from the ability to change the composition at run-time

Structural Patterns

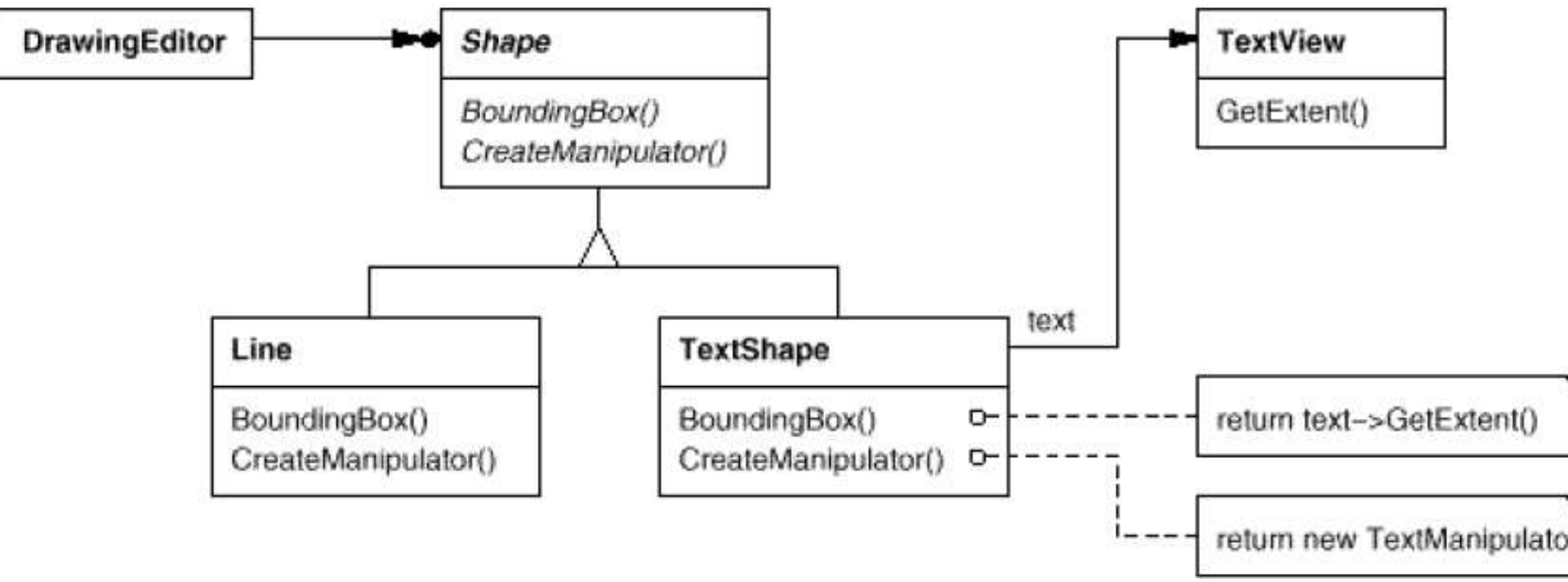
- ▶ Adapter
- ▶ Bridge
- ▶ Composite
- ▶ Decorator
- ▶ Façade
- ▶ Flyweight
- ▶ Proxy

Structural Patterns – Adapter

- ▶ **Intent:** Convert the interface of a class into another interface clients expect. Adapter lets classes work together that couldn't otherwise because of incompatible interfaces.
- ▶ **Also Known As:** Wrapper
- ▶ **Motivation:** Consider for example a drawing editor that lets users draw and arrange graphical elements (lines, polygons, text, etc.) into pictures and diagrams. The interface for graphical objects is defined by an abstract class called Shape. The editor defines a subclass of Shape for each kind of graphical object: a LineShape class for lines, a PolygonShape class for polygons, and so forth.

Adapter 1

- ▶ A TextShape subclass that can display and edit text is considerably more difficult to implement
- ▶ We suppose the existence of a TextView class for displaying and editing text. So we can consider TextShape derived from these classes

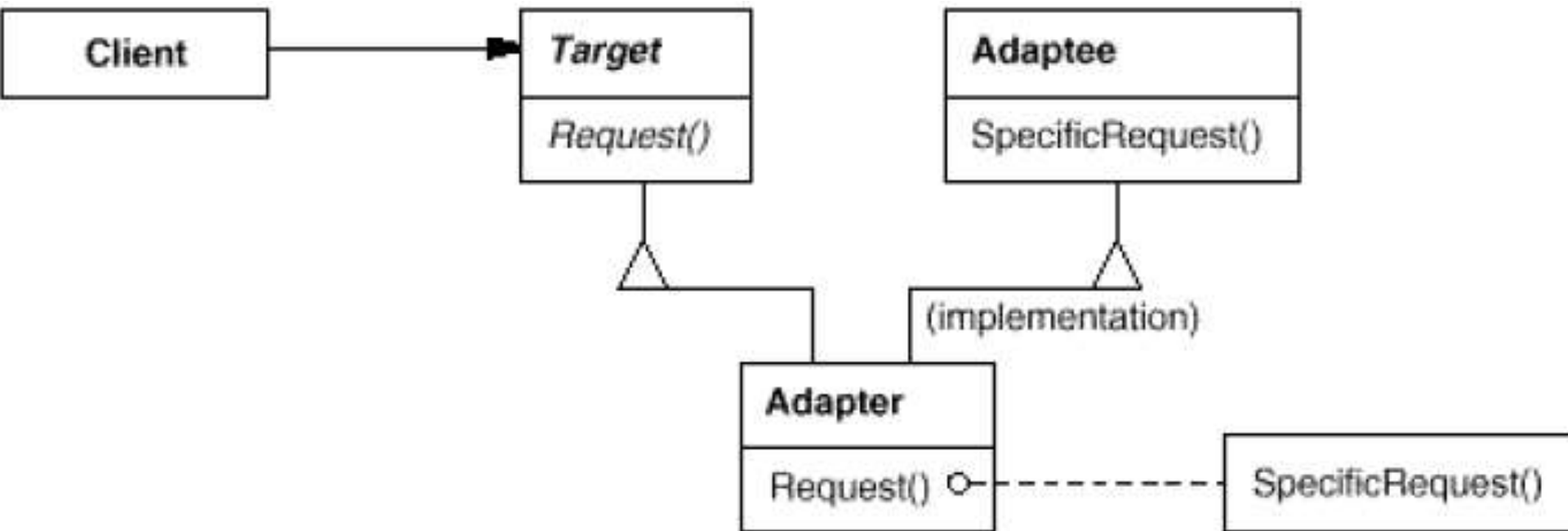


Adapter 2

- ▶ **Applicability** – Use the Adapter pattern when
 - you want to use an existing class, and its interface does not match the one you need
 - you want to create a reusable class that cooperates with unrelated or unforeseen classes, that is, classes that don't necessarily have compatible interfaces
 - *(object adapter only) you need to use several existing subclasses, but it's impractical to adapt their interface by sub classing every one.*

Adapter 3

- ▶ Structure – The Adapter pattern is used so that two unrelated interfaces can work together. This is something like we convert interface of one class into interface expected by the client.



Adapter – Example

- ▶ We all have electric sockets in our houses of different sizes and shapes. I will take an example of a socket of 15 Ampere. This is a bigger socket and the other one which is smaller is of 5 Ampere. A 15 Amp plug cannot fit into a 5 Amp socket => we will use an Adapter
- ▶ We have a 5 Amp plug and want a 5 Amp socket so that it can work. We DO NOT have a 5 Amp socket, what we have is a 15 Amp socket in which the 5 Amp plug cannot fit. The problem is how to cater to the client without changing the plug or socket.

Adapter – Java 1

```
/** The socket class has a specs for 15 AMP.*/  
public interface Socket {  
    public String getOutput();  
}
```

```
public class Plug {  
    private String specification = "5 AMP";  
    public String getInput() {  
        return specification;  
    }  
}
```

Adapter – Java 2

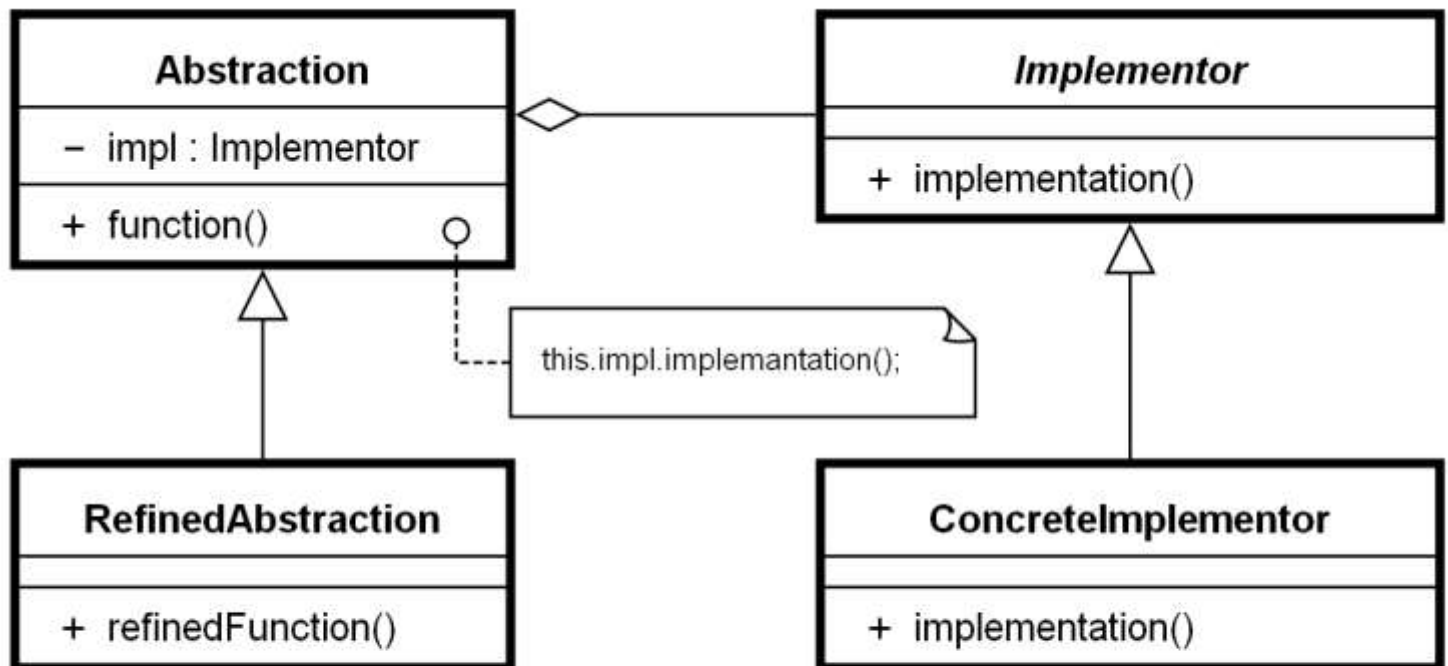
```
public class ConnectorAdapter implements Socket
{
    public String getOutput() {
        Plug plug = new Plug();
        String output = plug.getInput();
        return output;
    }
}
```

Structural Patterns – Bridge

- ▶ **Intent** – Decouple an abstraction from its implementation so that the two can vary independently
- ▶ **Also Known As** – Handle/Body
- ▶ **Motivation** – Consider the abstraction of shapes, each with its own properties. One thing all shapes can do is draw themselves. Drawing graphics to a screen can be dependent on different graphics implementations or operating systems. Shapes have to be able to be drawn on many types of operating systems

Bridge 1

- ▶ The bridge helps by allowing the creation of new implementation classes that provide the drawing implementation. Shape class provides methods for getting the size or properties of a shape. Drawing class provides an interface for drawing graphics



Bridge – Java 1

```
interface DrawingAPI {/** "Implementor" */
    public void drawCircle(double x, double y, double
radius);
}
/** "ConcretelImplementor" 1,2 */
class DrawingAPI1 implements DrawingAPI {
    public void drawCircle(double x, double y, double
radius) { System.out.printf("API1" + x + y + radius);}
}
class DrawingAPI2 implements DrawingAPI {
    public void drawCircle(double x, double y, double
radius) { System.out.printf("API2" + x + y + radius);}
}
```

Bridge – Java 2

```
interface Shape {/** "Abstraction" */  
    public void draw();  
    public void resizeByPercentage(double pct); }  
  
/** "Refined Abstraction" */  
class CircleShape implements Shape {  
    private double x, y, radius;  
    private DrawingAPI drawingAPI;  
    public CircleShape(double x, double y, double radius,  
        DrawingAPI drawingAPI) {  
        this.x = x; this.y = y; this.radius = radius;  
        this.drawingAPI = drawingAPI;  
    }  
    public void draw() {drawingAPI.drawCircle(x, y, radius); }  
    public void resizeByPercentage(double pct) { radius *= pct; }  
}
```

Bridge – Java 3

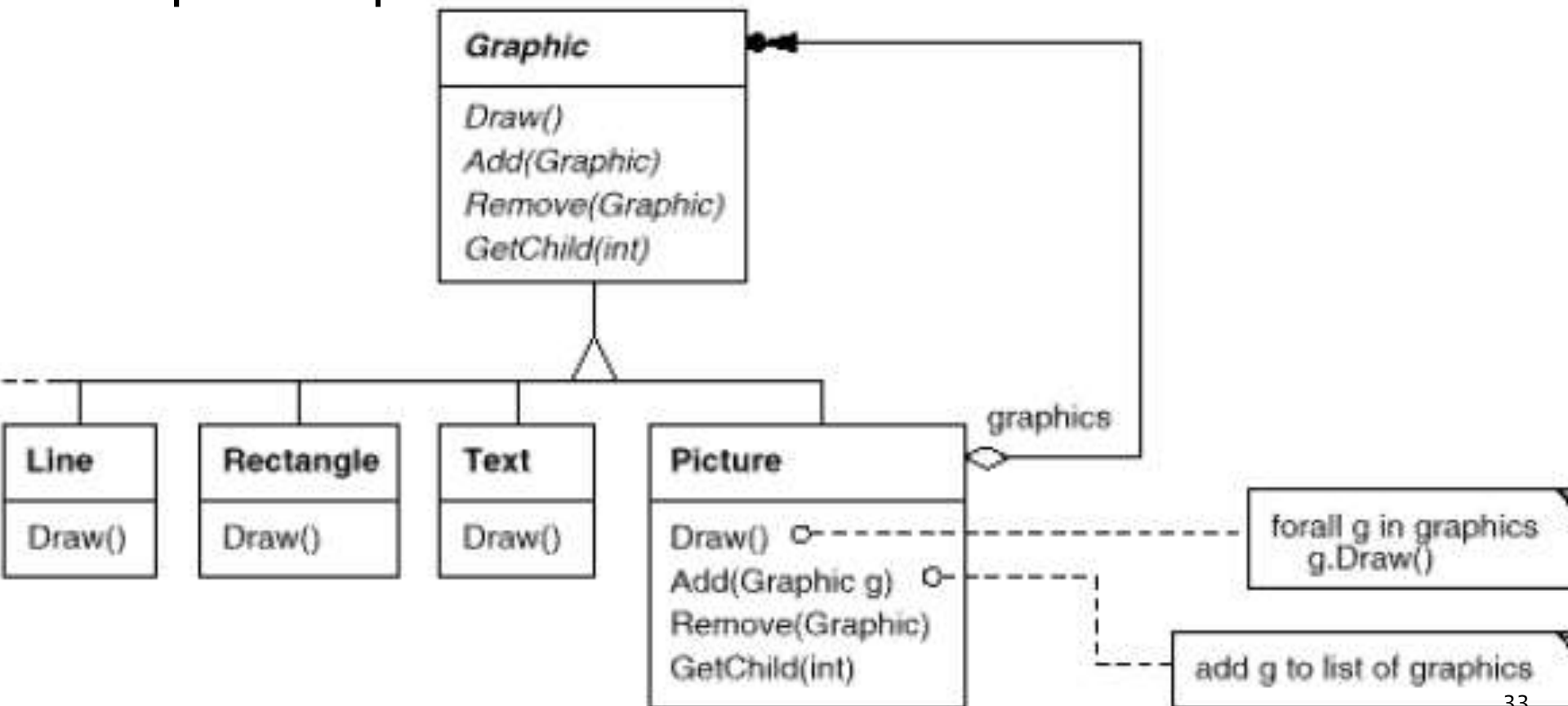
```
/** "Client" */  
class BridgePattern {  
    public static void main(String[] args) {  
        Shape[] shapes = new Shape[2];  
        shapes[0] = new CircleShape(1, 2, 3, new DrawingAPI1());  
        shapes[1] = new CircleShape(5, 7, 8, new DrawingAPI2());  
        for (Shape shape : shapes) {  
            shape.resizeByPercentage(2.5);  
            shape.draw();  
        }  
    }  
}
```

Structural Patterns – Composite

- ▶ **Intent** – Compose objects into tree structures to represent part-whole hierarchies. **Composite** lets clients treat individual objects and compositions of objects uniformly
- ▶ **Motivation** – Code that uses these classes must treat primitive and container objects differently, even if most of the time the user treats them identically.

Composite 1

- ▶ Graphics applications like drawing editors and schematic capture systems let users build complex diagrams out of simple components

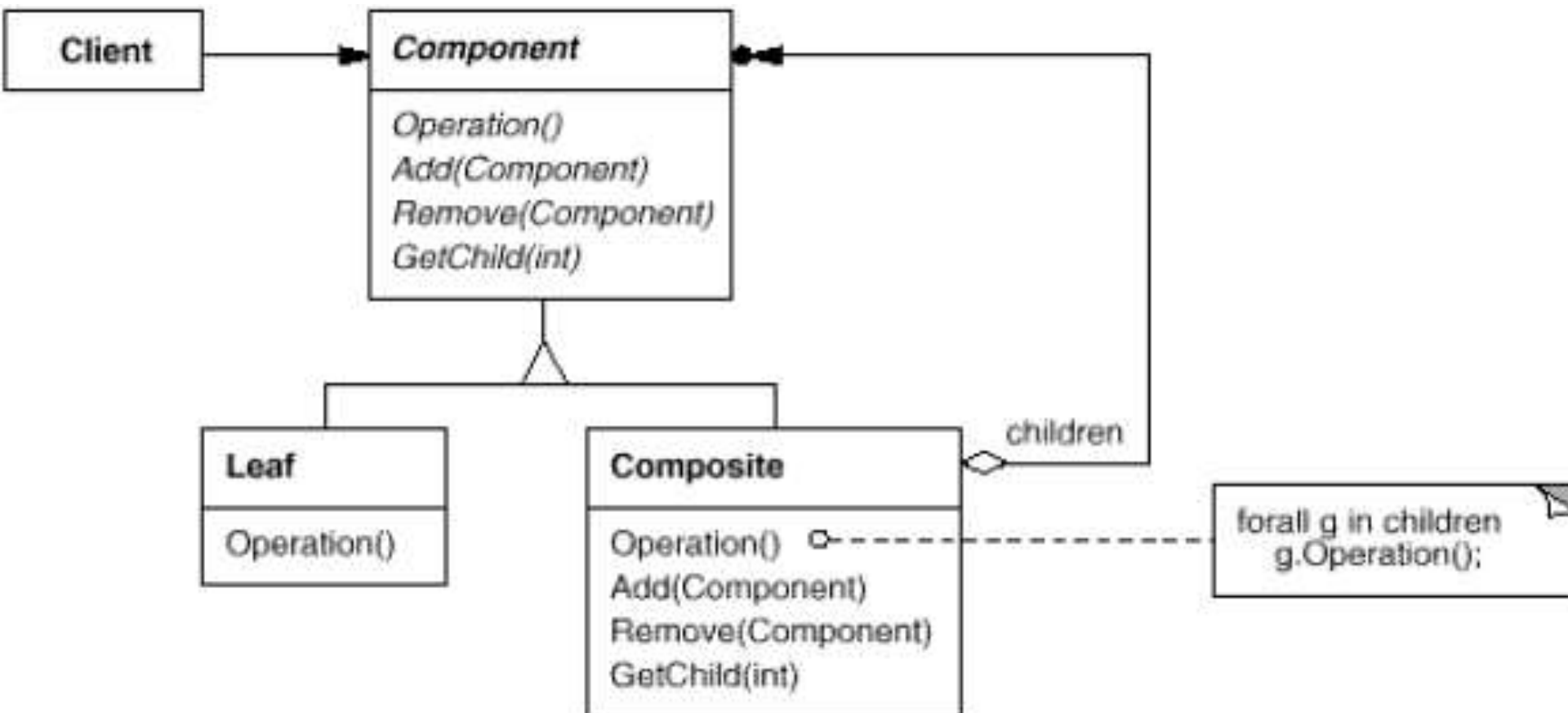


Composite 2

- ▶ **Applicability** – Use this pattern when
 - you want to represent part-whole hierarchies of objects
 - you want clients to be able to ignore the difference between compositions of objects and individual objects
 - Clients will treat all objects in the composite structure uniformly

Composite 3

► Structure



Composite – Example

- ▶ The most common example in this pattern is of a company's employee hierarchy
- ▶ The employees of a company are at various positions. Now, say in a hierarchy, the manager has subordinates; also the Project Leader has subordinates, i.e. employees reporting to him/her. The developer has no subordinates

Composite – Java 1

```
public class Employee {  
    private String name; private double salary;  
    private Vector subordinates;  
  
    public Vector getSubordinates() {return subordinates;}  
    public void setSubordinates(Vector subordinates) {  
        this.subordinates = subordinates;}  
  
    public Employee(String name, double sal) {  
        setName(name);setSalary(sal);  
        subordinates = new Vector();  
    }  
    public void add(Employee e) {subordinates.addElement(e);}  
    public void remove(Employee e) {subordinates.remove(e);}  
}
```

Composite – Java 2

```
private void addEmployeesToTree() {  
    Employee CFO = new Employee("CFO", 3000);  
    Employee headFinance1 = new Employee("HF. North", 2000);  
    Employee headFinance2 = new Employee("HF. West", 2200);  
    Employee accountant1 = new Employee("Accountant1", 1000);  
    Employee accountant2 = new Employee("Accountant2", 900);  
    Employee accountant3 = new Employee("Accountant3", 1100);  
    Employee accountant4 = new Employee("Accountant4", 1200);  
  
    CFO.add(headFinance1); CFO.add(headFinance2);  
    headFinance1.add(accountant1); headFinance1.add(accountant4);  
    headFinance2.add(accountant2); headFinance2.add(accountant3);  
}
```

CFO = chief financial officer

Composite – Java 3

- ▶ Once we have filled the tree up, now we can get the tree for any employee and find out whether that employee has subordinates with the following condition.

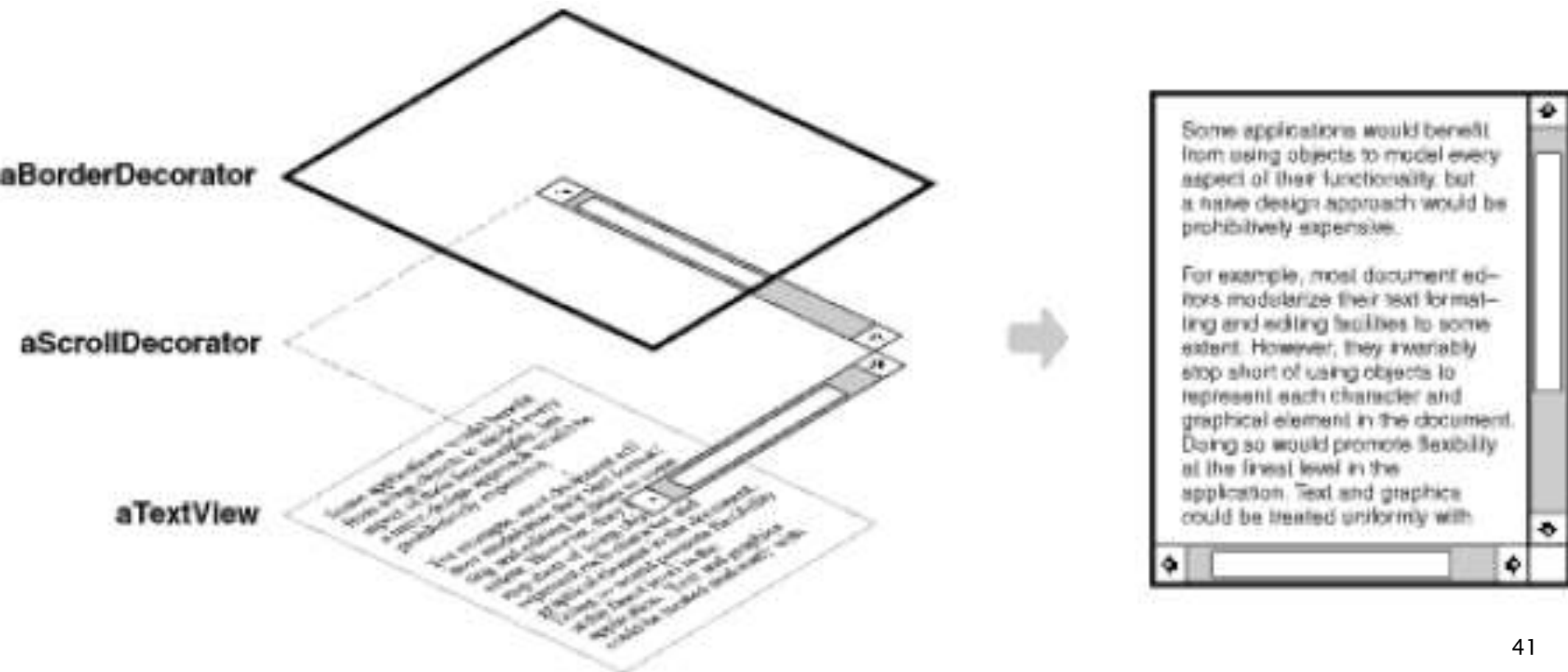
```
Vector subOrdinates = emp.getSubordinates();  
if (subOrdinates.size() != 0)  
    getTree(subOrdinates);  
else  
    System.out.println("No Subordinates for the  
Employee: "+emp.getName());
```

Structural Patterns – Decorator

- ▶ **Intent** – Attach additional responsibilities to an object dynamically. Decorators provide a flexible alternative to subclassing for extending functionality
- ▶ **Also Known As** – Wrapper (*similar Adapter*)
- ▶ **Motivation** – Sometimes we want to add responsibilities to individual objects, not to an entire class. A graphical user interface toolkit, for example, should let you add properties like borders or behaviors like scrolling to any user interface component

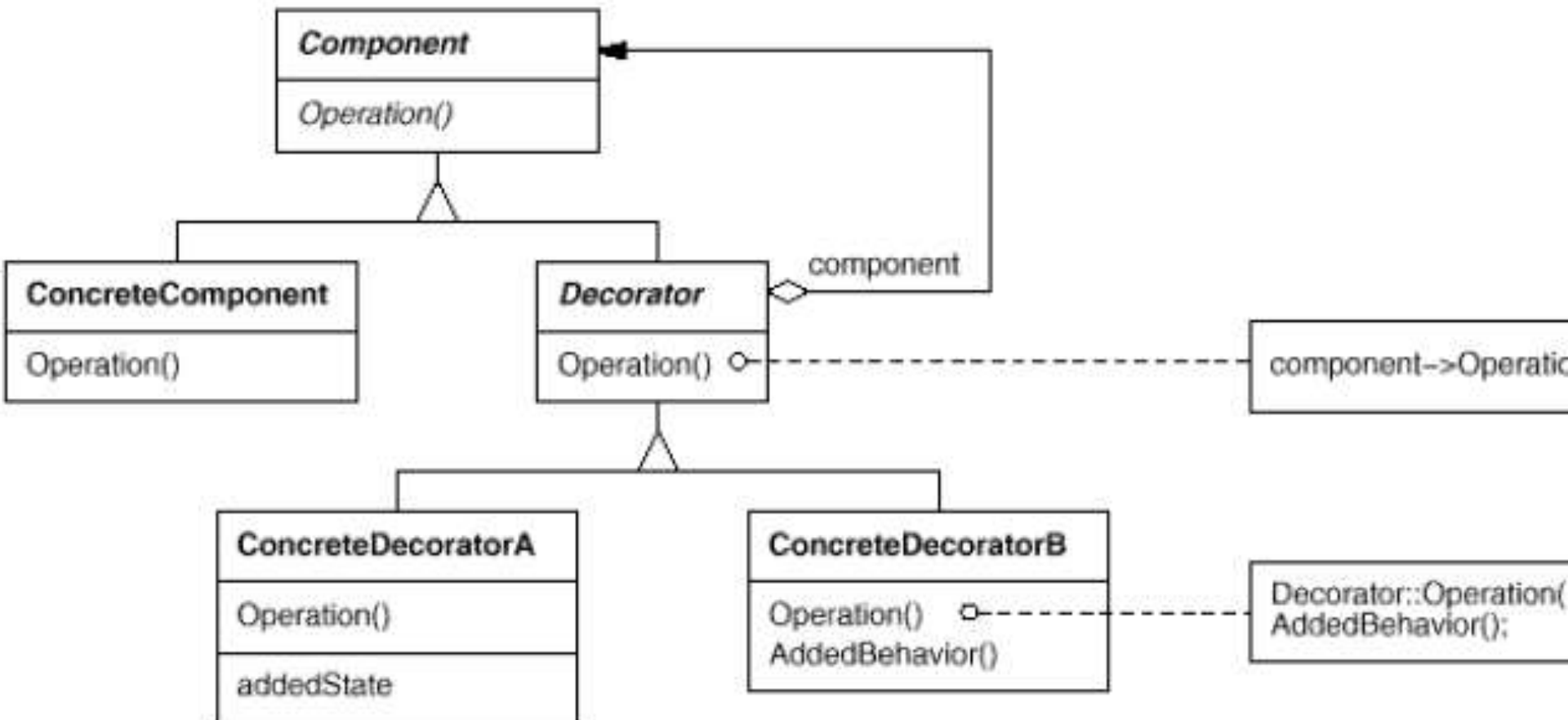
Decorator 1

- ▶ A more flexible approach is to enclose the component in another object that adds the border. The enclosing object is called a **decorator**



Decorator 2

► Structure



Decorator 3

- ▶ **Applicability – Use Decorator**
 - to add responsibilities to individual objects dynamically and transparently
 - for responsibilities that can be withdrawn
 - when extension by subclassing is impractical

Decorator – Example

- ▶ Suppose we have some 6 objects and 2 of them need a special behavior, we can do this with the help of a decorator
- ▶ Let's take an example of a **Christmas tree**. There is a need to decorate a Christmas tree. Now we have many branches which need to be decorated in different ways

Decorator – Java 1

```
public abstract class Decorator {  
    /** The method places each decorative item on  
    the tree. */  
    public abstract void place(Branch branch);  
}  
  
public class ChristmasTree {  
    private Branch branch;  
    public Branch getBranch() {  
        return branch;  
    }  
}
```

Decorator – Java 2

```
public class BallDecorator extends Decorator {  
    public BallDecorator(ChristmasTree tree) {  
        Branch branch = tree.getBranch();  
        place(branch);  
    }  
  
    public void place(Branch branch) {  
        branch.put("ball");  
    }  
}
```

Decorator – Java 3

- ▶ Similarly, we can make StarDecorator and RufflesDecorator

StarDecorator decorator = new StarDecorator(new ChristmasTree());

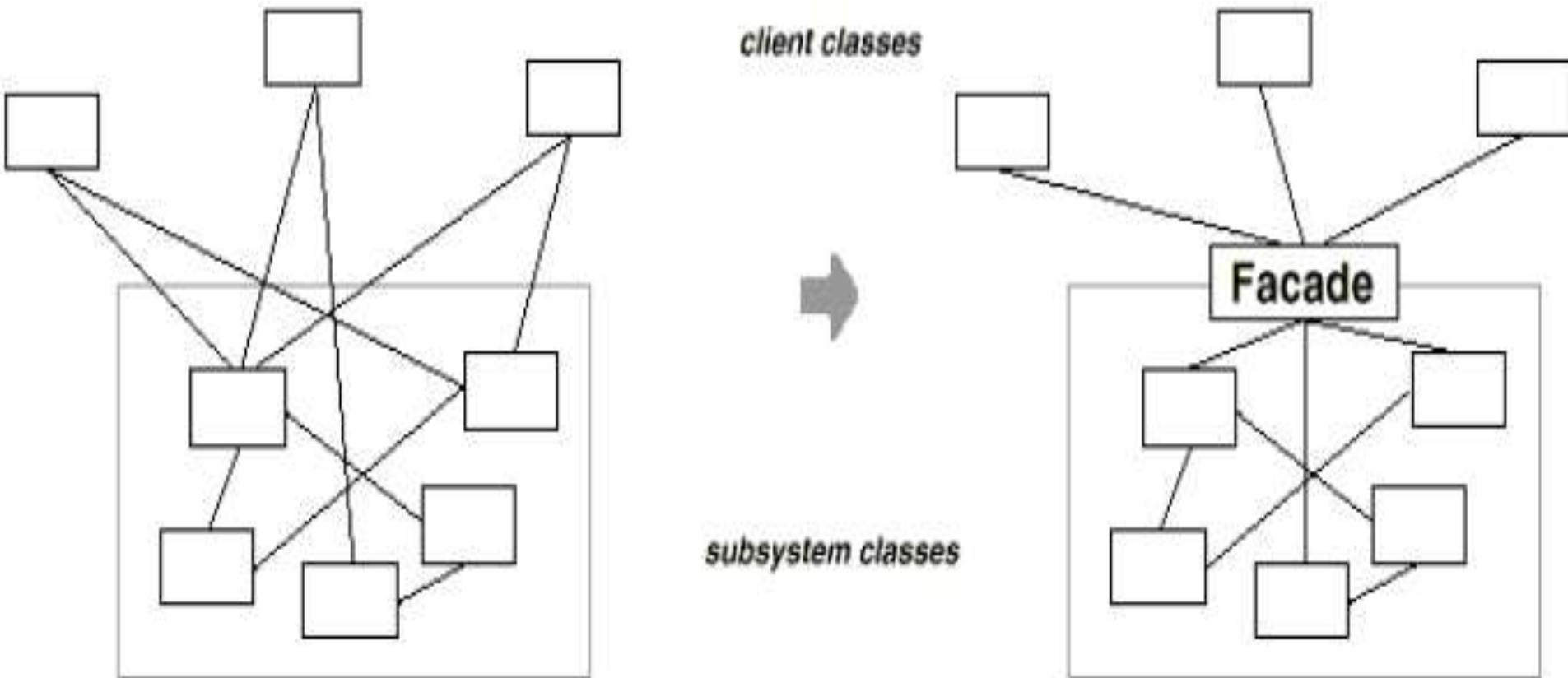
- ▶ This way the decorator will be instantiated and a branch of the Christmas tree will be decorated.

Structural Patterns – Façade

- ▶ **Intent** – Provide a unified interface to a set of interfaces in a subsystem
- ▶ **Motivation** – Consider for example a programming environment that gives applications access to its compiler subsystem. This subsystem contains classes such as *Scanner*, *Parser*, *ProgramNode*, *BytecodeStream*, and *ProgramNodeBuilder* that implement the compiler. Some specialized applications might need to access these classes directly. But most clients of a compiler want to compile some code

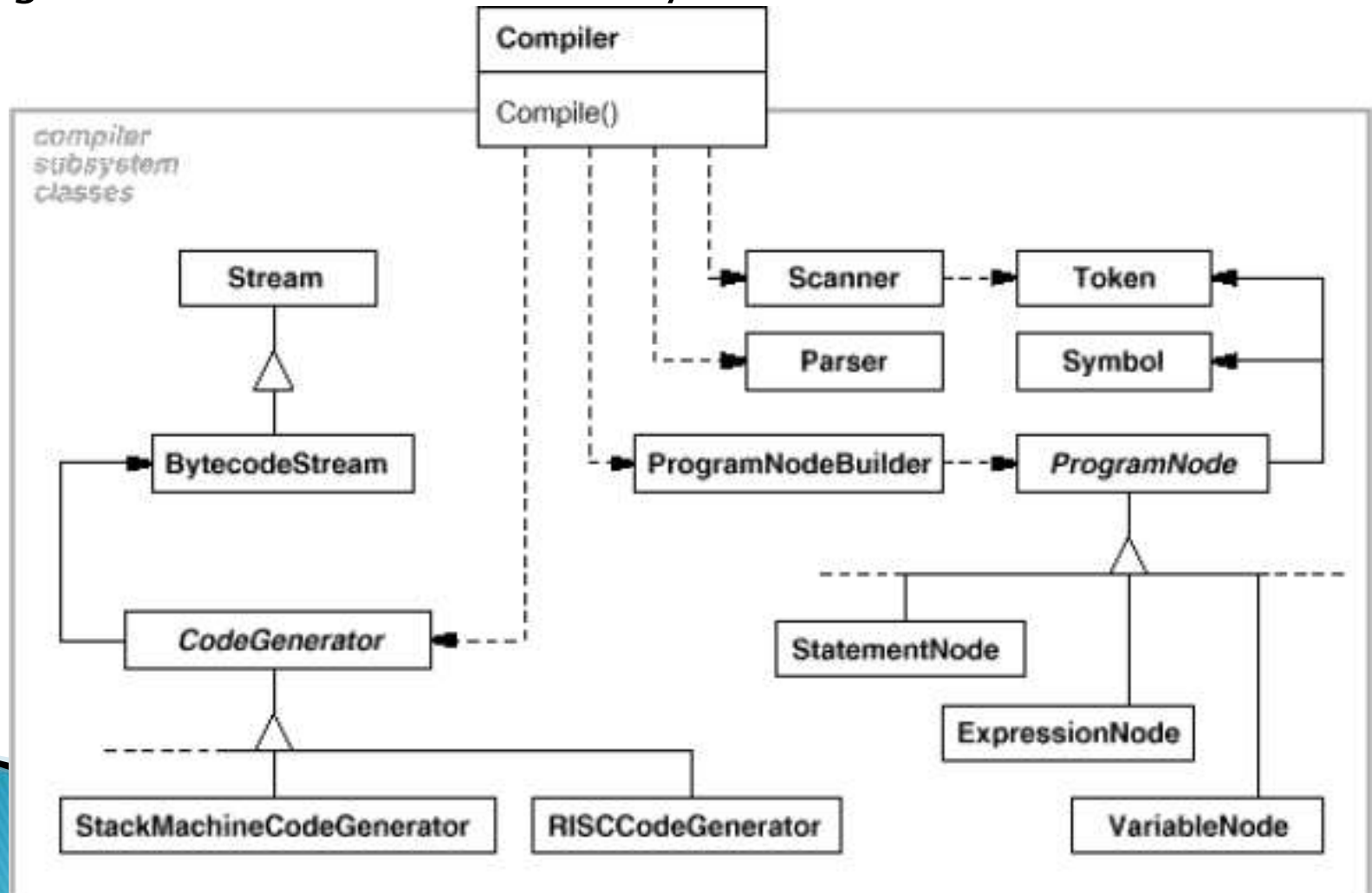
Façade 1

- ▶ A common design goal is to **minimize the communication and dependencies between subsystems**



Façade 2

- ▶ The compiler facade makes life easier for most programmers without hiding the lower-level functionality from the few that need it



Façade 3

- ▶ **Applicability** – Use the Facade pattern when
 - you want to provide a simple interface to a complex subsystem
 - there are many dependencies between clients and the implementation classes of an abstraction
 - you want to layer your subsystems

Façade – Example 1

- ▶ Facade as the name suggests means the face of the building. The people walking past the road can only see this glass face of the building. The face hides all the complexities of the building and displays a friendly face.
- ▶ Facade hides the complexities of the system and provides an interface to the client from where the client can access the system. In Java, the interface JDBC can be called a façade
- ▶ Other examples?

Façade – Example 2

- ▶ Let's consider a **store**. This store has a store keeper. In the storage, there are a lot of things stored e.g. **packing material, raw material and finished goods**.
- ▶ You, as client want access to different goods. You do not know where the different materials are stored. You just have access to store keeper who knows his store well. Here, the store keeper acts as the facade, as he hides the complexities of the system Store.

Façade – Java 1

```
public interface Store {  
    public Goods getGoods();  
}
```

```
public class FinishedGoodsStore implements Store  
{  
    public Goods getGoods() {  
        FinishedGoods finishedGoods = new FinishedGoods();  
        return finishedGoods;  
    }  
}
```

Façade – Java 2

```
public class StoreKeeper {  
    public RawMaterialGoods getRawMaterialGoods() {  
        RawMaterialStore store = new RawMaterialStore();  
        RawMaterialGoods rawMaterialGoods =  
(RawMaterialGoods)store.getGoods();  
        return rawMaterialGoods;  
    }  
    ...  
}
```

Façade – Java 3

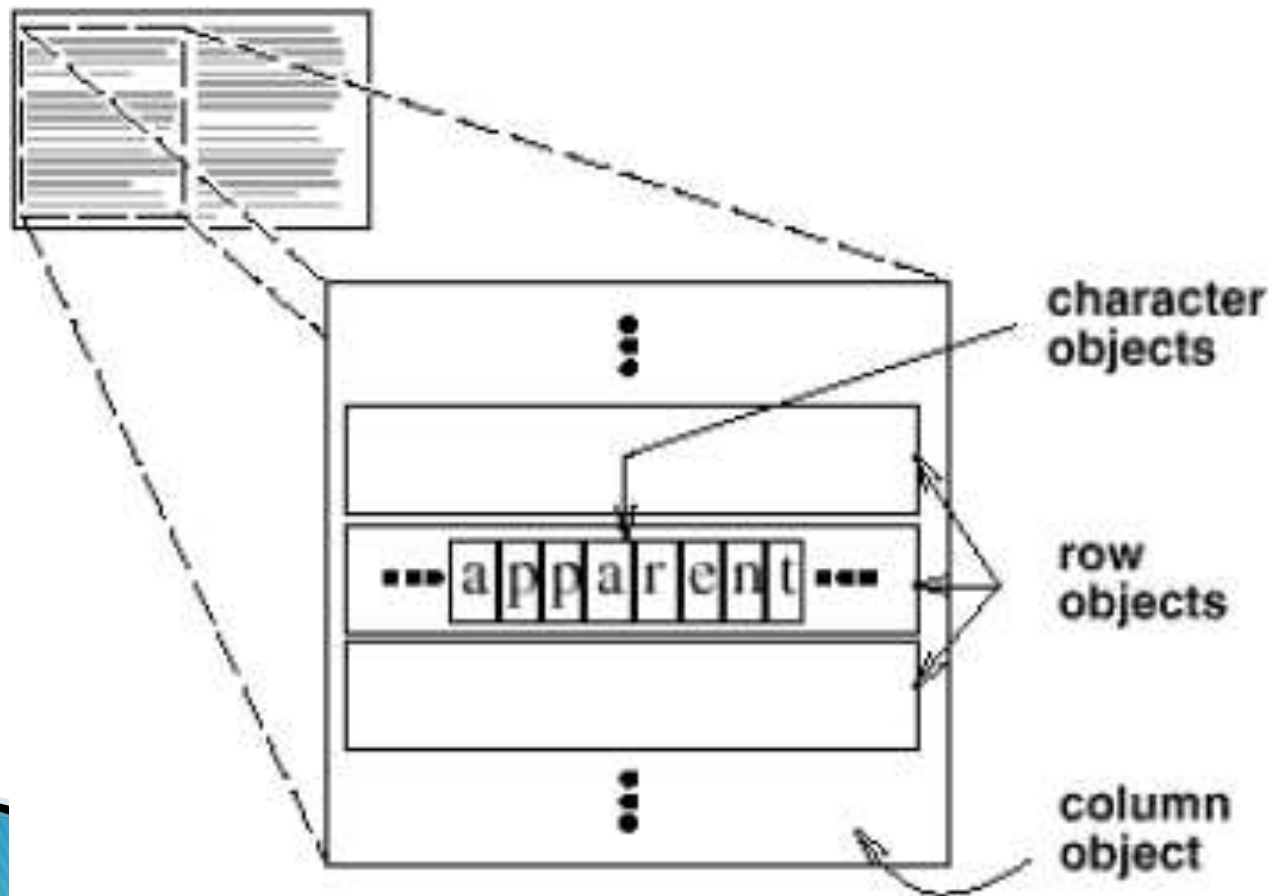
```
public class Client {  
    public static void main(String[] args) {  
        StoreKeeper keeper = new StoreKeeper();  
        RawMaterialGoods rawMaterialGoods =  
            keeper.getRawMaterialGoods();  
    }  
}
```


Structural Patterns – Flyweight

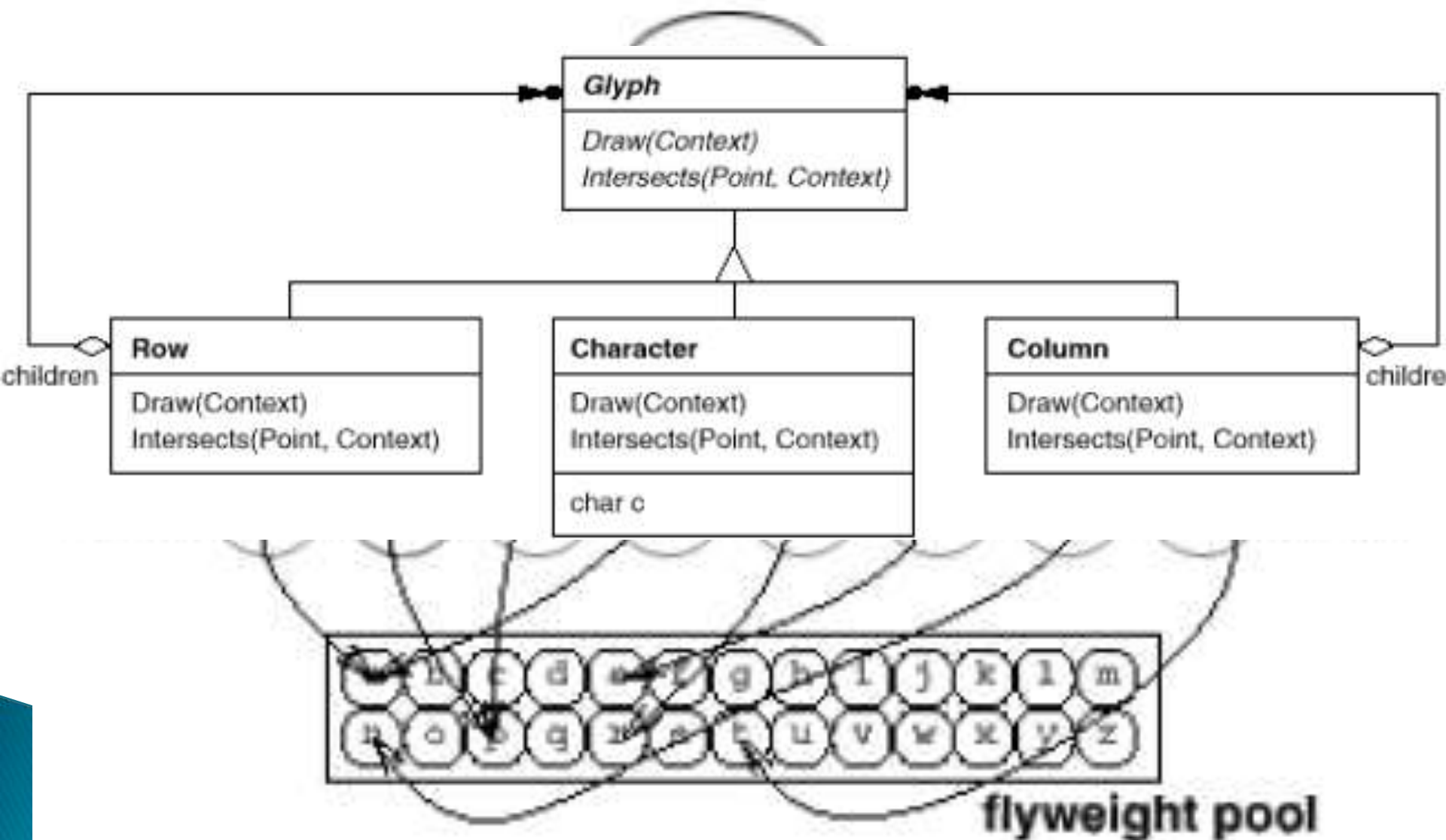
- ▶ **Intent** – Use sharing to support large numbers of fine-grained objects efficiently
- ▶ **Motivation** – Some applications could benefit from using objects throughout their design, but a naive implementation would be prohibitively expensive.
- ▶ For example, most document editor implementations have text formatting and editing facilities that are modularized to some extent.

Flyweight 1

- ▶ The following diagram shows how a document editor can use objects to represent characters



Flyweight 2



Flyweight – Example

- ▶ A Flyweight is an object that minimizes memory use by sharing as much data as possible with other similar objects
- ▶ A classic example usage of the flyweight pattern are the data structures for graphical representation of characters in a word processor. It would be nice to have, for each character in a document, a glyph object containing its *font outline*, *font metrics*, and other formatting data, but it would amount to hundreds or thousands of bytes for each character. Instead, are used the flyweights called **FontData**

Flyweight – Java 1

```
public enum FontEffect {  
    BOLD, ITALIC, SUPERScript, SUBSCRIPT, STRIKETHROUGH  
}  
public final class FontData {  
    private static final WeakHashMap<FontData,  
    WeakReference<FontData>> FLY_WEIGHT_DATA = new  
    WeakHashMap<FontData, WeakReference<FontData>>();  
    private final int pointSize;  
    private final String fontFace;  
    private final Color color;  
    private final Set<FontEffect> effects;  
  
    private FontData(int pointSize, String fontFace, Color color,  
    EnumSet<FontEffect> effects) {  
        this.pointSize = pointSize;  
        this.fontFace = fontFace;  
        this.color = color;  
        this.effects = Collections.unmodifiableSet(effects);  
    }  
}
```

Flyweight – Java 2

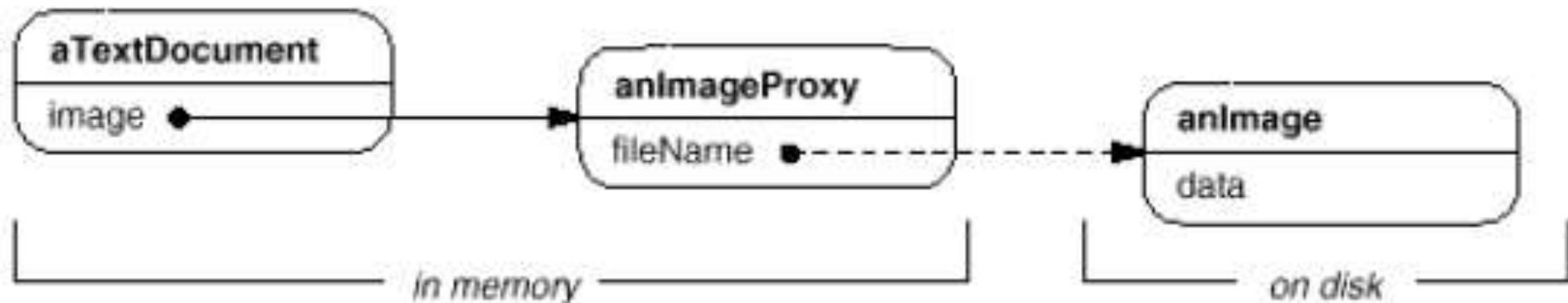
```
public static FontData create(int pointSize, String
    fontFace, Color color, FontEffect... effects) {
    EnumSet<FontEffect> effectsSet =
        EnumSet.noneOf(FontEffect.class);
    for (FontEffect fontEffect : effects) {
        effectsSet.add(fontEffect); }
    FontData data = new FontData(pointSize, fontFace,
        color, effectsSet);
    if (!FLY_WEIGHT_DATA.containsKey(data)) {
        FLY_WEIGHT_DATA.put(data, new
            WeakReference<FontData> (data));
    }
    return FLY_WEIGHT_DATA.get(data).get();
}
```

Structural Patterns – Proxy

- ▶ **Intent** – Provide a surrogate or placeholder for another object to control access to it.
- ▶ **Also Known As** – Surrogate
- ▶ **Motivation** – Consider a document editor that can embed graphical objects in a document. Some graphical objects, like large raster images, can be expensive to create. But opening a document should be fast, so we should avoid creating all the expensive objects at once when the document is opened. This isn't necessary anyway, because not all of these objects will be visible in the document at the same time

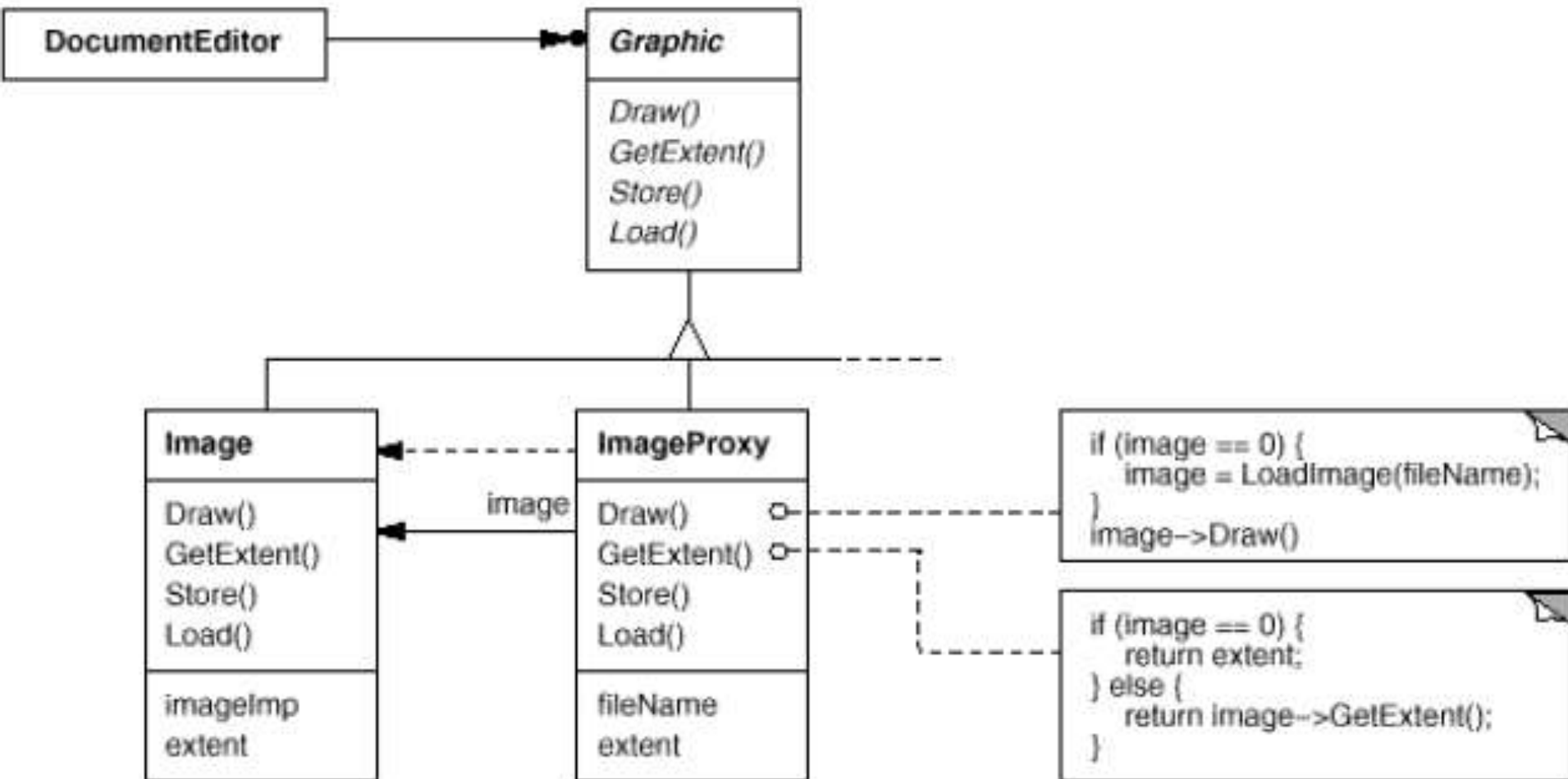
Proxy 1

- ▶ The solution is to use another object, an **image proxy**, that acts as a **stand-in** for the real image. The proxy acts just like the image and takes care of instantiating it when it's required.



Proxy 2

- ▶ The following class diagram illustrates this example in more detail



Proxy – Example

- ▶ Let' say we need to withdraw money to make some purchase. The way we will do it is, go to an ATM and get the money, or purchase straight with a cheque.
- ▶ In old days when ATMs and cheques were not available, what used to be the way??? Well, get your passbook, go to bank, get withdrawal form there, stand in a queue and withdraw money. Then go to the shop where you want to make the purchase.
- ▶ In this way, we can say that ATM or cheque in modern times act as proxies to the Bank.

Proxy – Java 1

```
public class Bank {  
    private int numberInQueue;  
  
    public double getMoneyForPurchase(double amountNeeded) {  
        You you = new You("Prashant");  
        Account account = new Account();  
        String accountNumber = you.getAccountNumber();  
        boolean gotPassbook = you.getPassbook();  
        int number = getNumberInQueue();  
  
        while (number != 0) {number--;}  
  
        boolean isBalanceSufficient =  
account.checkBalance(accountNumber, amountNeeded);  
        if(isBalanceSufficient)  
            return amountNeeded;  
        else  
            return 0;  
    }  
  
    private int getNumberInQueue() {  
        return numberInQueue;  
    }  
}
```

Proxy – Java 2

```
public class ATMProxy {  
    public double getMoneyForPurchase(double amountNeeded){  
        You you = new You("Prashant");  
        Account account = new Account();  
        boolean isBalanceAvailable = false;  
        if(you.getCard()) {  
            isBalanceAvailable =  
                account.checkBalance(you.getAccountNumber(),  
                    amountNeeded);  
        }  
  
        if(isBalanceAvailable)  
            return amountNeeded;  
        else  
            return 0;  
    }  
}
```

portal.info.uaic.ro

- ▶ Ingineria Programarii\Grupa
 - SharedDocuments\2013
 - Modul1 –
 - Modul2 –
 - ...

Bibliografie

- ▶ Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides: *Design Patterns: Elements of Reusable Object-Oriented Software* (GangOfFour)

Links

- ▶ Design Patterns: <http://www.oodesign.com/>
- ▶ Gang-Of-Four: <http://c2.com/cgi/wiki?GangOfFour>,
<http://www.uml.org.cn/c%2B%2B/pdf/DesignPatterns.pdf>
- ▶ Design Patterns Book: <http://c2.com/cgi/wiki?DesignPatternsBook>
- ▶ About Design Patterns: <http://www.javacamp.org/designPattern/>
- ▶ Design Patterns – Java companion:
<http://www.patterndepot.com/put/8/JavaPatterns.htm>
- ▶ Java Design patterns:
http://www.allapplabs.com/java_design_patterns/java_design_patterns.htm
- ▶ Overview of Design Patterns:
http://www.mindspring.com/~mgrand/pattern_synopses.htm
- ▶ Lazy initialization: http://en.wikipedia.org/wiki/Lazy_initialization
- ▶ Use Lazy Initialization to Conserve Resources:
<http://www.devx.com/tips/Tip/18007>