SOFT2201/COMP9201: Software Design and Construction 1

Singleton, Decorator, and Façade

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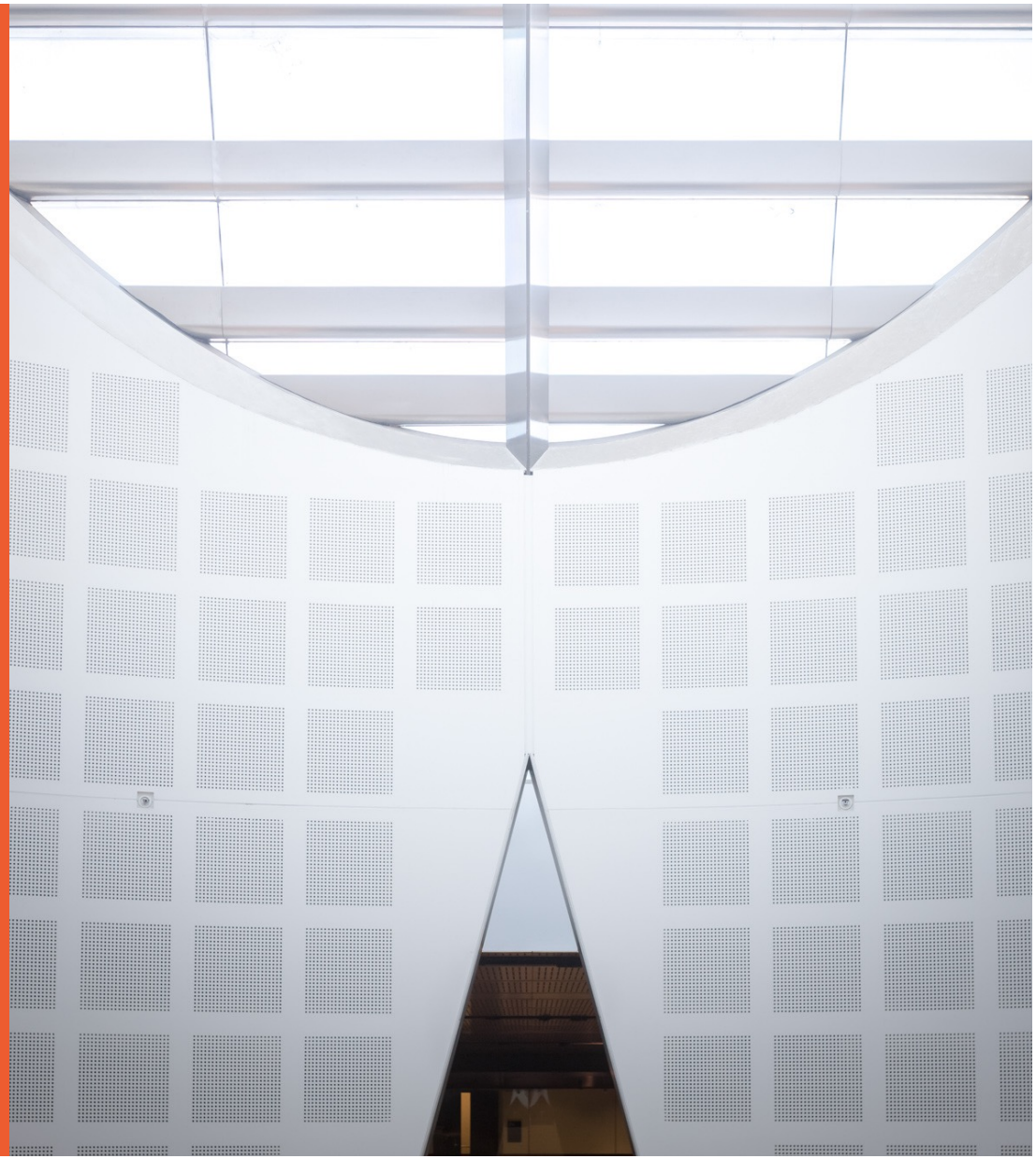

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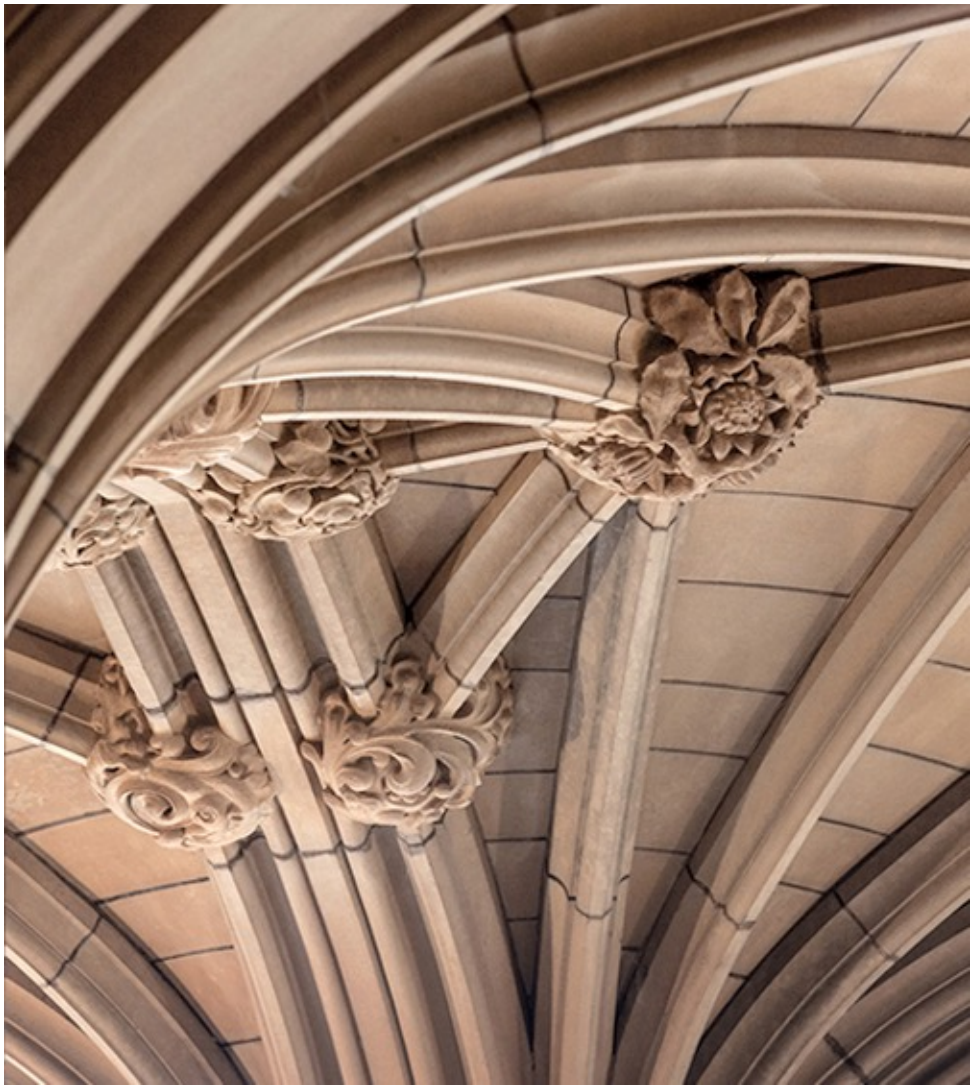
Agenda

- Creational Design Pattern
  - Singleton

- Structural Design Pattern
  - Decorator and Façade

Singleton Pattern

Object Creational



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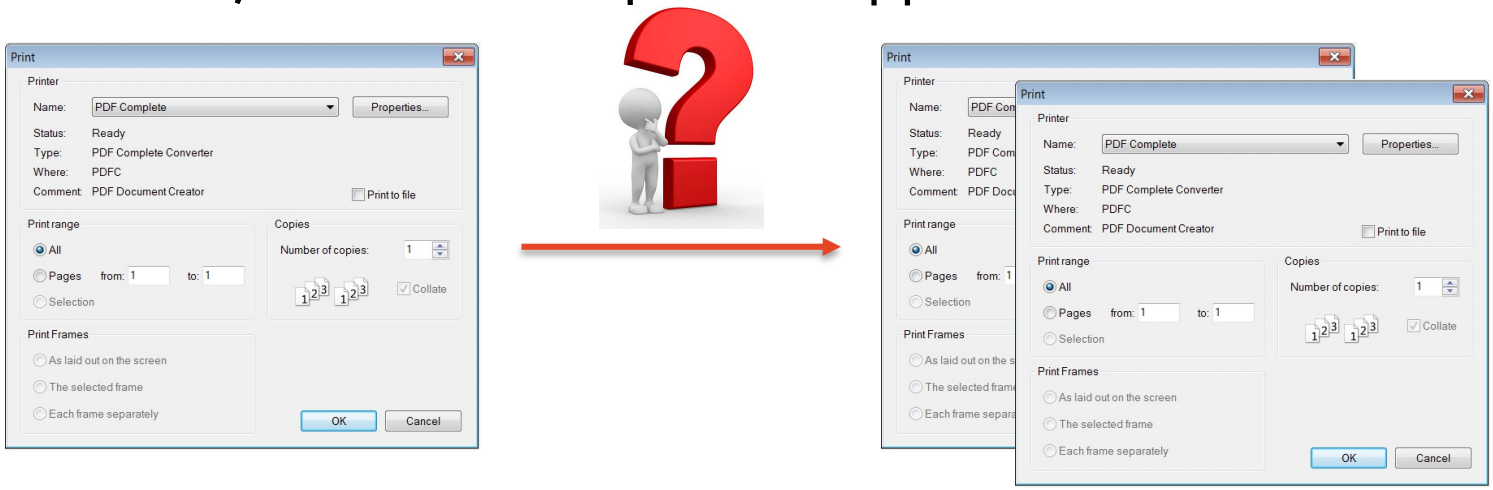
Creational Patterns (GoF)

Pattern Name	Description
Factory Method	Define an interface for creating an object, but let sub-class decide which class to instantiate (class instantiation deferred to subclasses)
Builder	Separate the construction of a complex object from its representation so that the same construction process can create different representations
Prototype	Specify the kinds of objects to create using a prototype instance, and create new objects by copying this prototype
Singleton	**Ensure a class only has one instance, and provide global point of access to it**

Motivated Scenario

- Suppose you have finished your assignment report in your computer and would like to print it out.
  - The first time you click on “print”, it pops up a printing set up window
  - The second time you click on “print” without closing the previous printing window, what do we expect to happen?

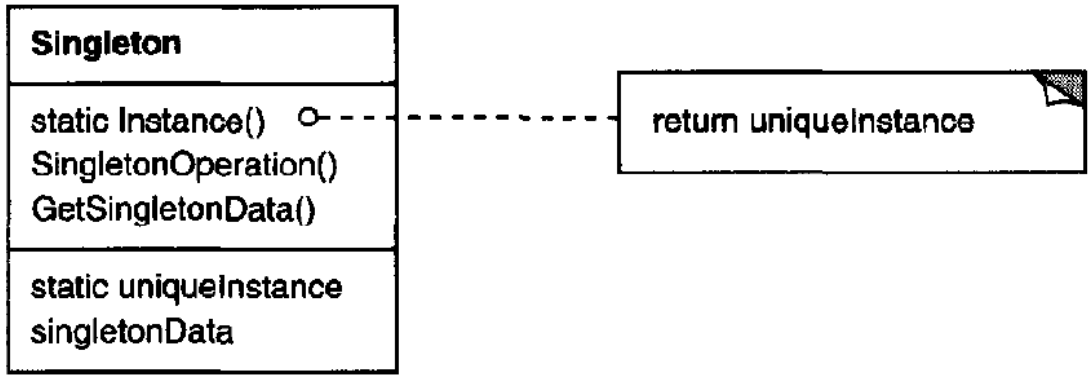


Singleton

- Intent
  - Ensure a class only has one instance, and provide a global point of access to it
- Motivation
  - Make the class itself responsible for keeping track of its sole instance (intercept requests to create new objects and provide a way to access its instance)

Singleton

- Structure



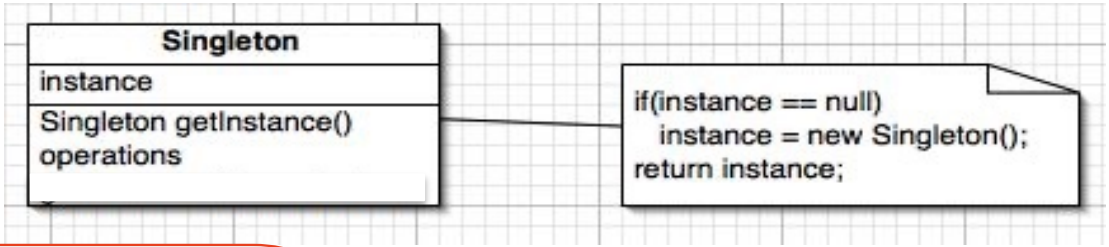
- Participants
  - Defines an instance() operation that lets clients access its unique instance. instance() is a class operation
  - May be responsible for creating its own unique instance

Singleton

- Collaboration
  - Clients access a Singleton instance solely through Singleton's instance() operation.

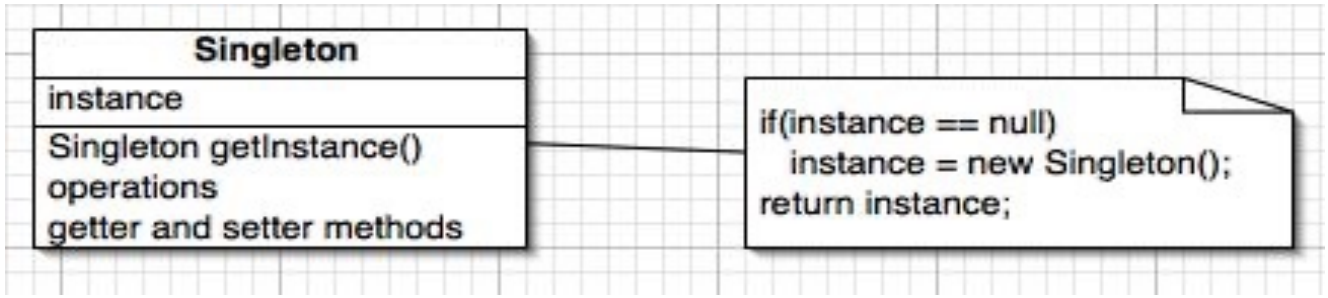
- Applicability
  - There must be exactly one instance of a class, and it must be accessible to clients from a well-known access point
  - The sole instance should be extensible by subclassing, and clients should be able to use an extended instance without modifying their code

Singleton Implementation




```
public class Singleton {
      private static Singleton instance = null;
        // Private constructor to prevent direct
   initialisation.
      private Singleton() {
      }
      public static Singleton getInstance() {
         if (instance == null) {
            instance = new Singleton();
         }
         return instance;
      }
}
public class Client {
       …
       Singleton single = Singleton.getInstance();
}
```

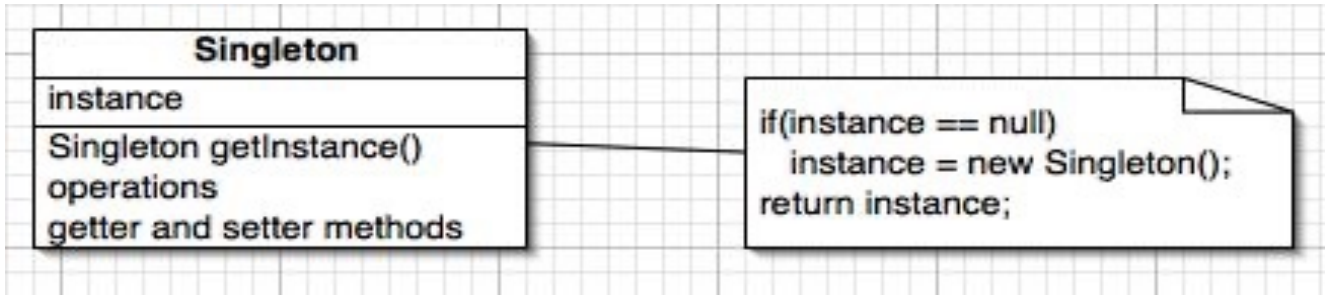
Singleton Example




```
public class ConfigurationReader {
   private static ConfigurationReader instance = null;

   private ConfigurationReader() { }
   public static ConfigurationReader getInstance() {
      if (instance == null) {
         instance = new ConfigurationReader();
      }
      return instance;
   }
}
public class Client {
    public boolean doStuff() {
        …
        ConfigurationReader theOneAndOnlyConfigurationFileReader = ConfigurationReader.getInstance();
    }
```

Singleton Example

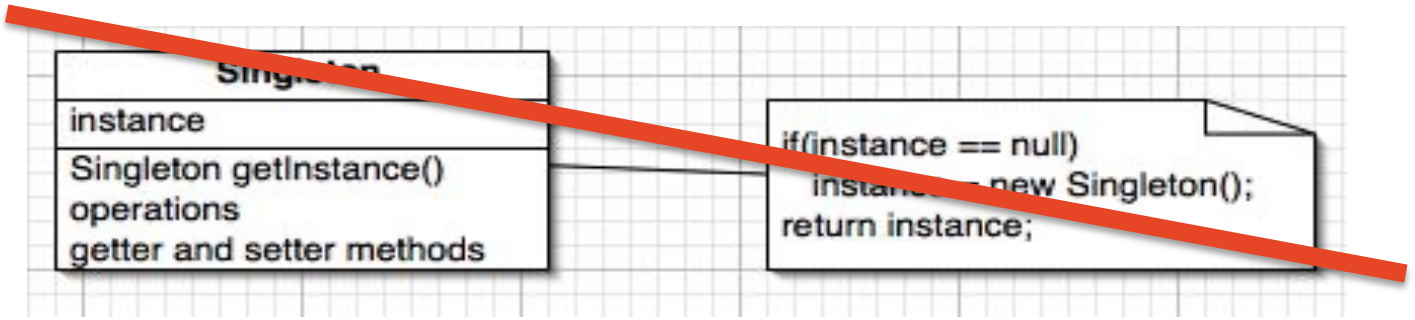



```
public class ConfigurationReader2 {
   private static ConfigurationReader2 instance = null;

   private ConfigurationReader2() { }
   public static ConfigurationReader2 getInstance() {
      if (instance == null) {
         instance = new ConfigurationReader2();
      }
      return instance;
   }
}
public class Client {
    public boolean doStuff() {
        …
        ConfigurationReader theOneAndOnlyConfigurationFileReader = ConfigurationReader.getInstance();
        ConfigurationReader2 theOtherConfigurationFileReader = ConfigurationReader2.getInstance();
    }
```

Do you really always want one specific instance of one specific class?

Singleton Alternative Example

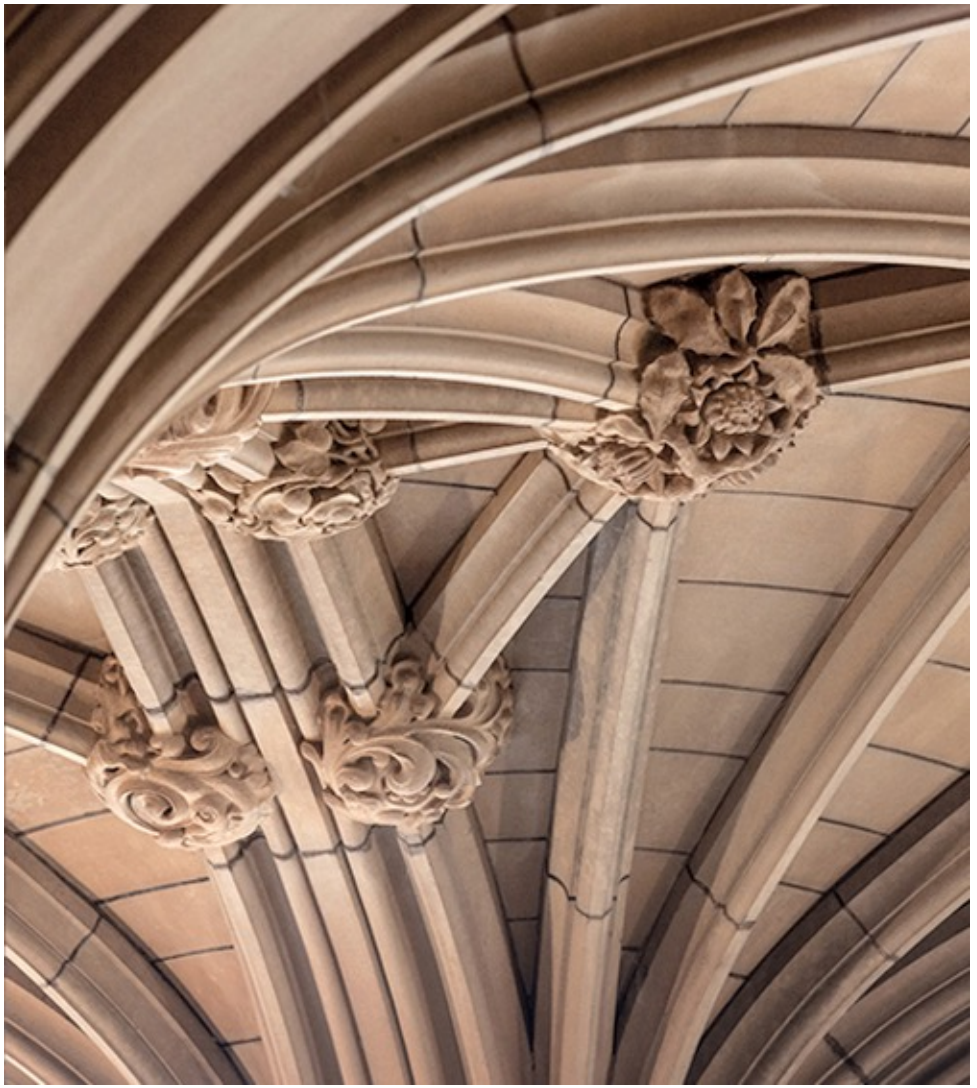



```
public class ConfigurationReader {
    public ConfigurationReader() { }
    // . . .
}

public class Client {
    // Explicit dependency in interface.
    // The 'single' instance is passed around by reference
    public boolean doStuff(ConfigurationReader configurationReader) {
        // . . .
}
```

Decorator Pattern

Object Structural



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Structural Patterns (GoF)

Pattern Name	Description
Adapter	Allow classes of incompatible interfaces to work together. Convert the interface of a class into another interface clients expect.
Decorator	**Attach additional responsibilities to an object dynamically (flexible alternative to subclassing for extending functionality)**
Façade	Provides a unified interface to a set of interfaces in a subsystem. Defines a higher-level interface that simplifies subsystem use.

Motivated Scenario

- Suppose you are shopping in a famous store, which has a virtual clothing try on application.
  - T-Shirts, Trousers and Sneakers
  - Suit and Leather Shoes

Motivated Scenario

```
public class People {
    2 usages
    private String name;
    1 usage
    public People (String name){this.name = name;}
    1 usage
    public void wearTShirt() {System.out.print("T-Shirt ");}
    1 usage
    public void wearTrousers() {System.out.print("Trousers ");}
    1 usage
    public void wearSneakers() {System.out.print("Sneakers ");}
    public void wearSuit() {System.out.print("Suit ");}
    public void wearLeatherShoes() {System.out.print("Leather Shoes ");}
    1 usage
    public void show() {System.out.println(name + " is trying on:");}
}
```

Client Perspective:

```
People people = new People( name: "Happy");
people.show();
people.wearTShirt();
people.wearTrousers();
people.wearSneakers();
```

Output:

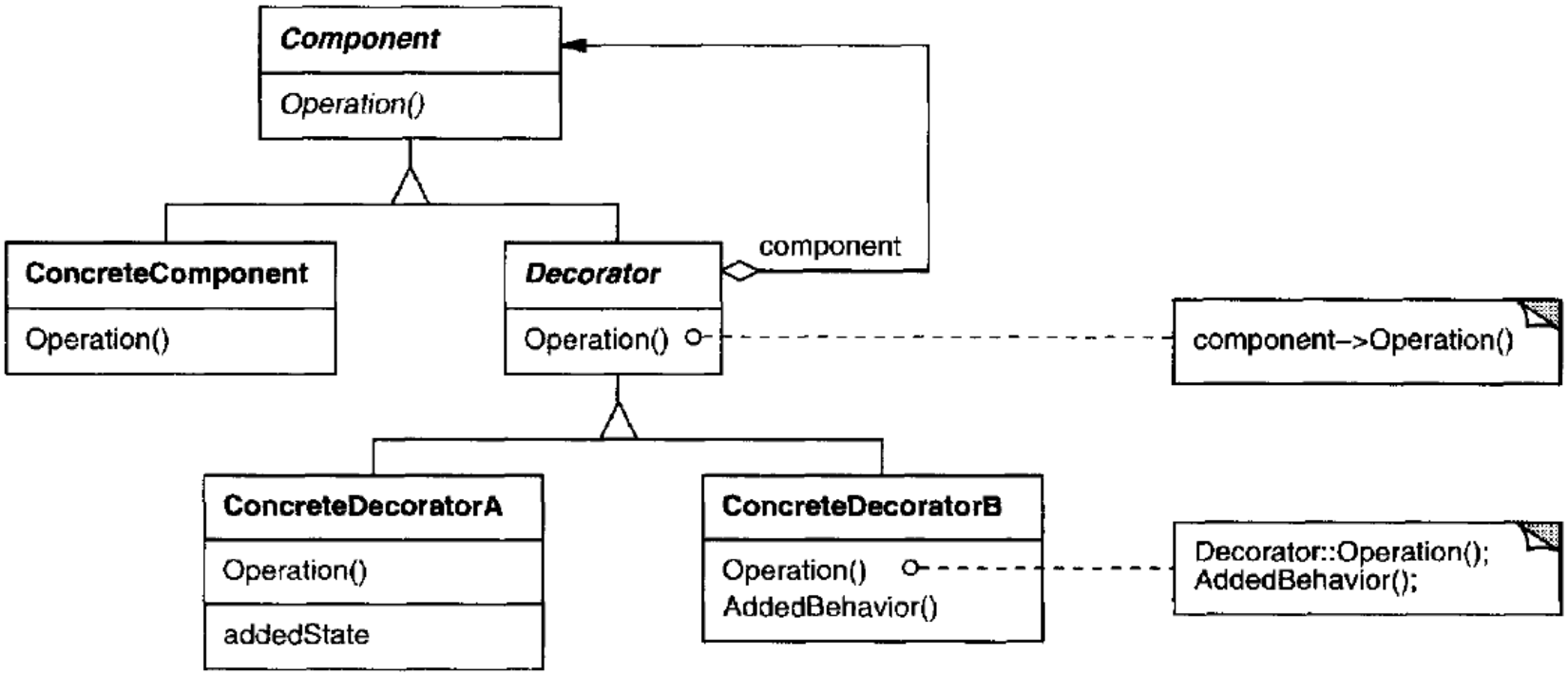
```
Happy is trying on:
T-Shirt Trousers Sneakers
```

Question: I also want to try on Dress and Boots. What will happen here?

Decorator Pattern

- **Intent**
  - Attach additional responsibilities to an object dynamically. Decorators provide a flexible alternative to sub-classing for extending functionality

Decorator – Structure



Decorator – Participants

- **Component**
  - Defines the interface for objects that can have responsibilities added to them dynamically
- **ConcreteComponent**
  - Defines an object to which additional responsibilities can be attached
- **Decorator**
  - Maintains a reference to a Component object and defines an interface that conforms to Component's interface.
- **ConcreteDecorator**
  - Adds responsibilities to the component

Revisit the Motivated Example

```
public interface People {
    7 usages  7 implementations
    public void show();
}
```

```
public class Women implements People{
    2 usages
    private String name;
    1 usage
    public Women(String name){this.name = name;}
    7 usages
    public void show() {System.out.println(name + " is trying on:");}
}
```

```
public abstract class Cloth implements People {
    2 usages
    protected People people;
    5 usages
    public Cloth (People people){this.people = people;}
    7 usages  5 overrides
    public void show(){people.show();}
}
```

Revisit the Motivated Example

```java
public abstract class Cloth implements People {
    2 usages
    protected People people;
    5 usages
    public Cloth (People people){this.people = people;}
    7 usages  5 overrides
    public void show(){people.show();}
}
```

```java
public class TShirt extends Cloth{
    1 usage
    public TShirt(People people) {super(people);}
    7 usages
    public void show() {
        super.show();
        System.out.print("T-Shirt ");
    }
}
```

```java
public class Trousers extends Cloth{
    1 usage
    public Trousers (People people) {super(people);}
    7 usages
    public void show() {
        super.show();
        System.out.print("Trousers ");}
}
```

```java
public class Sneakers extends Cloth{
    1 usage
    public Sneakers(People people){super(people);}
    7 usages
    public void show(){
        super.show();
        System.out.print("Sneakers ");}
}
```

Revisit the Motivated Example

Client Perspective

```
People people = new Women( name: "Happy");

TShirt tShirt = new TShirt(people);
Trousers trousers = new Trousers(tShirt);
Sneakers sneakers = new Sneakers(trousers);

sneakers.show();
```

Output

```
Happy is trying on:
T-Shirt Trousers Sneakers
```

Question 1:
I also want to try on Dress and Boots.
What will happen here?

Question 2:
This system opens to Men and Baby.
What will happen here?

Decorator Pattern – Why Not Inheritance?

- We want to add responsibilities to individual objects, not an entire class
  - E.g., A GUI toolkit should let you add properties like borders or behaviors like scrolling to any user interface component

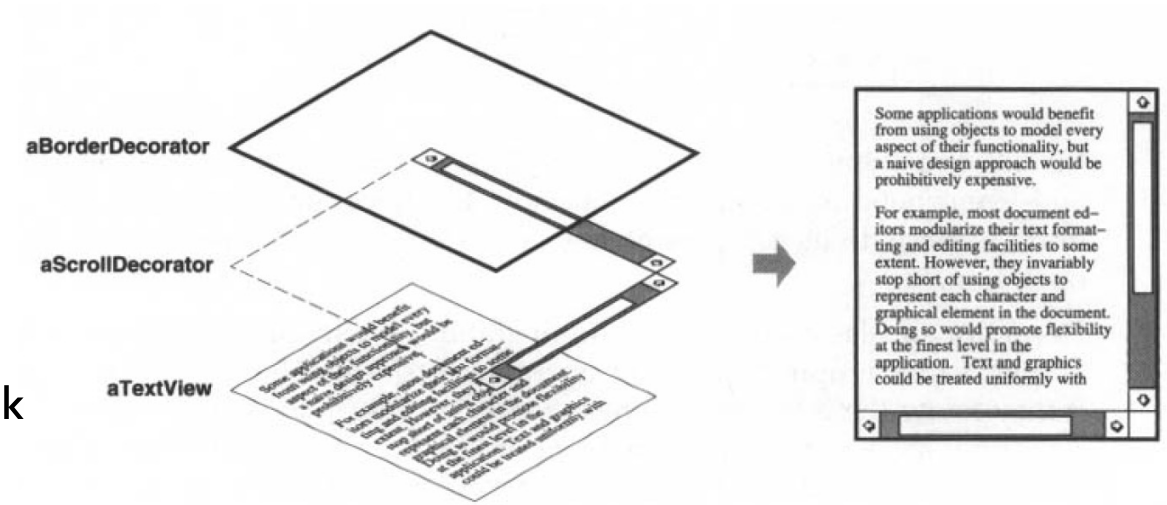
- Is adding responsibilities using inheritance a good design? For example, inheriting a border class puts a border every subclass instance
  - Why, why not?

Decorator Pattern – Why Not Inheritance?

- Adding responsibilities using inheritance restricts runtime change, and requires an implementation for every decoration.
  - This design is inflexible
    - The choice of border is made statically; a client cannot control how and when to decorate the component with a border
    - More flexible design is to enclose the component in another object that adds the border

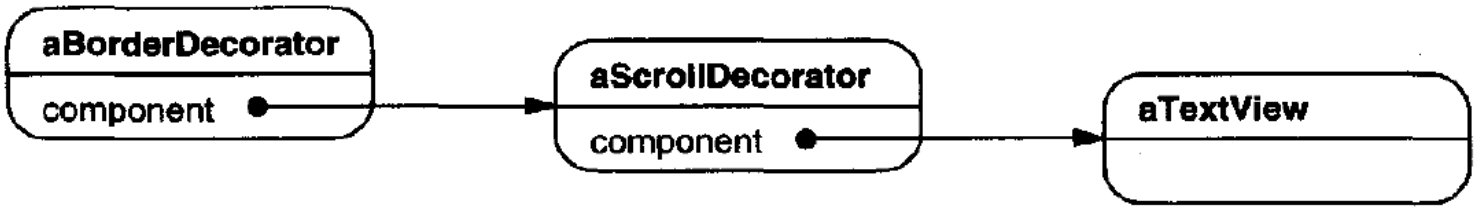
Decorator Pattern – Text Viewer Example

- TextView object has no scroll bars and border by default (not always needed)
- ScrollDecorator to add them
- BorderDecorator to add a thick black border around the TextView

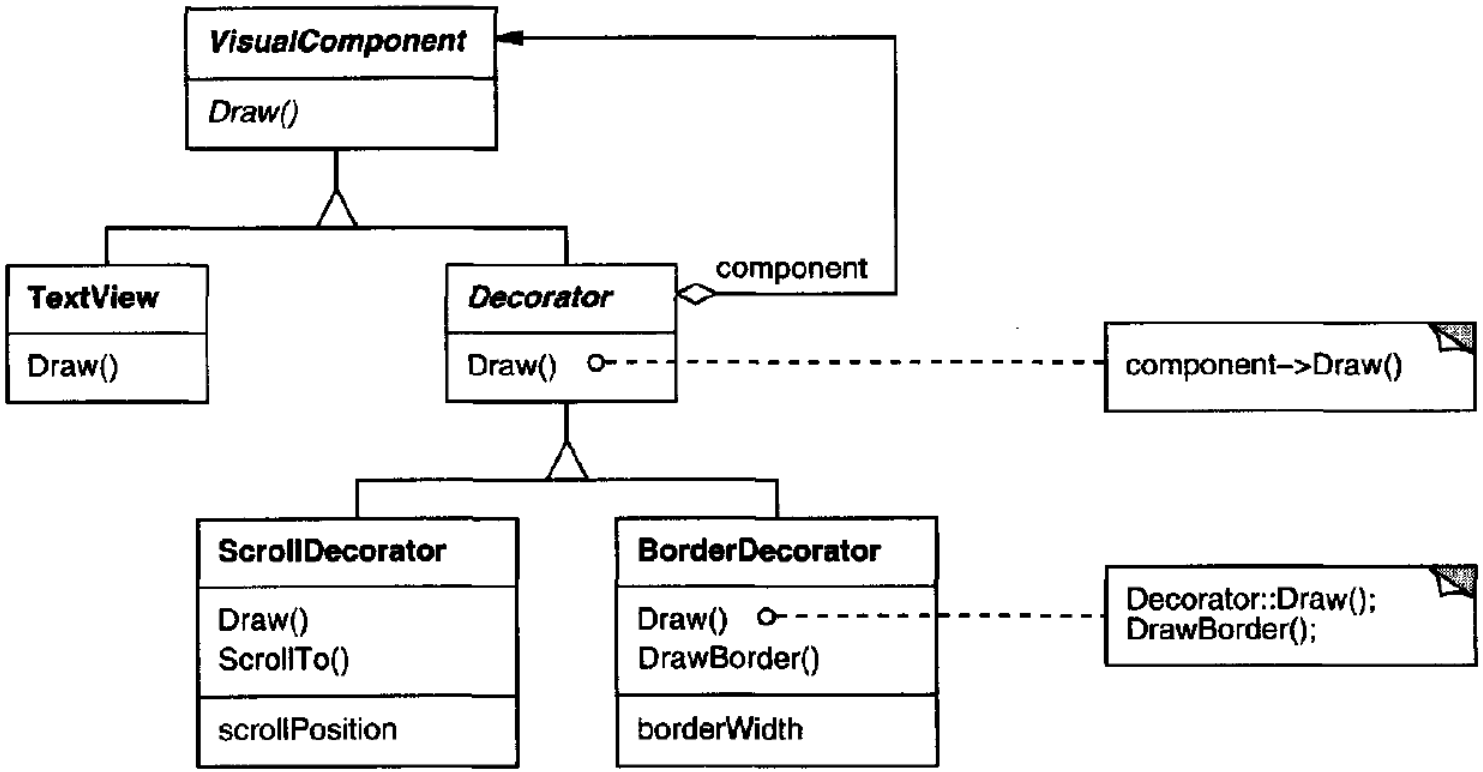


Decorator Pattern – Text Viewer Example

- Compose the decorators with the TextView to produce both the border and the scroll behaviours for the TextView



Decorator Pattern – Text Viewer Example



Decorator – Participants

- **Component** (*VisualComponent*)
  - Defines the interface for objects that can have responsibilities added to them dynamically
- **ConcreteComponent** *(TextView)*
  - Defines an object to which additional responsibilities can be attached
- **Decorator**
  - Maintains a reference to a Component object and defines an interface that conforms to Component's interface.
- **ConcreteDecorator** *(BorderDecorator, ScrollDecorator)*
  - Adds responsibilities to the component

Decorator – Text Viewer Example

- VisualComponent is the abstract class for visual objects
  - It defines their drawing and event handling interface
- Decorator is an abstract class for visual components that decorate the other visual components
  - It simply forwards draw requests to its component; Decorator subclasses can extend this operation
- The ScrollDecorator and BorderDecorator classes are subclasses of Decorator
  - Can add operations for specific functionality (e.g., ScrollTo)

Decorator

- Collaborations
  - Decorator forwards requests to its Component object. It may optionally perform additional operations before and after forwarding the request.
- Applicability
  - to add responsibilities to individual objects dynamically and transparently, without affecting other objects
  - For responsibilities that can be withdrawn
  - When extension by sub-classing is impractical
    - Sometimes a large number of independent extensions are possible and would produce an explosion of subclasses to support every combination.

Consequences (1)

- More flexibility and less complexity than static inheritance
  - Can add and remove responsibilities to objects at run-time
  - Inheritance requires adding new class for each responsibility (increase complexity)

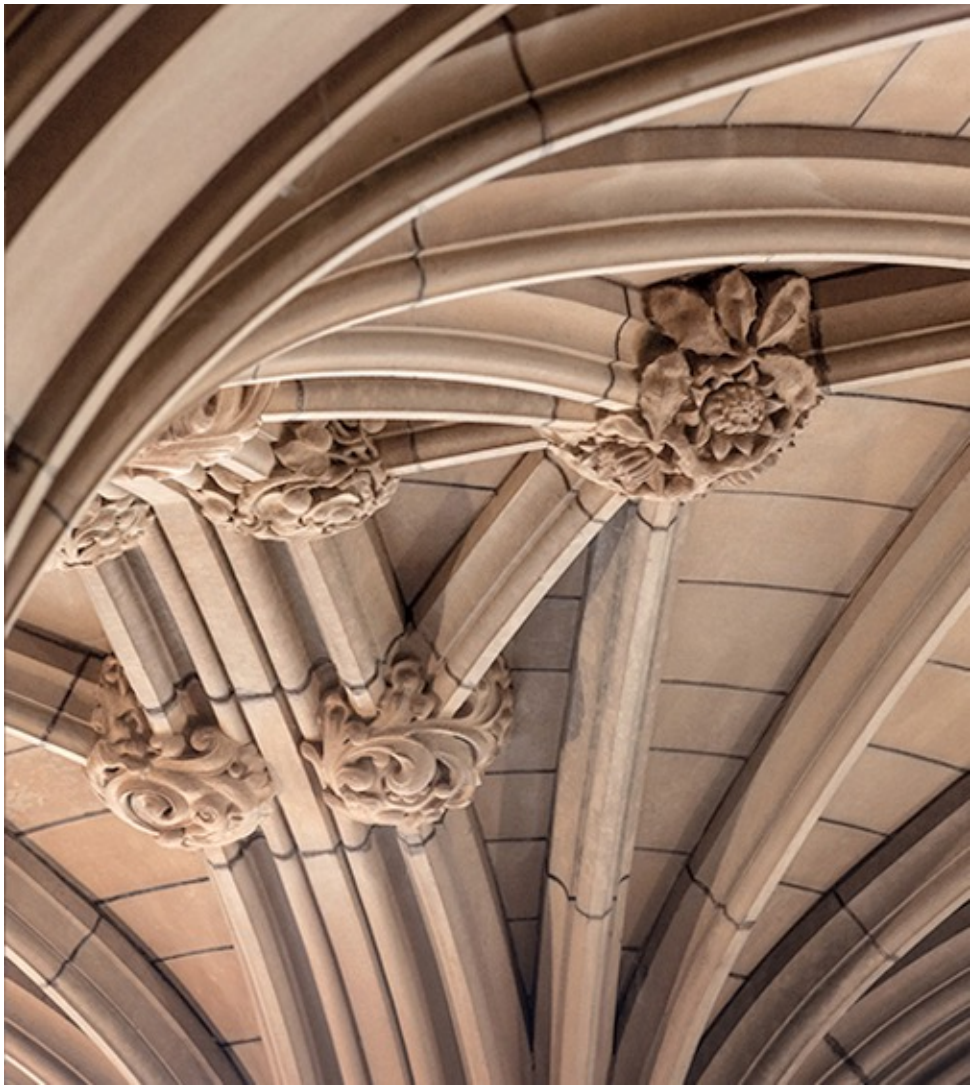
- Avoids feature-laden (heavily loaded) classes high up in the hierarchy
  - Defines a simple class and add functionality incrementally with Decorator objects – applications do not need to have un-needed features
  - You can define new kinds of Decorators independently from the classes of objects they extend, even for unforeseen extensions

Consequences (2)

- Decorator and its component are not identical
  - Decorated component is not identical to the component itself - you shouldn't rely on object identity when you use decorator
- Many little objects
  - Can become hard to learn and debug when lots of little objects that look alike
  - Still not difficult to customize by those who understand them

Façade Pattern

Object Structural



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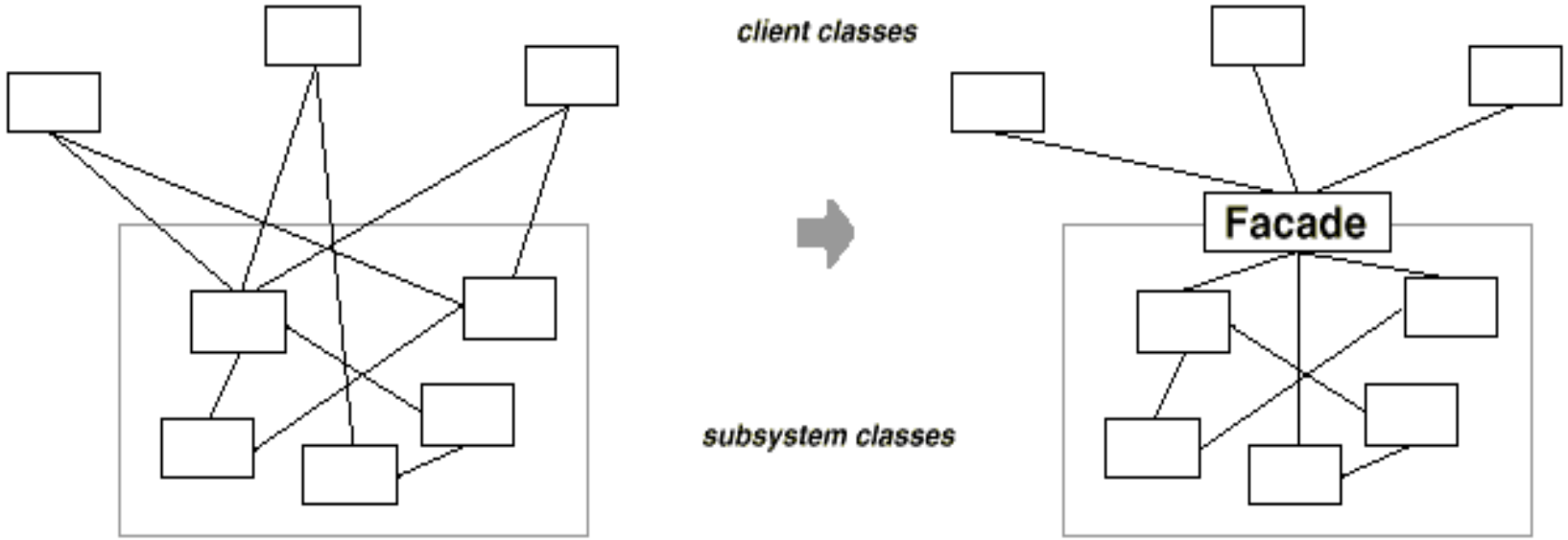
Adapter	Allow classes of incompatible interfaces to work together. Convert the interface of a class into another interface clients expect.
Decorator	Attach additional responsibilities to an object dynamically (flexible alternative to subclassing for extending functionality)
Façade	**Provides a unified interface to a set of interfaces in a subsystem. Defines a higher-level interface that simplifies subsystem use.**

Motivated Scenario

- Suppose you are going to seek some advices from your UG/PG academic advisors. However, there are many academics and you might know who takes care of your major.

Façade Motivation



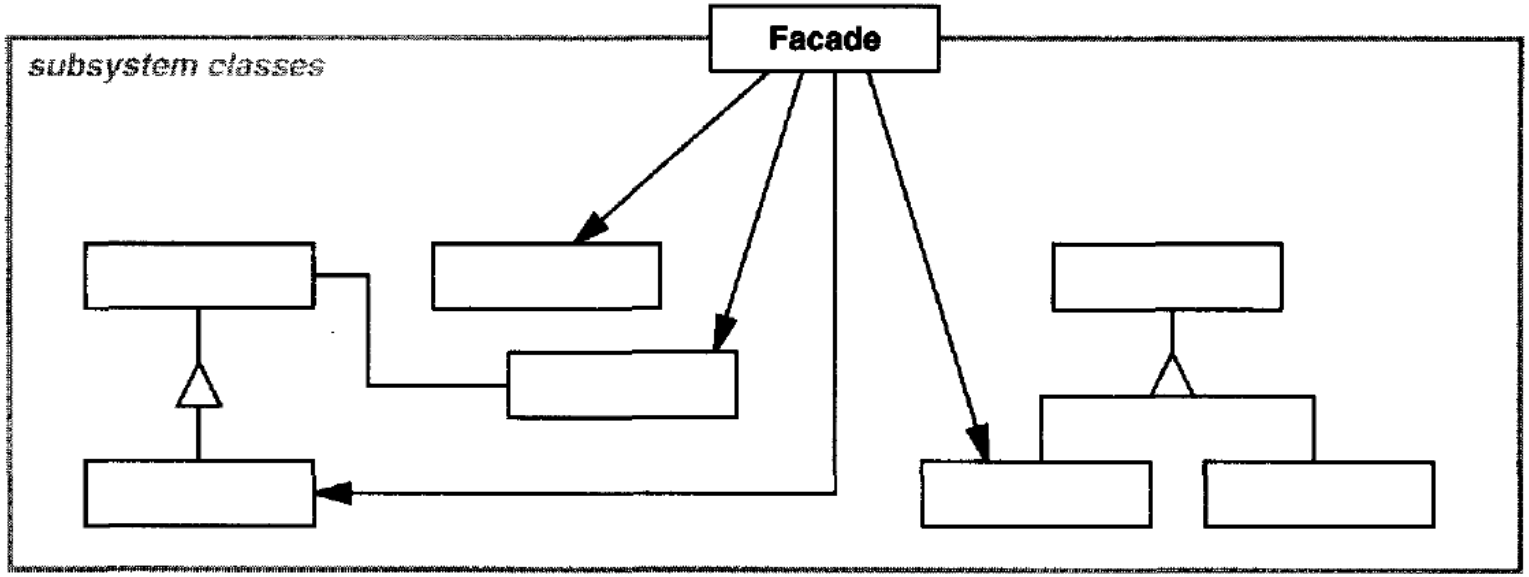
A **facade** object provides a single, simplified interface to the more general facilities of a subsystem

Façade Pattern

- Intent
  - Provide a unified interface to a set of interfaces in a subsystem. It defines a higher-level interface that makes the subsystem easier to use

- Applicability
  - 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 subsystem. Façade would define an entry point to each subsystem level

Façade – Structure



Façade – Participants

- **Facade**
  - Knows which subsystem classes are responsible for a request.
  - Delegates client requests to appropriate subsystem objects.
- **Subsystem classes**
  - Implement subsystem functionality.
  - Handle work assigned by the Façade object
  - Have no knowledge of the facade; they keep no references to it.
- **Collaborations**
  - Clients communicate with the subsystem by sending requests to Façade, which forwards them to the appropriate subsystem object(s).
    - Although the subsystem objects perform the actual work, the façade may have to do work of its own to translate its interface to subsystem interfaces
  - Clients that use the facade don't have to access its subsystem objects directly

Façade

- **Collaborations**
  - Clients communicate with the subsystem by sending requests to Façade, which forwards them to the appropriate subsystem object(s).
    - Although the subsystem objects perform the actual work, the façade may have to do work of its own to translate its interface to subsystem interfaces
  - Clients that use the facade don't have to access its subsystem objects directly

Façade Pattern - Example

```
class subClass1 {
        public void method1() {
                // method body }
}
class subClass2 {
        public void method2() {
                // method body }
}
```

How about Client?

```
Façade façade = new Façade();
façade.methodA();
```

```
class Façade {
        subClass1 s1;
        subClass2 s2;
        public Façade() {
                s1 = new subClass1();
                s2 = new subClass2();
        }
        public void methodA() {
                s1.method1();
                s2.method2();
        }
}
```

Consequences

- Simplify the usage of an existing subsystem by defining your own interface
- Shields clients from subsystem components, reduce the number of objects that clients deal with and make the subsystem easier to use.
- Promote weak coupling between the subsystem and the clients
  - Vary the components of the subsystem without affecting its clients
  - Reduce compilation dependencies (esp. large systems) – when subsystem classes change
- Does not prevent applications from using subsystem classes if they need to. Choice between ease of use and flexibility.

Façade – A Brief Summary

- Name: **Façade**

- Problem: A common, unified interface to a disparate set of implementations or interfaces is required. There may be undesirable coupling to many things in the subsystem, or the implementation of the subsystem may change

- Solution: Define a single point of contact to the subsystem – a façade object that wraps the subsystem. It represents a single unified interface and is responsible for collaborating with the subsystem components.

Task for Week 12

- Submit weekly exercise on canvas before 23.59pm Saturday
- Well organize time for assignment 3

What are we going to learn on week 13?

- Unit Review

References

- Craig Larman. 2004. *Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and Iterative Development (3rd Edition)*. Prentice Hall PTR, Upper Saddle River, NJ, USA.

- Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides. 1995. *Design Patterns: Elements of Reusable Object-Oriented Software*. Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA.