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Object Oriented Design and Design Patterns

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Introduction

Welcome to the Object Oriented Design and Design Patterns Task!

This task will attempt to provide a brief overview of what design patterns are in the realm of software development. We will also take a closer look at a few specific design patterns.

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WHAT ARE DESIGN PATTERNS?

A design pattern is a general repeatable solution to commonly occurring problems faced by software developers during software design. They represent the best practices used by experienced object-oriented software developers. They have been obtained by trial and error by numerous software developers over a substantial period of time. A design pattern is not a finished design that can be transformed directly into code. Rather, it is a description or template for how to solve a problem that can be used in many different situations.

The Hillside Group (http://hillside.net), which is dedicated to maintaining information about patterns, describes design patterns as follows:

Patterns and Pattern Languages are ways to describe best practices, good designs, and capture experience in a way that it is possible for others to reuse this experience.

Design patterns have made a huge impact on object-oriented software design. Not only are they tested solutions to common problems, but they also have provided a vocabulary for talking about design. Therefore, you can explain your design by describing the patterns that you have used.

BENEFITS OF USING DESIGN PATTERNS

- Using them can speed up the development process by providing tested, proven development paradigms.

- Reusing design patterns helps to prevent subtle issues that may only become visible later in the implementation, which can cause major problems.

- It improves code readability for coders and architects familiar with the patterns.

- Design patterns provide general solutions, documented in a format that does not require specifics tied to a particular problem.

- They allow developers to communicate using well-known, well-understood names for software interactions.

- Design patterns are constantly improved over time, making them more robust than ad-hoc designs.

- They are language neutral and so can be applied to any object-orientated programming language.

THE GANG OF FOUR

The best-known design patterns are described in a book entitled: Design Patterns - Elements of Reusable Object-Oriented Software. This book initiated the concept of Design Pattern in Software development. It was written by four authors, Erich Gamma, Richard Helm, Ralph Johnson and John Vlissides, who collectively became known as the "Gang of Four" (GOP).

According to the Gang of Four, design patterns are primarily based on the following principles of object orientated design:

- "Program to an 'interface', not an 'implementation'." (Gang of Four 1995:18)
- Composition over inheritance: "Favor 'object composition' over 'class inheritance'." (Gang of Four 1995:20)
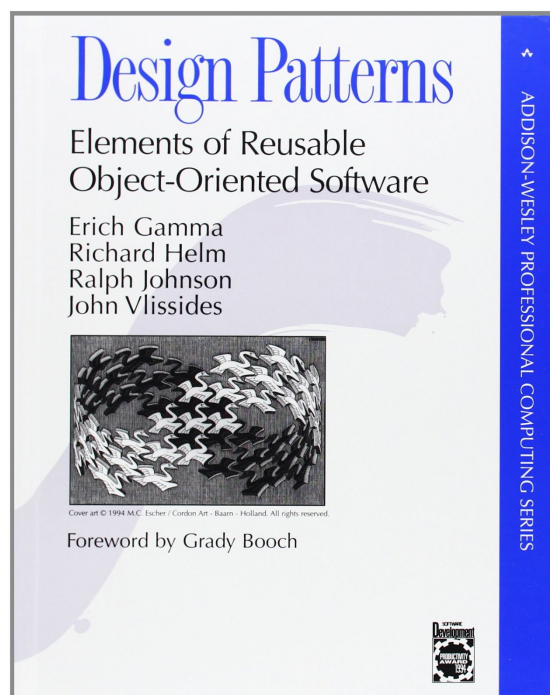
The cover of Design Patterns - Elements of Reusable Object-Oriented Software

TYPES OF DESIGN PATTERNS

According to the book Design Patterns - Elements of Reusable Object-Oriented Software, design patterns can be classified into three categories:

1. Creational
2. Structural
3. Behavioural

Creational Design Patterns
Creational design patterns provide a way to create objects while hiding the creation logic, instead of instantiating objects directly using the new operator. This gives programs more flexibility in deciding which objects need to be created for a given use case.

Structural Design Patterns
Structural design patterns are all about class and object composition. Interfaces are composed using the concept of inheritance. The concept of inheritance is also used to define ways to compose objects to obtain new functionalities.

Behavioural Design Patterns
Behavioural design patterns are concerned with communication between objects.

We will now take a closer look at a few popular design patterns.

FACTORY PATTERN

One of the most popular and widely used design patterns in Java is the Factory pattern. The Factory Pattern is a creational pattern as it provides one of the best ways to create an object. As the name implies, it is a class that acts as a factory of object instances.

The main goal of the Factory Pattern is to encapsulate the creational procedure that may span different classes into one single function. The factory method will be able to return the correct object if it is provided with the correct context.

WHEN TO USE THE FACTORY PATTERN

If you have multiple different variations of a single entity, the factory pattern can be useful. For example, let's say that you have a Shape class. This class has different variations, such as Circle, Square and Rectangle. You need to be able to create different shapes depending on your needs. This is where you can use a factory to create the Shapes for you!

IMPLEMENTATION OF THE FACTORY PATTERN

We are first going to create a Shape interface and concrete classes that implement the Shape interface. We then are going to define the factory class ShapeFactory. Our demo class FactoryPatternDemo will use this factory class to get a Shape object.
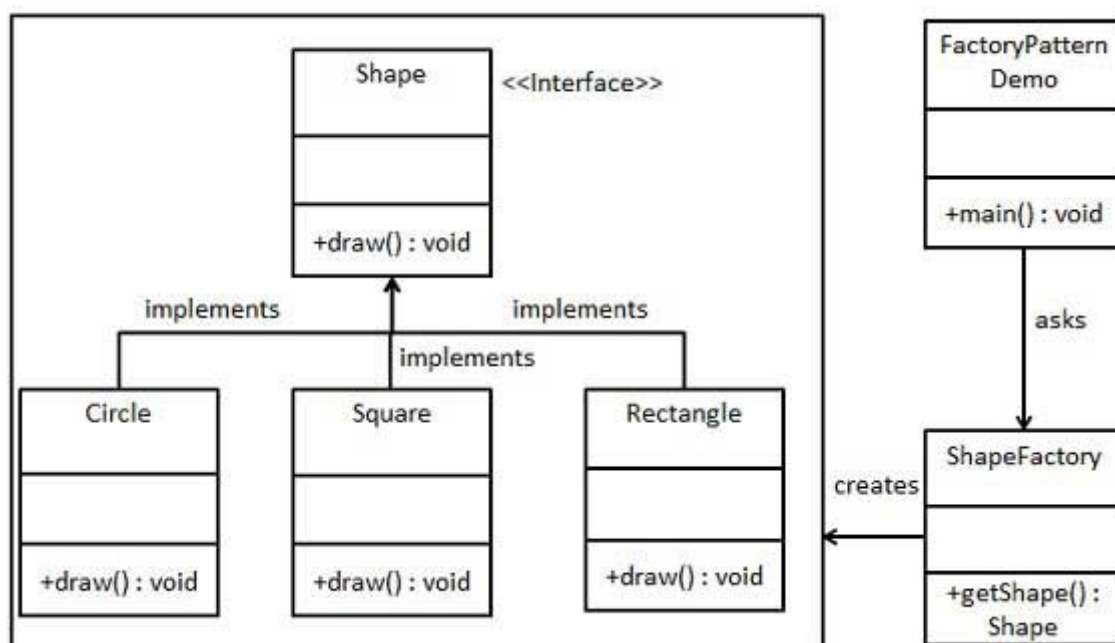
1. First, we create an interface.
    Interfaces are a key concept in OOP. A class can implement an interface. An interface defines which methods and properties a class must implement. The interface itself does not contain any code to implement an object. An interface will, for example, specify that a class that is built based on it should contain a method called "doSomething()" but won't contain any code to implement it. Interfaces specify what a class must do but not how they go about doing it. An interface is often referred to as a contract because it is agreed that a class that implements the interface will implement the properties and methods defined in the interface.

The code below shows an example of an interface in Java. As you can see, the interface defines a method that any class that implements the interface must implement. The interface does not implement the method. It just shows that this method must be implemented in the class.

```java
public interface Shape {
    void draw();
}
```

2. We then create concrete classes to implement the interface.

Rectangle.java

```java
public class Rectangle implements Shape {

    @Override
    public void draw() {
        System.out.println("Inside Rectangle::draw() method.");
    }
}
```

Square.java

```java
public class Square implements Shape {

    @Override
    public void draw() {
        System.out.println("Inside Square::draw() method.");
    }
}
```

Circle.java

```java
public class Circle implements Shape {

    @Override
    public void draw() {
        System.out.println("Inside Circle::draw() method.");
    }
}
```

3. We now create a Factory class to generate an object of concrete class based on given information.

ShapeFactory.java

```java
public class ShapeFactory {

   //use getShape method to get object of type shape
   public Shape getShape(String shapeType){
      if(shapeType == null){
         return null;
      }
      if(shapeType.equalsIgnoreCase("CIRCLE")){
         return new Circle();

      } else if(shapeType.equalsIgnoreCase("RECTANGLE")){
         return new Rectangle();

      } else if(shapeType.equalsIgnoreCase("SQUARE")){
         return new Square();
      }

      return null;
   }
}
```

4. The Factory class is then used to get an object of the concrete class by passing some information. In this case, we pass the type of shape.

FactoryPatternDemo.java

```java
public class FactoryPatternDemo {

   public static void main(String[] args) {
      ShapeFactory shapeFactory = new ShapeFactory();

      //get an object of Circle and call its draw method.
      Shape shape1 = shapeFactory.getShape("CIRCLE");

      //call draw method of Circle
      shape1.draw();

      //get an object of Rectangle and call its draw method.
      Shape shape2 = shapeFactory.getShape("RECTANGLE");

      //call draw method of Rectangle
      shape2.draw();

      //get an object of Square and call its draw method.
      Shape shape3 = shapeFactory.getShape("SQUARE");

      //call draw method of circle
      shape3.draw();
```

```
    }
}
```

5. The output should be the following:

```
Inside Circle::draw() method.
Inside Rectangle::draw() method.
Inside Square::draw() method.
```

SINGLETON PATTERN

One of the simplest patterns in Java is the Singleton pattern. This creational design pattern involves a single class which is responsible for creating a single object and making sure that only that single object gets created. This class provides a way to access this single object which can be accessed directly without the need to instantiate the object of the class.

WHEN TO USE THE SINGLETON PATTERN

You can use the singleton pattern to avoid having to pass an instance via constructor or argument if you need to pass a specific instance from one class to another.

IMPLEMENTATION OF THE SINGLETON PATTERN

We will now create a SingleObject class which has its constructor as private and a static instance of itself. This class has a static method to get its static instance. The demo class SingletonPatternDemo, will use SingleObject class to get a SingleObject object.
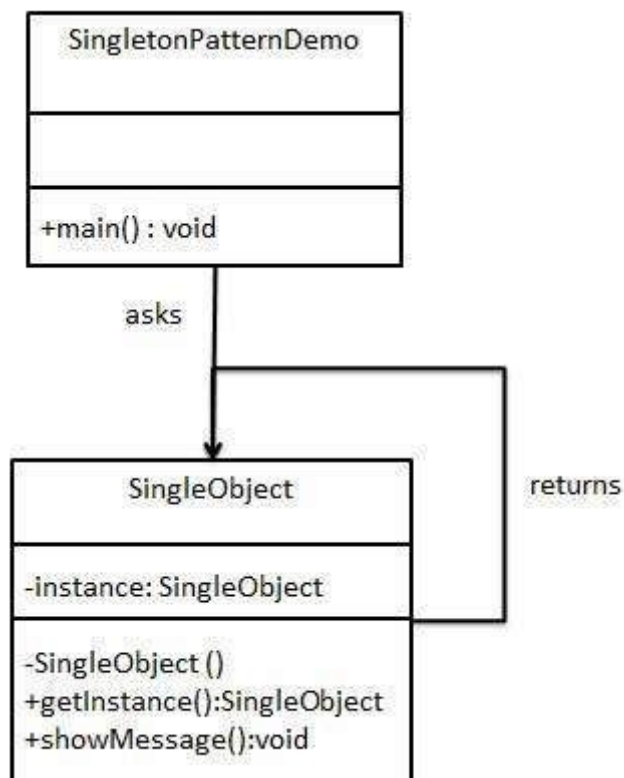
1. First, we create a Singleton class.

SingleObject.java

```java
public class SingleObject {

   //create an object of SingleObject
   private static SingleObject instance = new SingleObject();

   //make the constructor private so that this class cannot be
   //instantiated
   private SingleObject(){}

   //Get the only object available
   public static SingleObject getInstance(){
      return instance;
   }

   public void showMessage(){
      System.out.println("Hello World!");
   }
}
```

2. Now, get the single object from the Singleton class.

SingletonPatternDemo.java

```java
public class SingletonPatternDemo {
   public static void main(String[] args) {

      //illegal construct
      //Compile Time Error: The constructor SingleObject() is not visible
      //SingleObject object = new SingleObject();

      //Get the only object available
      SingleObject object = SingleObject.getInstance();

      //show the message
      object.showMessage();
   }
}
```

3. The output should be as follows:

```
Hello World!
```

ADAPTER PATTERN

The Adapter pattern is a structural pattern that works as a bridge between two incompatible interfaces. It involves a single class which is responsible for joining functionalities of independent or incompatible interfaces. The adapter class is also known as a wrapper because it lets you "wrap" actions into a class and reuse these actions in the correct situations.

IMPLEMENTATION OF THE ADAPTOR PATTERN

We will now demonstrate how the Adapter pattern is used in the following example where an audio player device can play mp3 files only and wants to use an advanced audio player capable of playing vlc and mp4 files.
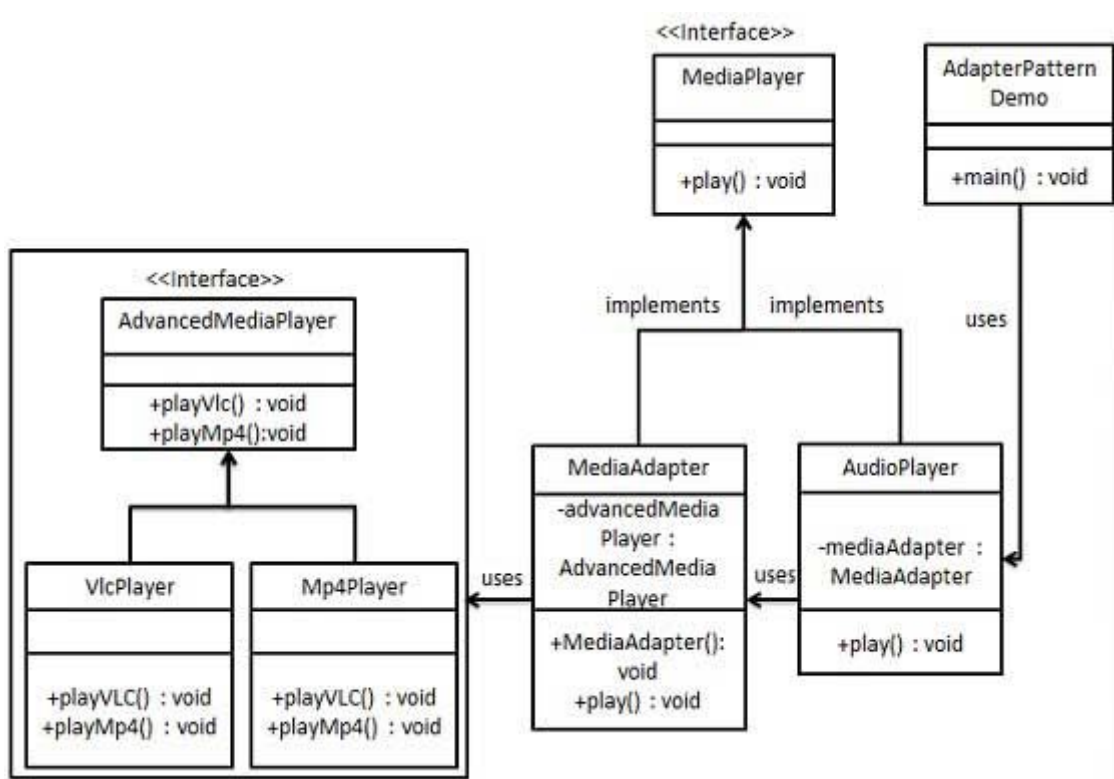
We have a concrete class named AudioPlayer that implements the MediaPlayer interface. AudioPlayer can play mp3 format audio files by default. We also have concrete classes that implement the AdvancedMediaPlayer interface. These classes can play vlc and mp4 format files.

We want AudioPlayer to play these other formats as well. To do this, we have created an adapter class (MediaAdapter) which implements the MediaPlayer interface and uses AdvancedMediaPlayer objects to play the required format.

AudioPlayer uses the adapter class MediaAdapter and passes it the desired audio type without knowing the actual class which can play the desired format. The demo class, AdapterPatternDemo, will use AudioPlayer class to play various formats.

1. Firstly, create the MediaPlayer and AdvancedMediaPlayer interfaces.

MediaPlayer.java

```java
public interface MediaPlayer {
    public void play(String audioType, String fileName);
}
```

AdvancedMediaPlayer.java

```java
public interface AdvancedMediaPlayer {
    public void playVlc(String fileName);
    public void playMp4(String fileName);
}
```

2. Next, create the concrete classes that implement that AdvancedMediaPlayer interface.

VlcPlayer.java

```java
public class VlcPlayer implements AdvancedMediaPlayer{
    @Override
    public void playVlc(String fileName) {
        System.out.println("Playing vlc file. Name: "+ fileName);
    }

    @Override
    public void playMp4(String fileName) {

    }
}
```

Mp4Player.java

```java
public class Mp4Player implements AdvancedMediaPlayer{

    @Override
    public void playVlc(String fileName) {

    }
```

```java
    @Override
    public void playMp4(String fileName) {
        System.out.println("Playing mp4 file. Name: "+ fileName);
    }
}
```

3. The class MediaAdpter that implements the MediaPlayer interface is then created.

MediaAdapter.java

```java
public class MediaAdapter implements MediaPlayer {

    AdvancedMediaPlayer advancedMusicPlayer;

    public MediaAdapter(String audioType){

        if(audioType.equalsIgnoreCase("vlc") ){
            advancedMusicPlayer = new VlcPlayer();

        }else if (audioType.equalsIgnoreCase("mp4")){
            advancedMusicPlayer = new Mp4Player();
        }
    }

    @Override
    public void play(String audioType, String fileName) {

        if(audioType.equalsIgnoreCase("vlc")){
            advancedMusicPlayer.playVlc(fileName);
        }
        else if(audioType.equalsIgnoreCase("mp4")){
            advancedMusicPlayer.playMp4(fileName);
        }
    }
}
```

4. Then, the concrete class AudioPlayer that implements the MediaPlayer interface is created.

AudioPlayer.java

```java
public class AudioPlayer implements MediaPlayer {
    MediaAdapter mediaAdapter;

    @Override
    public void play(String audioType, String fileName) {
```

```java
        //inbuilt support to play mp3 music files
        if(audioType.equalsIgnoreCase("mp3")){
            System.out.println("Playing mp3 file. Name: " + fileName);

        }

        //mediaAdapter is providing support to play other file formats
        else if(audioType.equalsIgnoreCase("vlc") ||
audioType.equalsIgnoreCase("mp4")){
            mediaAdapter = new MediaAdapter(audioType);
            mediaAdapter.play(audioType, fileName);
        }

        else{
            System.out.println("Invalid media. " + audioType + " format not
supported");
        }
    }
}
```

5. Finally , AudioPlayer is used to play different types of audio formats.

```java
public class AdapterPatternDemo {
    public static void main(String[] args) {
        AudioPlayer audioPlayer = new AudioPlayer();

        audioPlayer.play("mp3", "beyond the horizon.mp3");
        audioPlayer.play("mp4", "alone.mp4");
        audioPlayer.play("vlc", "far far away.vlc");
        audioPlayer.play("avi", "mind me.avi");
    }
}
```

6. The output should be as follows:

```
Playing mp3 file. Name: beyond the horizon.mp3
Playing mp4 file. Name: alone.mp4
Playing vlc file. Name: far far away.vlc
Invalid media. avi format not supported
```

DECORATOR PATTERN

The Decorator Pattern is a structural design pattern that allows you to add new functionality to an existing object without altering its structure. It creates a

decorator class which wraps the original class and provides additional functionality, keeping class methods signature intact.

WHEN TO USE THE DECORATOR PATTERN

The best place to use the decorator pattern is when you have an entity which needs to have new behaviour only if the situation requires it.

IMPLEMENTATION OF THE DECORATOR PATTERN

We will now demonstrate how the Decorator pattern is used in the following example where a shape will be decorated with some colour without altering shape class.
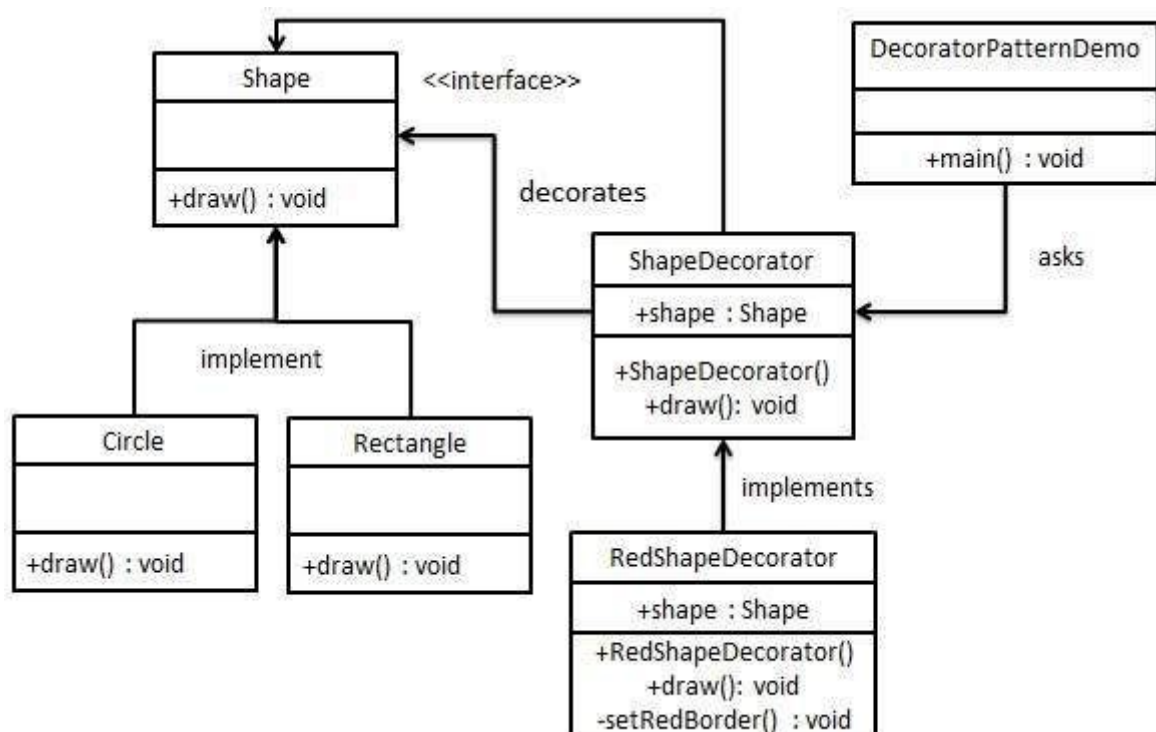
1. Firstly create a Shape interface.

    Shape.java
    ```java
    public interface Shape {
        void draw();
    }
    ```

2. Then, create concrete classes which implement the Shape interface.

    Rectangle.java

```java
public class Rectangle implements Shape {

    @Override
    public void draw() {
        System.out.println("Shape: Rectangle");
    }
}
```

Circle.java

```java
public class Circle implements Shape {

    @Override
    public void draw() {
        System.out.println("Shape: Circle");
    }
}
```

3. Then, create an abstract decorator class called ShapeDecorator, which implements the Shape interface and has a Shape object as its instance variable.

ShapeDecorator.java

```java
public abstract class ShapeDecorator implements Shape {
    protected Shape decoratedShape;

    public ShapeDecorator(Shape decoratedShape){
        this.decoratedShape = decoratedShape;
    }

    public void draw(){
        decoratedShape.draw();
    }
}
```

4. Now create RedShapeDecorator, which is a concrete class implementing ShapeDecorator.

RedShapeDecorator.java

```java
public class RedShapeDecorator extends ShapeDecorator {

    public RedShapeDecorator(Shape decoratedShape) {
        super(decoratedShape);
    }
```

```java
    @Override
    public void draw() {
        decoratedShape.draw();
        setRedBorder(decoratedShape);
    }

    private void setRedBorder(Shape decoratedShape){
        System.out.println("Border Color: Red");
    }
}
```

5. Lastly, use the RedShapeDecorator class to decorate Shape objects.

DecoratorPatternDemo.java

```java
public class DecoratorPatternDemo {
    public static void main(String[] args) {

        Shape circle = new Circle();

        Shape redCircle = new RedShapeDecorator(new Circle());

        Shape redRectangle = new RedShapeDecorator(new Rectangle());
        System.out.println("Circle with normal border");
        circle.draw();

        System.out.println("\nCircle of red border");
        redCircle.draw();

        System.out.println("\nRectangle of red border");
        redRectangle.draw();
    }
}
```

6. The output should be as follows:

```
Circle with normal border
Shape: Circle

Circle of red border
Shape: Circle
Border Color: Red

Rectangle of red border
```

```
Shape: Rectangle
Border Color: Red
```

STRATEGY PATTERN

The Strategy pattern is a behavioural design pattern in which a class behavior or its algorithm can be changed at runtime. With this pattern, we create objects which represent various strategies and a context object whose behaviour varies as per its strategy object. The strategy object changes the executing algorithm of the context object.

IMPLEMENTATION OF THE STRATEGY PATTERN
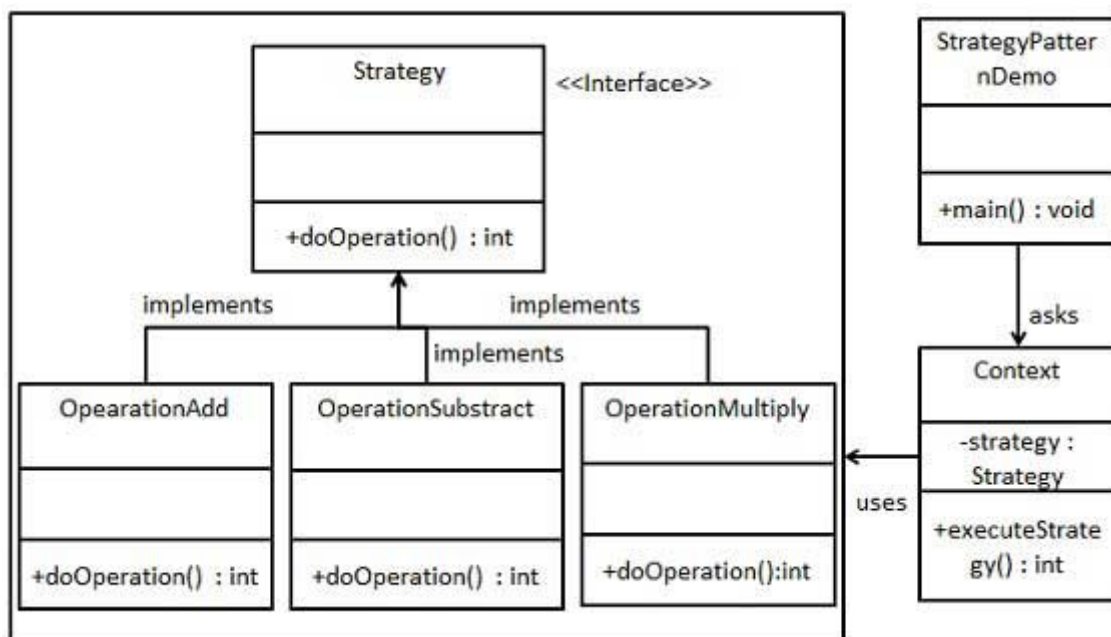
To demonstrate how the Strategy pattern is implemented, we are going to create a Strategy interface which defines an action and concrete strategy classes which implement this interface. We then create a Context class which uses a Strategy and finally a demo class called, StrategyPatternDemo, which will use Context and strategy objects to demonstrate change in Context behaviour based on the strategy it deploys or uses.

1. Firstly create an interface.

   Strategy.java

```java
public interface Strategy {
    public int doOperation(int num1, int num2);
}
```

2. Then, create concrete classes which implement the interface.

OperationAdd.java

```java
public class OperationAdd implements Strategy{
    @Override
    public int doOperation(int num1, int num2) {
        return num1 + num2;
    }
}
```

OperationSubstract.java

```java
public class OperationSubstract implements Strategy{
    @Override
    public int doOperation(int num1, int num2) {
        return num1 - num2;
    }
}
```

OperationMultiply.java

```java
public class OperationMultiply implements Strategy{
    @Override
    public int doOperation(int num1, int num2) {
        return num1 * num2;
    }
}
```

3. Now create the Context class.

Context.java

```java
public class Context {
    private Strategy strategy;

    public Context(Strategy strategy){
        this.strategy = strategy;
    }

    public int executeStrategy(int num1, int num2){
        return strategy.doOperation(num1, num2);
```

```
      }
}
```

4. Finally, create a demo class that uses the Context class to see the change in behaviour when it changes its Strategy.

StrategyPatternDemo.java

```java
public class StrategyPatternDemo {
    public static void main(String[] args) {
        Context context = new Context(new OperationAdd());
        System.out.println("10 + 5 = " + context.executeStrategy(10, 5));

        context = new Context(new OperationSubstract());
        System.out.println("10 - 5 = " + context.executeStrategy(10, 5));

        context = new Context(new OperationMultiply());
        System.out.println("10 * 5 = " + context.executeStrategy(10, 5));
    }
}
```

5. The output should be as follows:

```
10 + 5 = 15
10 - 5 = 5
10 * 5 = 50
```

Compulsory Task

Follow these steps:

- Download the SingletonExercise.java file.

- Change the Deck class into a Singleton class.

- Change the main method to get the Deck instance rather than creating a new object.

- The program should print all 52 cards in random order.

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