

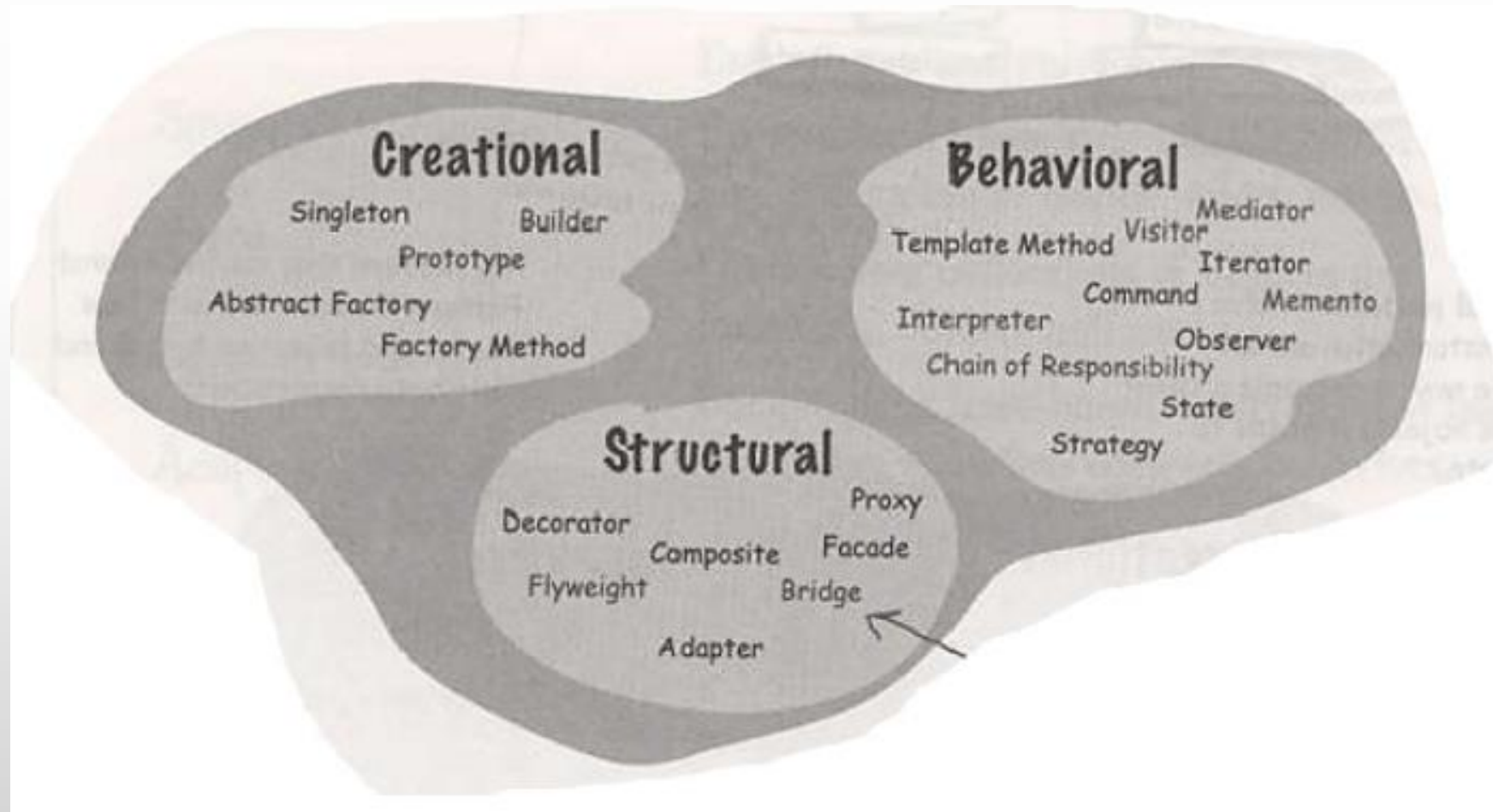
Design Patterns

Object Oriented Programming (OOP)

2nd Year – Semester 1

By Udara Samaratunge

Fundamental Design Patterns (Gang Of Four - GOF)



By Udara Samaratunge

- ③ **Creational:** Involve object initialization and provide a way to decouple client from the objects it needs to instantiate
- ③ **Structural:** Lets you compose classes or objects into larger structures
- ③ **Behavioral:** Concerned with how classes and objects interact or distribute responsibility

Gang of Four Patterns

Creational :

- Abstract Factory
- Builder
- Factory Method
- Prototype
- Singleton

Behavioral :

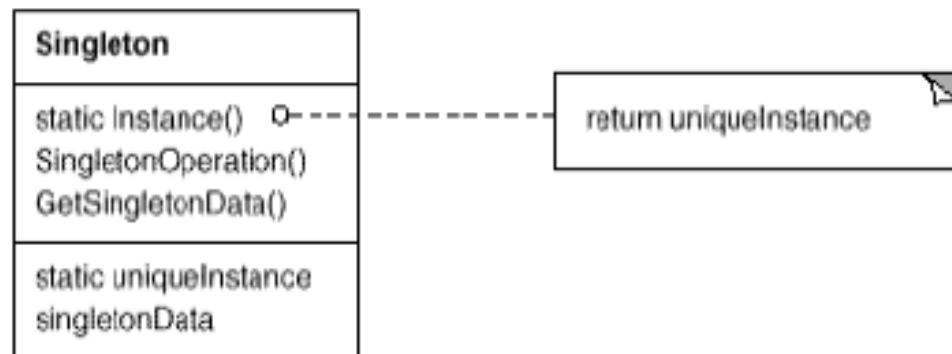
- Strategy
- Observer
- Command
- Interpreter
- Iterator
- Mediator

- Memento
- Chain of Responsibility
- State
- Template Method
- Visitor

Structural :

- Adapter
- Bridge
- Composite
- Decorator
- Facade
- Flyweight
- Proxy

Singleton Pattern



Ensure a class only has one instance, and provide a global point of access to it

Singleton

```
public class Singleton {  
    private static Singleton uniqueinstance;  
  
    private Singleton() {}  
  
    public static Singleton getInstance() {  
        if (uniqueinstance == null) {  
            uniqueinstance = new Singleton();  
        }  
        return uniqueinstance;  
    }  
}
```

*A static
instance*

*Need to have
a private
constructor to
block multiple
instances*

*Lazy
Loading*

This ensures only one object instance is ever created.

However, this is good only for a single-threaded application

By Udara Samaratunga

5

Singleton

```
public class Singleton {  
    private static Singleton uniqueinstance;  
  
    private Singleton() {}  
  
    public static synchronized Singleton getInstance() {  
  
        if (uniqueinstance == null) {  
            uniqueinstance = new Singleton();  
        }  
        return uniqueinstance;  
    }  
}
```

*This overcomes
the multiple
threading issue.*

However, the synchronization is bit expensive

This way is good if the performance is not an issue

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Singleton – with Double Check Lock

```
public class Singleton {  
    private volatile static Singleton uniqueinstance;  
  
    private Singleton() {}  
  
    public static Singleton getInstance() {  
        if (uniqueinstance == null) {  
            synchronized (Singleton.class) {  
                if (uniqueinstance == null) {  
                    uniqueinstance = new Singleton();  
                }  
            }  
        }  
  
        return uniqueinstance;  
    }  
}
```

Double
Check
Locking

Here the object is created and synchronized at the first time only. If the Double Check Is not there, two threads can get into the synchronized block one after the other

This way is good if the application is keen on its performance

Thread-safe singleton output

```
public class TestThreadSingleton implements Runnable{

    /**
     * @param args
     */
    public static void main(String[] args) {

        new Thread(new TestThreadSingleton()).start();

        for (int i = 0; i < 10; i++) {
            Singleton.getInstance();
            ThreadSafeSingleton.getInstance();
        }

    }

    /**
     * Invoke thread
     */
    public void run(){
        for (int i = 0; i < 10; i++) {
            Singleton.getInstance();
            ThreadSafeSingleton.getInstance();
        }
    }
}
```

```
<terminated> TestThreadSingleton [Java Application]
Singleton invocation
Singleton invocation
Object created for ThreadSafeSingleton.
```

Factory Pattern

The Factory Method

The factory method pattern encapsulates the object creation by letting subclasses to decide what objects to create

PizzaStore is now abstract (see why below).

```
public abstract class PizzaStore {
```

```
    public Pizza orderPizza(String type) {  
        Pizza pizza;
```

```
        pizza = createPizza(type);
```

```
        pizza.prepare();
```

```
        pizza.bake();
```

```
        pizza.cut();
```

```
        pizza.box();
```

```
        return pizza;
```

```
    }
```

```
    abstract createPizza(String type);
```

```
}
```

Now createPizza is back to being a call to a method in the PizzaStore rather than on a factory object.

All this looks just the same...

Now we've moved our factory object to this method.

Our "factory method" is now abstract in PizzaStore.

The Creator Classes

```
public abstract class PizzaStore {
```

```
    abstract Pizza createPizza(String item);
```

```
    public Pizza orderPizza(String type) {
        Pizza pizza = createPizza(type);
        System.out.println("--- Making a " + pizza.getName() + " ---");
        pizza.prepare();
        pizza.bake();
        pizza.cut();
        pizza.box();
        return pizza;
    }
}
```

This is the
"Factory Method"

Factory objects are created
through INHERITANCE

```
public class ChicagoPizzaStore extends PizzaStore {
```


```
    Pizza createPizza(String item) {
        if (item.equals("cheese")) {
            return new ChicagoStyleCheesePizza();
        } else if (item.equals("veggie")) {
            return new ChicagoStyleVeggiePizza();
        } else if (item.equals("clam")) {
            return new ChicagoStyleClamPizza();
        } else if (item.equals("pepperoni")) {
            return new ChicagoStylePepperoniPizza();
        } else return null;
    }
}
```

```
public class NYPizzaStore extends PizzaStore {
```


```
    Pizza createPizza(String item) {
        if (item.equals("cheese")) {
            return new NYStyleCheesePizza();
        } else if (item.equals("veggie")) {
            return new NYStyleVeggiePizza();
        } else if (item.equals("clam")) {
            return new NYStyleClamPizza();
        } else if (item.equals("pepperoni")) {
            return new NYStylePepperoniPizza();
        } else return null;
    }
}
```

Simple Factory Vs Factory Method

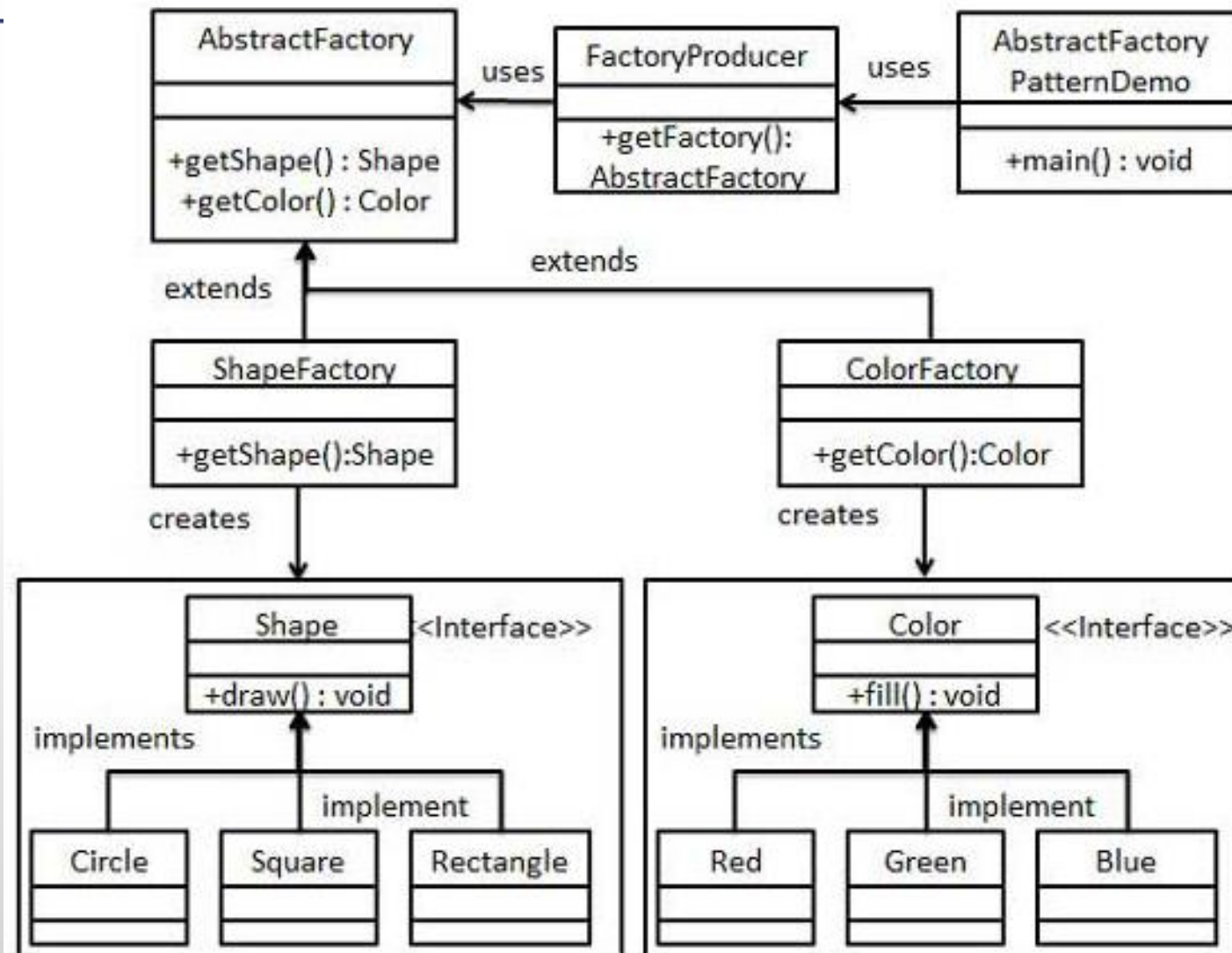
Simple Factory

-  Does not let you vary the product implementations being created

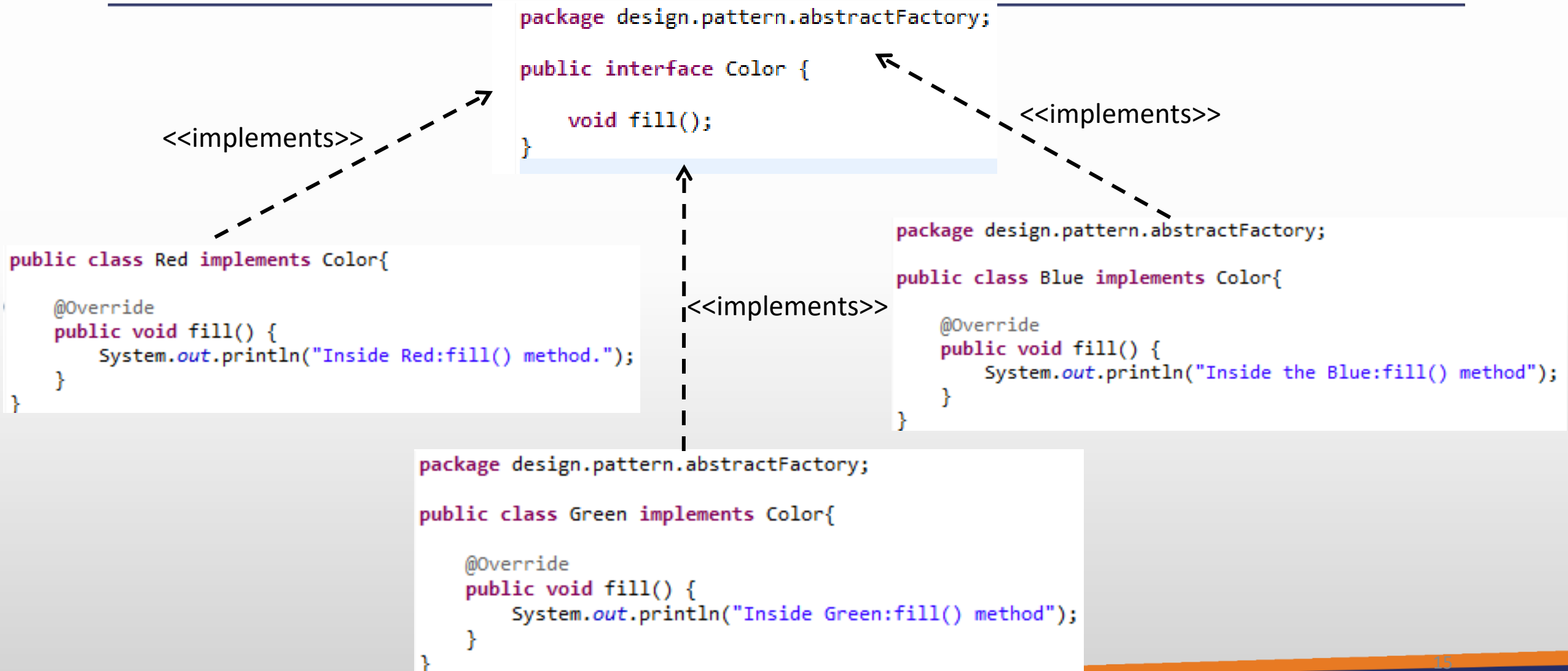
Factory Method

-  Creates a framework that lets the sub classes decides which product implementation will be used

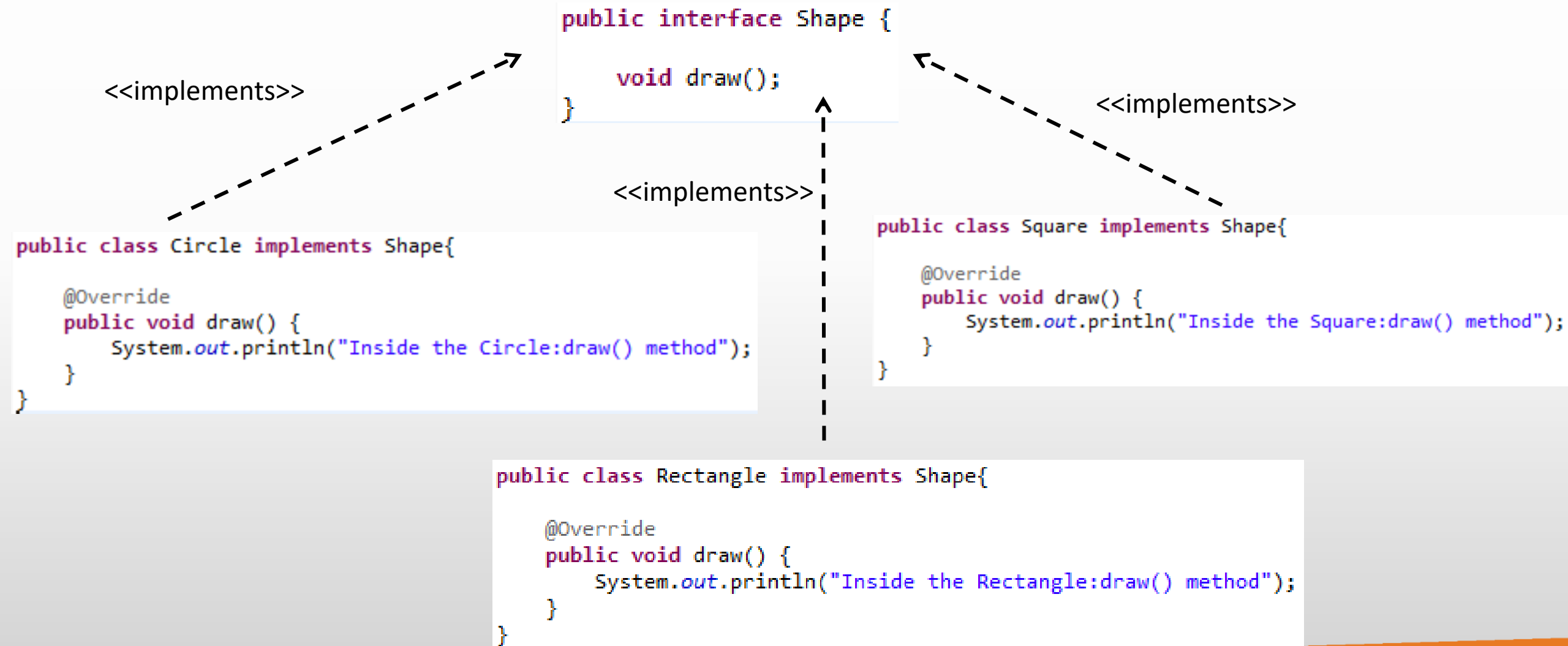
Abstract Factory Pattern



Abstract Factory Pattern



Abstract Factory Pattern



Abstract Factory Pattern

uses

```
public class ColorFactory extends AbstractFactory {  
  
    @Override  
    public Color getColor(String color) {  
  
        if(color.equalsIgnoreCase("RED")){  
            return new Red();  
        }  
        else if(color.equalsIgnoreCase("GREEN")){  
            return new Green();  
        }  
        else if(color.equalsIgnoreCase("BLUE")){  
            return new Blue();  
        }  
        else{  
            return null;  
        }  
    }  
  
    @Override  
    public Shape getShape(String type) {  
        return null;  
    }  
}
```

```
public class FactoryProducer {  
  
    public static AbstractFactory getFactory(String choice){  
  
        if(choice.equalsIgnoreCase("SHAPE")){  
            return new ShapeFactory();  
        }  
        else if(choice.equalsIgnoreCase("COLOR")){  
            return new ColorFactory();  
        }  
        else{  
            return null;  
        }  
    }  
}
```

uses

```
public class ShapeFactory extends AbstractFactory{  
  
    @Override  
    public Shape getShape(String shapeType) {  
  
        if(shapeType == null){  
            return null;  
        }  
        else if(shapeType.equalsIgnoreCase("CIRCLE")){  
            return new Circle();  
        }  
        else if(shapeType.equalsIgnoreCase("RECTANGLE")){  
            return new Rectangle();  
        }  
        else if(shapeType.equalsIgnoreCase("SQUARE")){  
            return new Square();  
        }  
        else{  
            return null;  
        }  
    }  
  
    @Override  
    public Color getColor(String type) {  
        return null;  
    }  
}
```

Abstract Factory Pattern

```
public abstract class AbstractFactory {

    public abstract Color getColor(String type);

    public abstract Shape getShape(String type);

}
```

uses

```
public class ShapeFactory extends AbstractFactory{

    @Override
    public Shape getShape(String shapeType) {
```

```
public class ColorFactory extends AbstractFactory{
```

```
    @Override
    public Color getColor(String color) {

        if(color.equalsIgnoreCase("RED")){
            return new Red();
        }
        else if(color.equalsIgnoreCase("GREEN")){
            return new Green();
        }
        else if(color.equalsIgnoreCase("BLUE")){
            return new Blue();
        }
        else{
            return null;
        }
    }

    @Override
    public Shape getShape(String type) {
        return null;
    }
}
```

```
class FactoryProducer {

    public static AbstractFactory getFactory(String choice){

        if(choice.equalsIgnoreCase("SHAPE")){
            return new ShapeFactory();
        }
        else if(choice.equalsIgnoreCase("COLOR")){
            return new ColorFactory();
        }
        else{
            return null;
        }
    }

}
```

```
        if(shapeType == null){
            return null;
        }
        else if(shapeType.equalsIgnoreCase("CIRCLE")){
            return new Circle();
        }
        else if(shapeType.equalsIgnoreCase("RECTANGLE")){
            return new Rectangle();
        }
        else if(shapeType.equalsIgnoreCase("SQUARE")){
            return new Square();
        }
        else{
            return null;
        }
    }

    @Override
    public Color getColor(String type) {
        return null;
    }
}
```

Abstract Factory Pattern

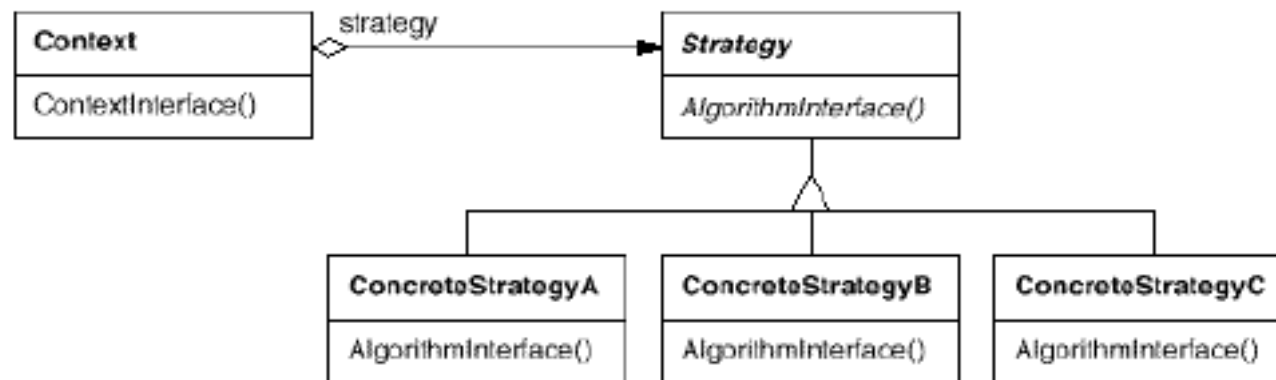
```
package design.pattern.abstractFactory;  
  
public class AbstractFactoryPatternDemo {  
  
    private static final String SHAPE = "SHAPE";  
    private static final String CIRCLE = "CIRCLE";  
    private static final String RECTANGLE = "RECTANGLE";  
    private static final String SQUARE = "SQUARE";  
  
    private static final String COLOR = "COLOR";  
    private static final String RED = "RED";  
    private static final String GREEN = "GREEN";  
    private static final String BLUE = "BLUE";  
  
    public static void main(String[] args) {  
  
        AbstractFactory shapeFactory = FactoryProducer.getFactory(SHAPE);  
        Shape shape = shapeFactory.getShape(CIRCLE);  
        shape.draw();  
  
        FactoryProducer.getFactory(SHAPE).getShape(RECTANGLE).draw();  
        FactoryProducer.getFactory(SHAPE).getShape(SQUARE).draw();  
  
        FactoryProducer.getFactory(COLOR).getColor(RED).fill();  
        FactoryProducer.getFactory(COLOR).getColor(GREEN).fill();  
        FactoryProducer.getFactory(COLOR).getColor(BLUE).fill();  
    }  
}
```

Problems Console Javadoc Declaration Search Progress Cross Ref

```
<terminated> AbstractFactoryPatternDemo [Java Application] C:\Program Files\Java\jdk1.7.0_71\bin\ja  
Inside the Circle:draw() method  
Inside the Rectangle:draw() method  
Inside the Square:draw() method  
Inside Red:fill() method.  
Inside Green:fill() method  
Inside the Blue:fill() method
```

Strategy Pattern

Strategy Pattern



Define a family of algorithms, encapsulate each one, and make them interchangeable. Strategy lets the algorithm vary independently from clients that use it.

By Udara Samaratunge

Design Principles covered - (3)

🕒 *Design Principle 1*

Identify the aspects of your application that vary and separate them from what stays the same

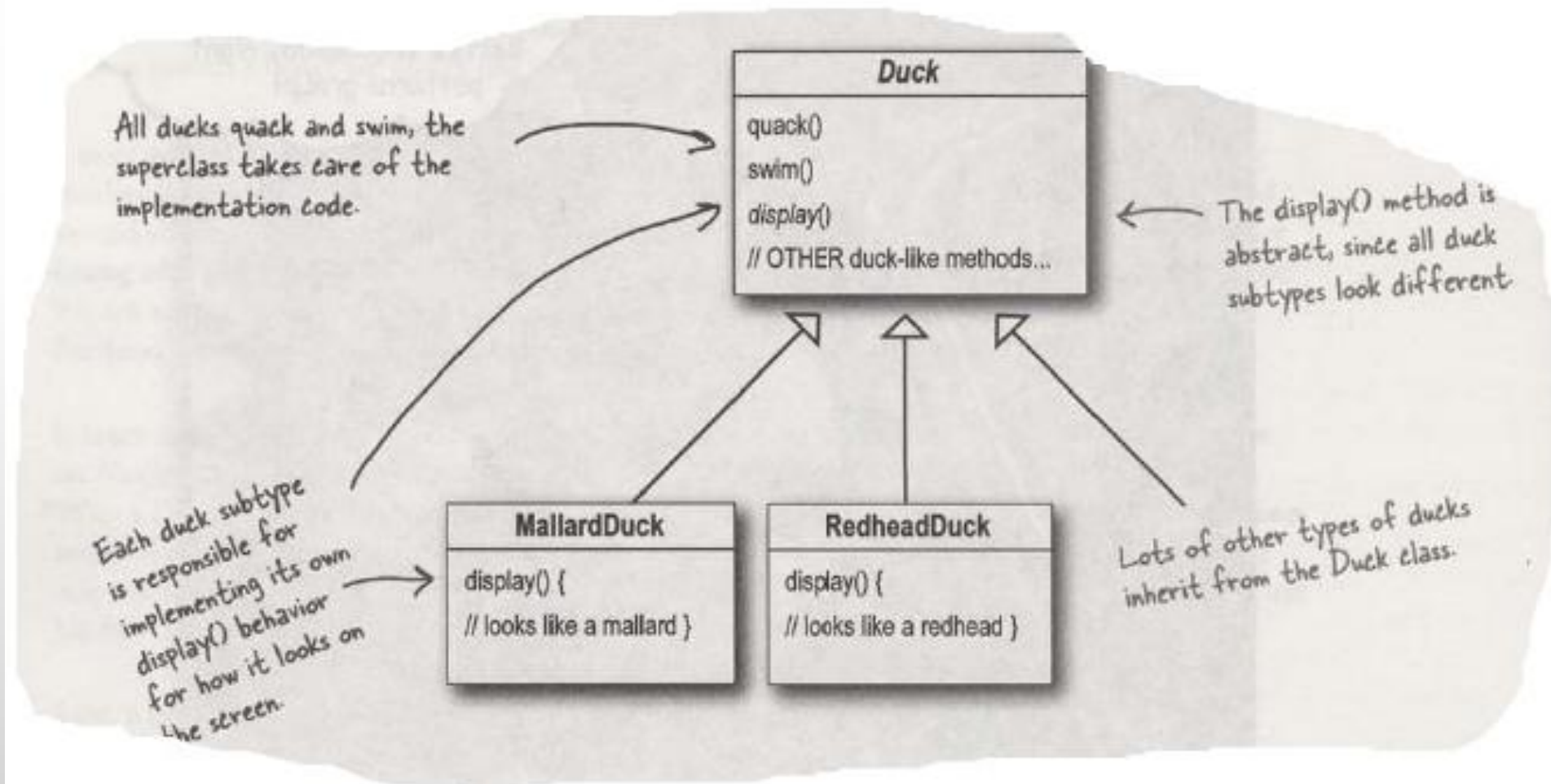
🕒 *Design Principle 2*

Program to an interface not to an implementation

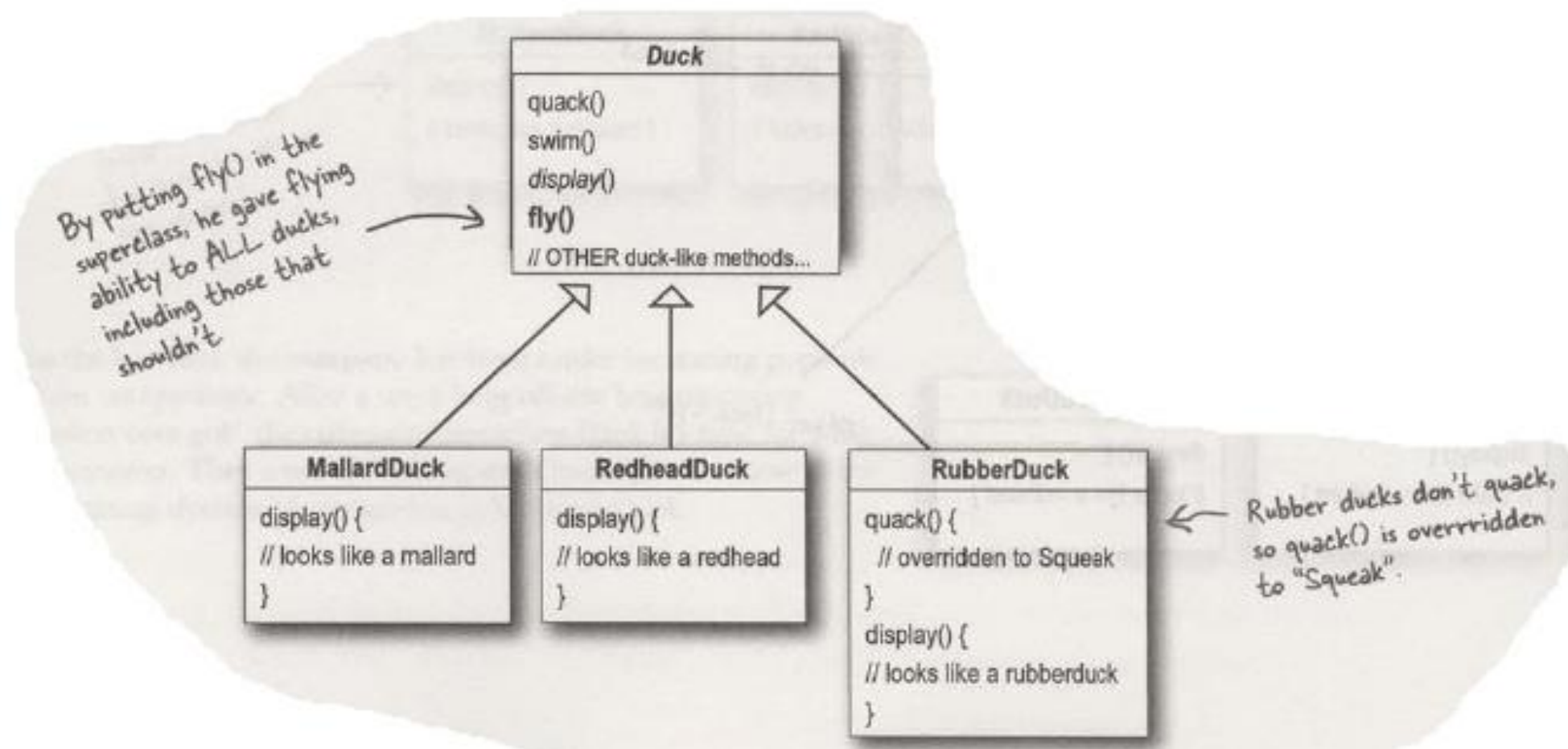
🕒 *Design Principle 3*

Favor composition over inheritance

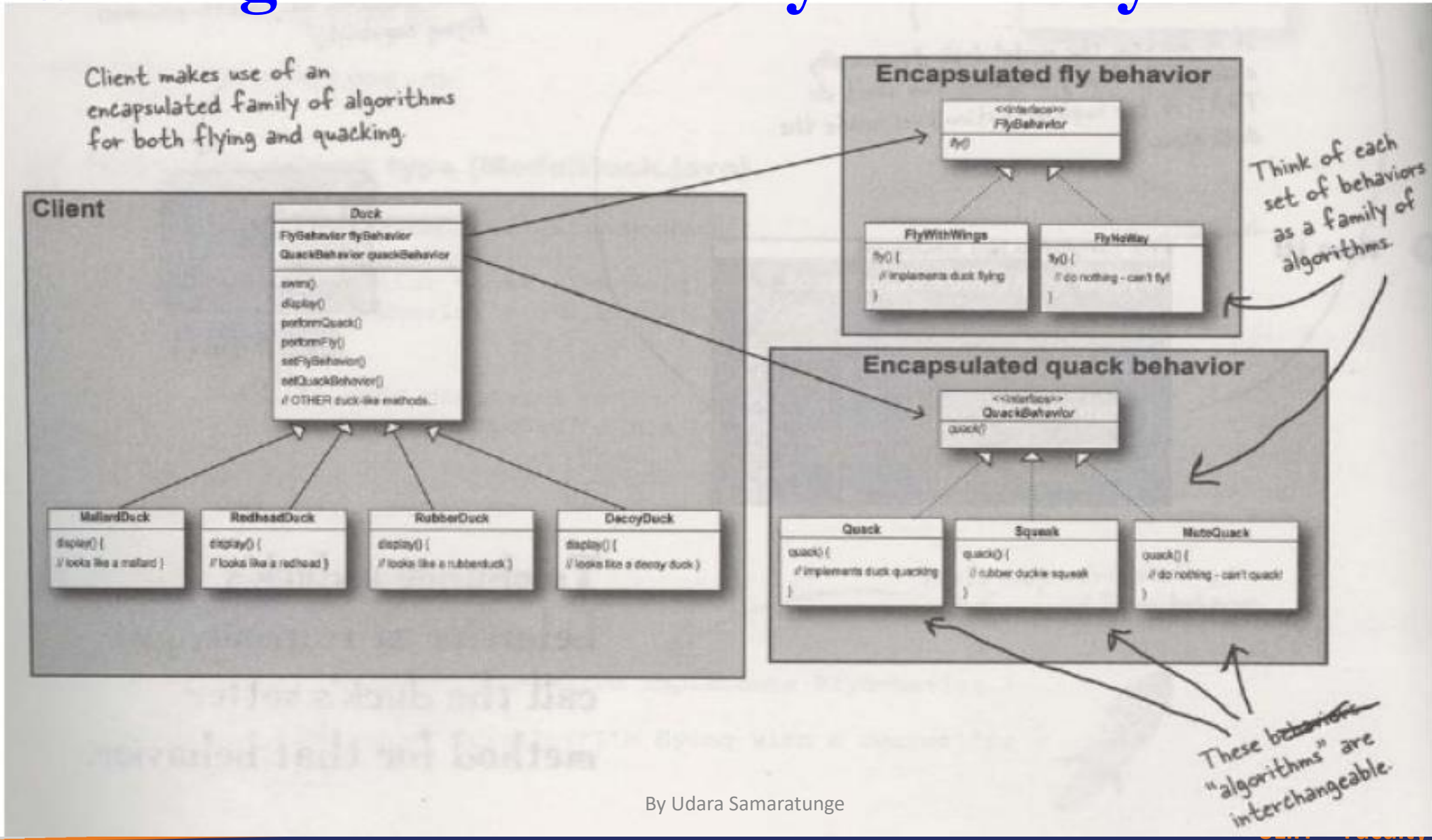
The Duck Simulation



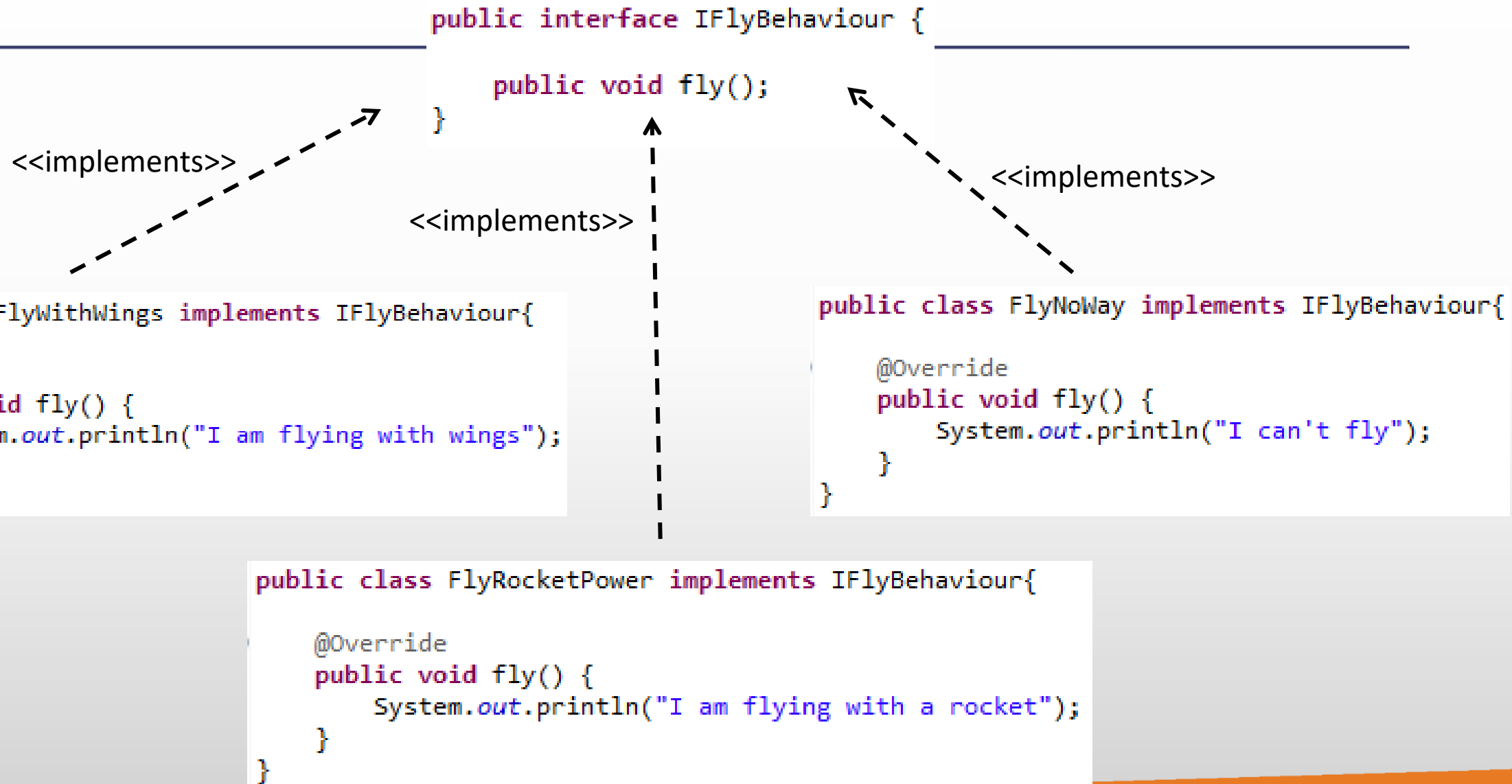
How about Inheritance?



Setting the behavior dynamically



Strategy Pattern Implementation



Strategy Pattern Implementation

```
public interface IQuackBehaviour {  
    public void quack();  
}
```

<<implements>>

```
public class Quack implements IQuackBehaviour{  
    @Override  
    public void quack() {  
        System.out.println("Quack..Quack...");  
    }  
}
```

<<implements>>

```
public class ModelQuack implements IQuackBehaviour{  
    @Override  
    public void quack() {  
        System.out.println("Quack Model duck");  
    }  
}
```

```
public abstract class Duck {
```

```
    IFlyBehaviour flyBehaviour;
```

```
    IQuackBehaviour quackBehaviour;
```

```
    public abstract void display();
```

```
    public void performFly(){
        flyBehaviour.fly();
    }
```

```
    public void performQuack(){
        quackBehaviour.quack();
    }
```

```
    public void swim(){
        System.out.println("All ducks float even Decoy");
    }
```

```
    public void setFlyBehaviour(IFlyBehaviour flyBehaviour) {
        this.flyBehaviour = flyBehaviour;
    }
```

```
    public void setQuackBehaviour(IQuackBehaviour quackBehaviour) {
        this.quackBehaviour = quackBehaviour;
    }
}
```

```
public interface IFlyBehaviour {

    public void fly();

}
```

```
public interface IQuackBehaviour {

    public void quack();

}
```

```
public class ModelDuck extends Duck{
```

```
    public ModelDuck() {
        quackBehaviour = new Quack();
        flyBehaviour = new FlyNoWay();
    }
```

```
    @Override
    public void display() {
        System.out.println("I am a model Duck");
    }
}
```

```
public class MollardDuck extends Duck{
```

```
    public MollardDuck() {
        quackBehaviour = new Quack();
        flyBehaviour = new FlyWithWings();
    }
```

```
    @Override
    public void display() {
        System.out.println("I am a real Mollard Duck.");
    }
}
```

Strategy Pattern Implementation

```
package design.pattern.strategy;

public class TestDuck {

    /**
     * @param args
     */
    public static void main(String[] args) {

        System.out.println("Start Mollard Duck");
        System.out.println("=====");
        Duck mollard = new MollardDuck();
        mollard.performFly();
        mollard.performQuack();

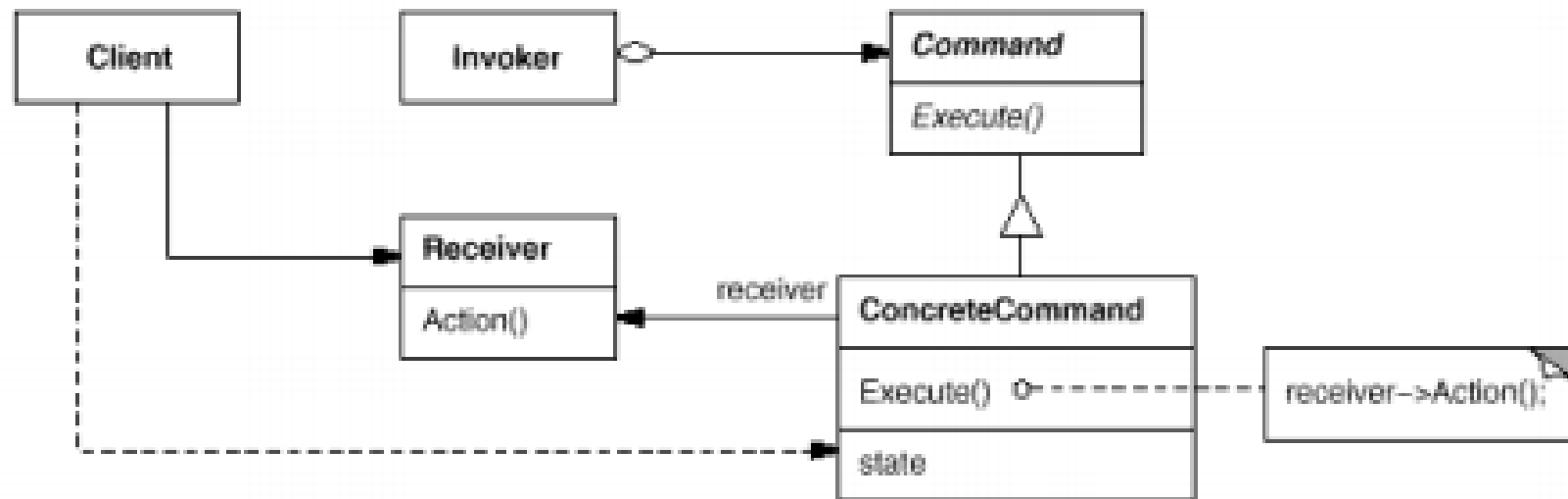
        System.out.println("Start Model Duck");
        System.out.println("=====");
        Duck model = new ModelDuck();

        model.performFly();
        model.setFlyBehaviour(new FlyRocketPower());
        model.performFly();

        model.performQuack();
        model.setQuackBehaviour(new ModelQuack());
        model.performQuack();
    }
}
```

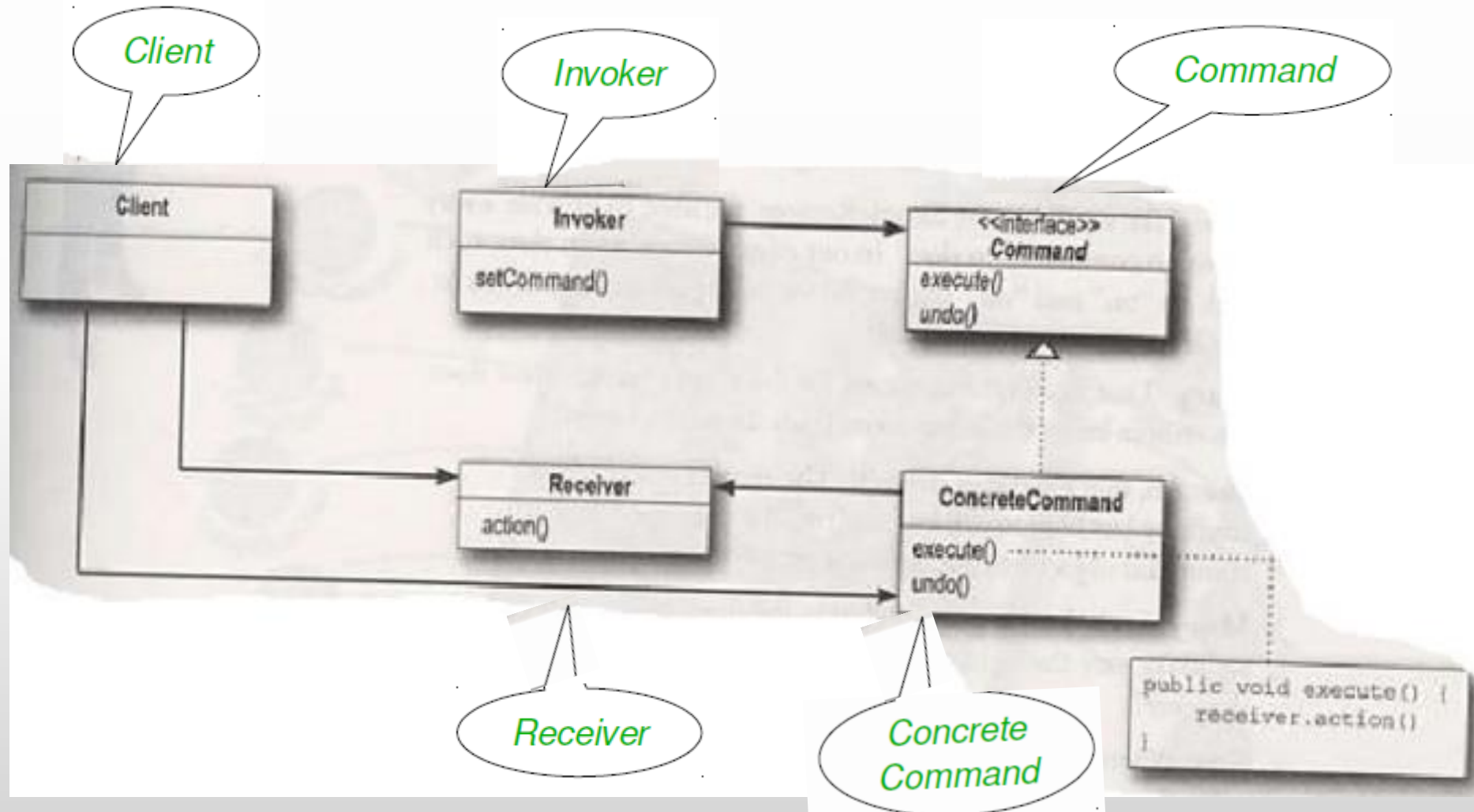
```
<terminated> TestDuck [Java Application] C:\P
Start Mollard Duck
=====
I am flying with wings
Quack..Quack...
Start Model Duck
=====
I can't fly
I am flying with a rocket
Quack..Quack...
Quack Model duck
```


Command Pattern

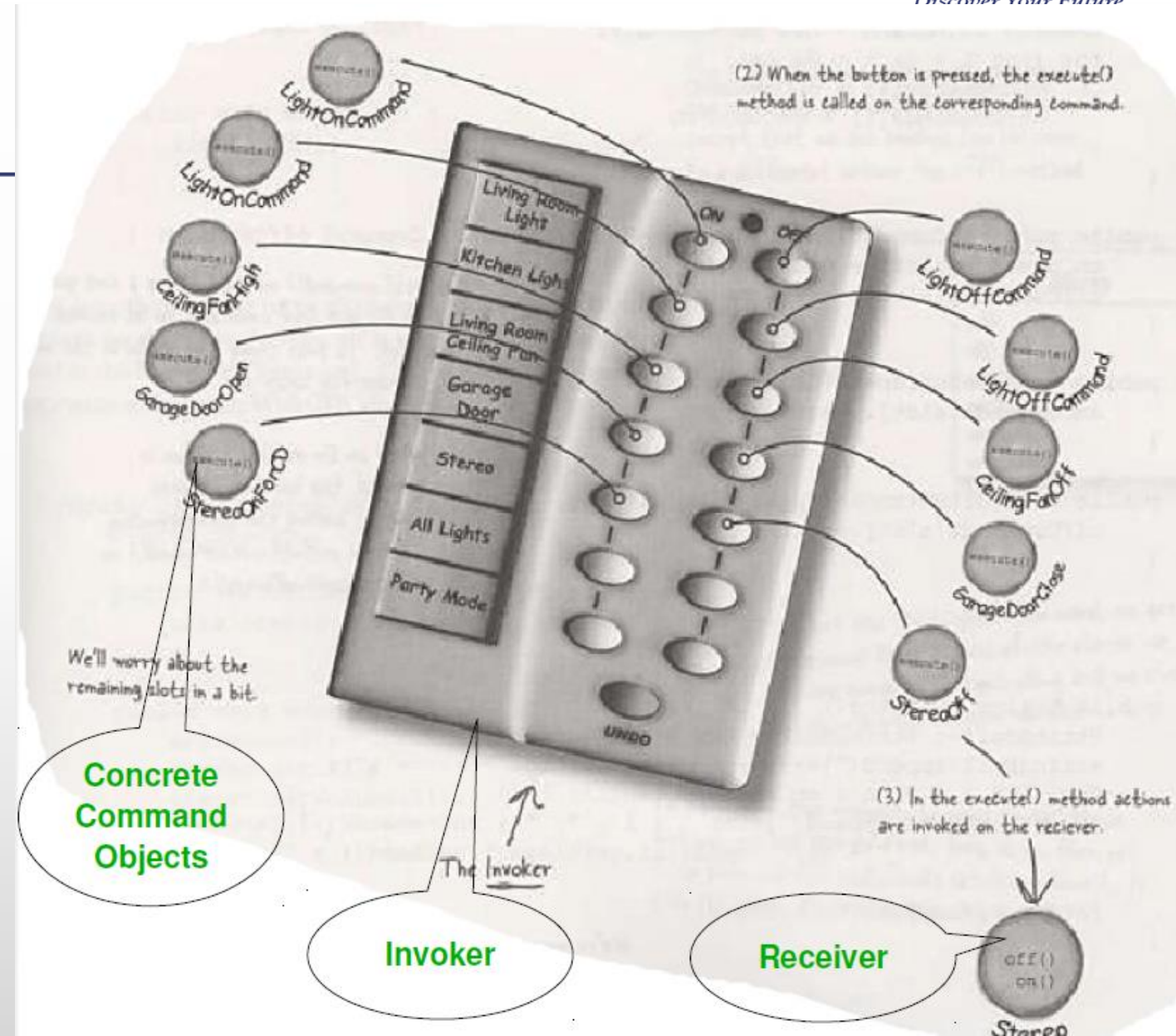


Encapsulate a request as an object, thereby letting you parameterize clients with different requests, queue or log requests, and support undoable operations

Command Pattern



Command Pattern



Command & Concrete Command

<<implements>>

```
package design.pattern.command;

public interface Command {

    public void execute();

}
```

<<implements>>

```
package design.pattern.command;

public class LightOffCommand implements Command{

    Light light;

    public LightOffCommand(Light light) {
        this.light = light;
    }

    @Override
    public void execute() {
        light.off();
    }

}
```

```
package design.pattern.command;

public class LightOnCommand implements Command{

    Light light;

    public LightOnCommand(Light light) {
        this.light = light;
    }

    @Override
    public void execute() {
        light.on();
    }

}
```

Receiver

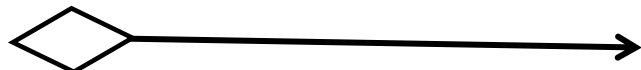
```
public class Light {  
  
    private String location;  
  
    public Light(String location) {  
        this.location = location;  
    }  
  
    public void on(){  
        System.out.println(location + " light is on.");  
    }  
  
    public void off(){  
        System.out.println(location + " light is off.");  
    }  
}
```

Command Pattern

```
package design.pattern.command;
```

```
public class RemoteController {
```

```
    Command [] onCommands;  
    Command [] offCommands;
```



```
    public RemoteController() {  
        onCommands = new Command[7];  
        offCommands = new Command[7];
```

```
        for (int i = 0; i < 7; i++) {  
            onCommands[i] = null;  
            offCommands[i] = null;  
        }  
    }
```

```
    public void setCommand(int slot, Command onCommand, Command offCommand){  
        onCommands[slot] = onCommand;  
        offCommands[slot] = offCommand;  
    }
```

```
    public void onButtonWasPushed(int slot){  
        onCommands[slot].execute();  
    }
```

```
    public void offButtonWasPushed(int slot){  
        offCommands[slot].execute();  
    }  
}
```

```
package design.pattern.command;
```

```
public interface Command {
```

```
    public void execute();
```

```
}
```

```
public class Light {
```

```
    private String location;
```

```
    public Light(String location) {  
        this.location = location;  
    }
```

```
    public void on(){  
        System.out.println(location + " light is on.");  
    }
```

```
    public void off(){  
        System.out.println(location + " light is off.");  
    }  
}
```

Invoker



The screenshot shows an IDE with several tabs: sample1.java, Client.java, RemoteContr..., LightOnComm..., and Command. The Client.java tab is active, displaying the following code:

```
package design.pattern.command;

public class Client {

    /**
     * @param args
     */
    public static void main(String[] args) {

        RemoteController remoteController = new RemoteController();

        Light livingRoomLight = new Light("Living Room Light");
        Light kitchenLight = new Light("Kitchen Light");

        LightOnCommand onLivingRoomLight = new LightOnCommand(livingRoomLight);
        LightOffCommand offLivingRoomLight = new LightOffCommand(livingRoomLight);
        LightOnCommand onKitchenLight = new LightOnCommand(kitchenLight);
        LightOffCommand offKitchenLight = new LightOffCommand(kitchenLight);

        remoteController.setCommand(0, onLivingRoomLight, offLivingRoomLight);
        remoteController.setCommand(1, onKitchenLight, offKitchenLight);

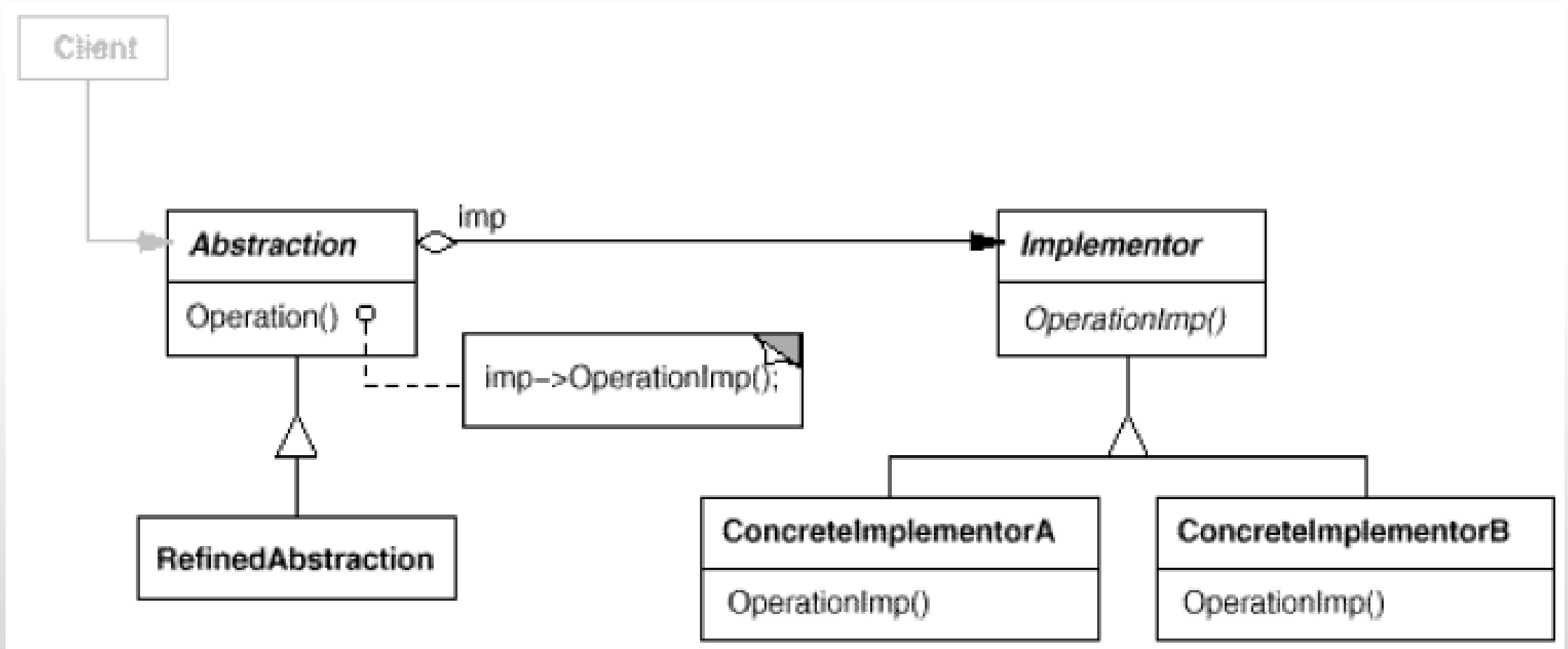
        remoteController.onButtonWasPushed(0);
        remoteController.offButtonWasPushed(0);
        remoteController.onButtonWasPushed(1);
        remoteController.offButtonWasPushed(1);
    }
}
```

The Problems tab is empty. The Console tab shows the output of the application:

```
<terminated> Client [Java Application] C:\
Living Room Light light is on.
Living Room Light light is off.
Kitchen Light light is on.
Kitchen Light light is off.
```

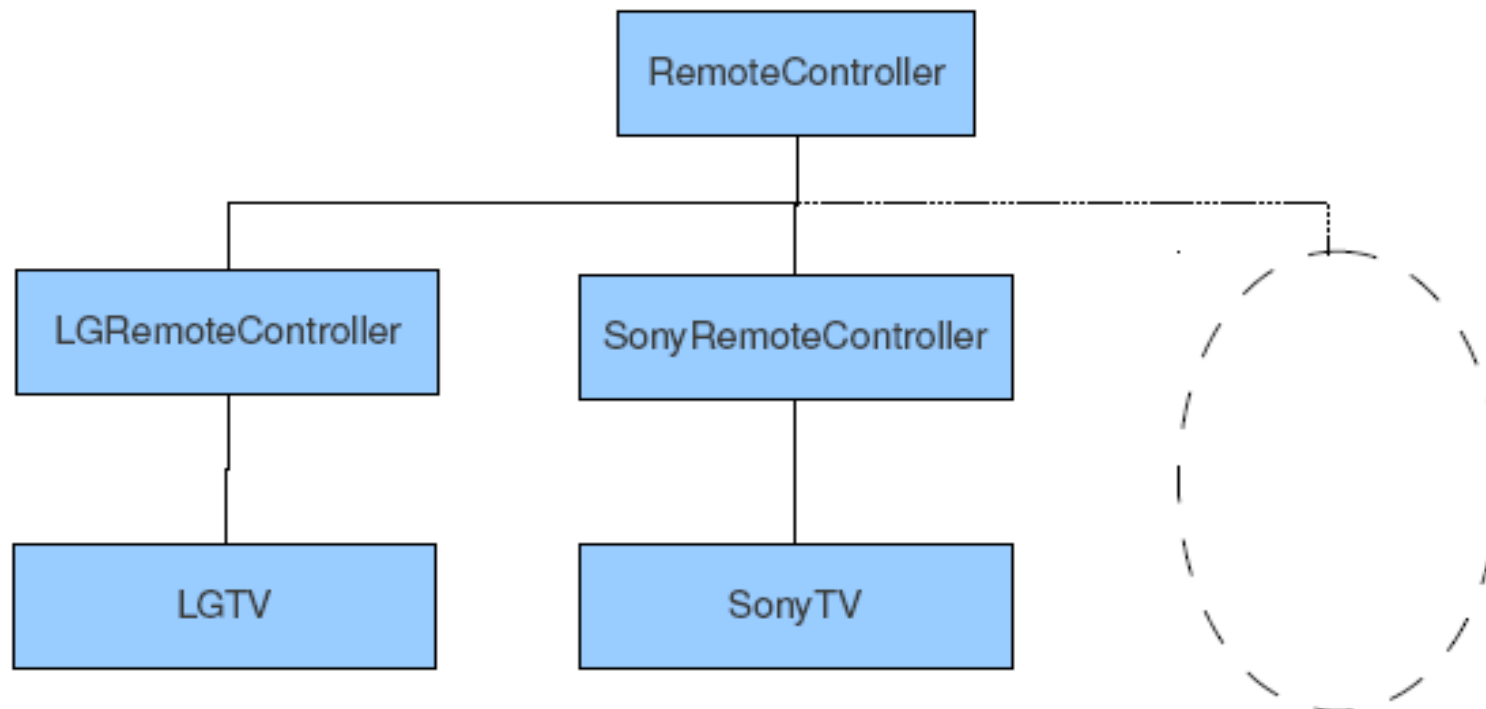
Bridge Pattern

Bridge Pattern



Example for Bridge Pattern

- There are two brands of TVs (Sony and LG) in your living room. So there are two remote controllers for each one. (See below diagram) Just assume a single remote controller can be used to **switch on**, **switch off** and **tune channels** of both TVs. Think of a design pattern that can solve this.



Bridge Pattern

```
public interface TV {
```

```
    void on();  
    void off();  
    void tune(int chanel);  
}
```

← - - - - -
<<implements>>

↑
<<implements>>

```
public class LGTV implements TV{
```

```
    @Override  
    public void on() {  
        System.out.println("Switch on LG TV");  
    }  
  
    @Override  
    public void off() {  
        System.out.println("Switch off LG TV");  
    }  
  
    @Override  
    public void tune(int chanel) {  
        System.out.println("Switch on chanel in LG TV is: " + chanel);  
    }  
}
```

```
public class SonyTV implements TV{
```

```
    @Override  
    public void on() {  
        System.out.println("Switch on Sony TV");  
    }  
  
    @Override  
    public void off() {  
        System.out.println("Switch off Sony TV");  
    }  
  
    @Override  
    public void tune(int chanel) {  
        System.out.println("Switch on chanel in Sony TV is: " + chanel);  
    }  
}
```

Bridge Pattern

```
public interface RemoteController {  
  
    void on();  
    void off();  
    void tune(int chanel);  
}
```

<<implements>>

```
public class RemoteControllerImpl implements RemoteController{  
  
    TV tv;  
  
    public RemoteControllerImpl(TV tv) {  
        this.tv = tv;  
    }  
  
    @Override  
    public void on() {  
        tv.on();  
    }  
  
    @Override  
    public void off() {  
        tv.off();  
    }  
  
    @Override  
    public void tune(int chanel) {  
        tv.tune(chanel);  
    }  
}
```

```
estDuck.java  ModelQuack.java  TV.java  LGTV.java  
package design.pattern.bridge;  
  
public class Test {  
    public static void main(String[] args) {  
        TV lgLv = new LGTV();  
        TV sontTv = new SonyTV();  
  
        new RemoteControllerImpl(lgLv).on();  
        new RemoteControllerImpl(lgLv).off();  
        new RemoteControllerImpl(lgLv).tune(10);  
        new RemoteControllerImpl(sontTv).on();  
        new RemoteControllerImpl(sontTv).off();  
        new RemoteControllerImpl(sontTv).tune(20);  
    }  
}
```

```
Switch on LG TV  
Switch off LG TV  
Switch on chanel in LG TV is: 10  
Switch on Sony TV  
Switch off Sony TV  
Switch on chanel in Sony TV is: 20
```

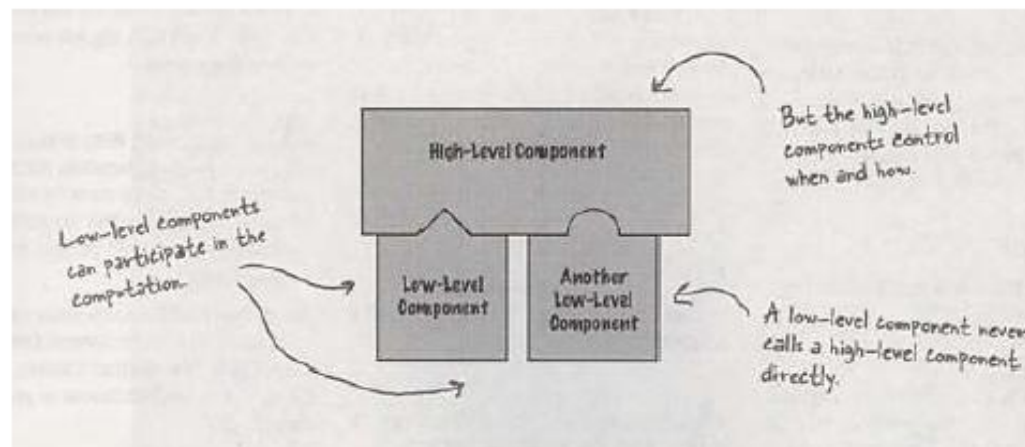
Template method pattern

Design Principles covered - (1)

🕒 *Design Principle*

“The Hollywood Principle” - *Don't call us, we will call you*

Allows low level components to hook themselves into a system. But the high-level components determine when they are needed and how.



● The *Template Method*,

Is a method, which serves as a **template** for an algorithm

● In the template,

- Each step of the algorithm is represented by a method (These are called as “hooks”)
- Some methods are handled by this class.
- Some methods are handled by the sub class.
- The methods, that need to be supplied by a subclass are declared *abstract*

Template method pattern

The template method defines the steps of an **algorithm** and follows subclasses to provide the implementation for one more steps

Template method pattern

An Example: Servlets

- ③ The servlet container invokes our servlet code
- ③ HttpServlet defines a *Template Method* **service()**, which takes care of general purpose handling of HTTP requests by calling **doGet()** and **doPost()** methods
- ③ We can extend the HttpServlet by overriding the steps of the algorithm, **doGet()** and **doPost()** methods to provide meaningful results

An Example: Servlets

Servlet Containers Hollywood Principle

Don't call me I will call you (servlet), whenever I hear from a browser

Servlet's Template Method

*Let me have the control of the algorithm and let me deal with HTTP.
You (Developer) just respond with some meaningful action when I call your methods*


```
protected void service(HttpServletRequest req, HttpServletResponse resp)
    throws ServletException, IOException {

    String method = req.getMethod();

    if (method.equals(METHOD_GET)) {
        long lastModified = getLastModified(req);
        if (lastModified == -1) {
            // servlet doesn't support if-modified-since, no reason
            // to go through further expensive logic
            doGet(req, resp);
        } else {
            long ifModifiedSince = req.getDateHeader(HEADER_IFMODSINCE);
            if (ifModifiedSince < (lastModified / 1000 * 1000)) {
                // If the servlet mod time is later, call doGet()
                // Round down to the nearest second for a proper compare
                // A ifModifiedSince of -1 will always be less
                maybeSetLastModified(resp, lastModified);
                doGet(req, resp);
            } else {
                resp.setStatus(HttpServletResponse.SC_NOT_MODIFIED);
            }
        }
    }

    } else if (method.equals(METHOD_HEAD)) {
        long lastModified = getLastModified(req);
        maybeSetLastModified(resp, lastModified);
        doHead(req, resp);

    } else if (method.equals(METHOD_POST)) {
        doPost(req, resp);

    } else if (method.equals(METHOD_PUT)) {
        doPut(req, resp);
    }
}
```

Template
Method

```
public abstract class CaffeineBeverage {
```

```
    void final prepareRecipe() {
```

```
        boilWater();
```

```
        brew();
```

```
        pourInCup();
```

```
        addCondiments();
```

```
    }
```

```
    abstract void brew();
```

```
    abstract void addCondiments();
```

```
    void boilWater() {  
        // implementation  
    }
```

```
    void pourInCup() {  
        // implementation  
    }
```

```
}
```

prepareRecipe() is our template method.
Why?

Because:

(1) It is a method, after all.

(2) It serves as a template for an algorithm, in this case, an algorithm for making caffeinated beverages.

In the template, each step of the algorithm is represented by a method.

Some methods are handled by this class...

...and some are handled by the subclass.

The methods that need to be supplied by a subclass are declared abstract.

Template method pattern

```
public abstract class Beverage {  
  
    final void prepareRecepie(){  
        boilWater();  
        brew();  
        addCondiments();  
        pourInCup();  
    }  
  
    abstract void brew();  
  
    abstract void addCondiments();  
  
    void boilWater(){  
        System.out.println("Boiling water.");  
    }  
  
    void pourInCup(){  
        System.out.println("Pour into cup.");  
    }  
}
```

```
public class Tea extends Beverage {  
  
    @Override  
    void brew() {  
        System.out.println("Steeping the Tea.");  
    }  
  
    @Override  
    void addCondiments() {  
        System.out.println("Adding Lemon.");  
    }  
}
```

```
public class Coffie extends Beverage {  
  
    @Override  
    void addCondiments() {  
        System.out.println("Add suger and milk.");  
    }  
  
    @Override  
    void brew() {  
        System.out.println("Stripping coffie through filter.");  
    }  
}
```


Template method pattern

```
package design.pattern.templateMethod;

public class TestTemplateMethod {

    static Beverage beverage = null;

    public static void main(String[] args) {

        System.out.println("=====Tea===== \n");
        Beverage tea = new Tea();
        tea.prepareRecepie();

        System.out.println("=====Coffie===== \n");
        Beverage coffie = new Coffie();
        coffie.prepareRecepie();
    }
}
```

<terminated> TestTemplateMethod [Java A

|=====Tea=====

Boiling water.

Steeping the Tea.

Adding Lemon.

Pour into cup.

=====Coffie=====

Boiling water.

Stripping coffie through filter.

Add suger and milk.

Pour into cup.

References

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The End

