CSE201: Monsoon 2020
Advanced Programming

Lecture 23: Template, Prototype, Factory & Façade Design Patterns

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Last Lecture

Adaptor Design Pattern

- Recurring problem -- We have an object that contains the functionality we need, but not in the way we want to use it
- Solution – Create an **adapter object** that bridges the provided and desired functionality

Strategy pattern

- Here, a class behavior (or its algorithm) can be changed at run time
- In Strategy pattern, we create objects which represent various strategies and a context object whose behavior varies as per its strategy object
- The strategy object changes the executing algorithm of the context object

```
public interface Movable {
    public void move();
}

public class Car implements Movable {
    public void move() {
       System.out.println("Car is moving");
    }
}

public class Bike implements Movable {
    public void move() {
       System.out.println("Bike is moving");
    }
}
```

```
public interface Flyable {
   public void fly();
}

public class Airplane implements Flyable {
   public void fly() {
      System.out.println("Airplane is flying");
   }
}

public class Drone implements Flyable {
   public void fly() {
      System.out.println("Drone is flying");
   }
}
```

```
public class Dabbler extends Duck {
    public Dabbler() {
        super("Dabbler", new CanFly());
    }
    ........
}
```

```
public class Rubber extends Duck {
    public Rubber() {
        super("Rubber", new CannotFly());
    }
    @Override
    public void speak() {
        System.out.println("I can Squeak");
    }
    public void home() {
        System.out.println("Your home is my home");
    }
}
```

```
public class Vehicle {
  public static void main(String[] args) {
    List<Movable> mylist = new ArrayList<Movable>();

    mylist.add(new Car());
    mylist.add(new Bike());

    mylist.add(new FlyableAdapter(new Airplane()));
    mylist.add(new FlyableAdapter(new Drone()));

    for(Movable obj: mylist) {
        obj.move();
    }
  }
}
```

```
public class FlyableAdapter implements Movable {
    Flyable type;
    public FlyableAdapter(Flyable type) {
        this.type = type;
    }
    public void move() {
        type.fly();
    }
}
```

```
public interface Flyable {
    public void fly();
}
```

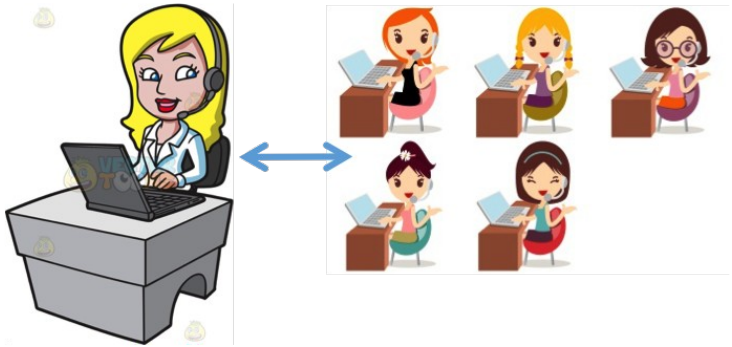
```
public abstract class Duck {
    private String name;
    private Flyable flyStatus;
    public Duck(String n, Flyable f) {
        this.name = n;
        this.flyStatus = f;
    }
    ........
    ........
    public void tryFlying() {
        flyStatus.fly();
    }
    public void display() {
        this.type();
        this.speak();
        this.swim();
        this.tryFlying();
        this.home();
    }
}
```

```
public class CannotFly implements Flyable {
    public void fly() {
        System.out.println("I don't Fly");
    }
}
```

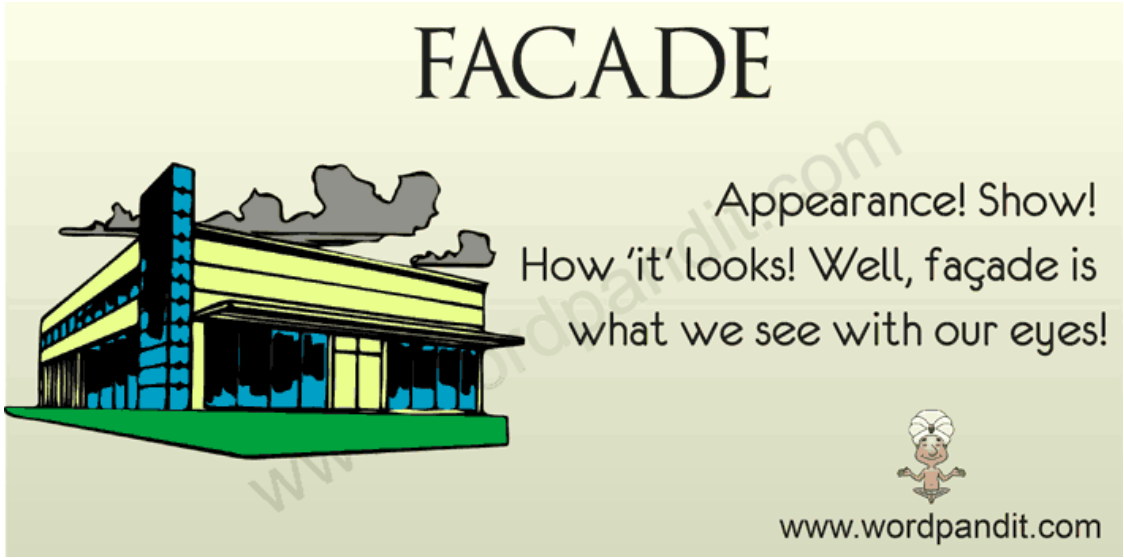
```
public class CanFly implements Flyable {
    public void fly() {
        System.out.println("I can Fly");
    }
}
```

Today’s Lecture

- Some more design patterns
  - Template (DP # 6)
  - Prototype (DP # 7)
  - Factory (DP # 8)
    - Abstract Factory (DP # 9)
  - Façade (DP # 10)



Pattern: Facade



Facade Pattern

- **Facade:** a structural design pattern used to identifying a simple way to realize relationships between entities
- Provide a unified “interface” to a set of interfaces in a subsystem. Facade defines a higher-level interface that makes the subsystem easier to use

The Tale of a Call Center

```
class CallCenter {
    public void handleNetwork() { / *Some code */
}
    public void handleBilling() { /* Some code */
}
    public void handleRoaming() { /* Some code */
}
    public void handleAccount() { /* Some code */
}
```

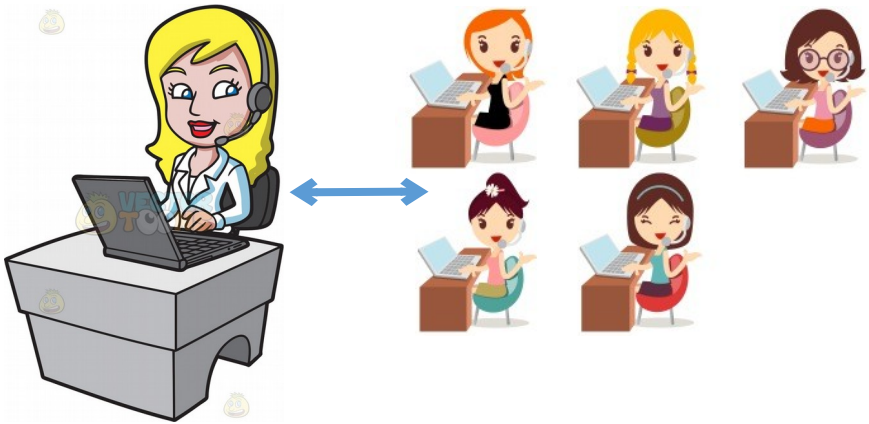
```
public class Client {
    public static void main(String[] args) {
        CallCenter c = new CallCenter();
        c.handleNetwork();
        c.handleBilling();
        c.handleRoaming();
        c.handleAccount();
    }
}
```

- Call center wants cost cutting and employees only one agent for handling all customer issues
  - Result?
    - Overloaded employee and bad customer satisfaction!

A Better Call Center Using Facade

```
class CallCenter {
    NetworkTeam net;
    BillingTeam bill;
    RoamingTeam roam;
    AccountTeam account;
    public CallCenter() { /* initializations */ }
    public void handleCalls(int option) {
        switch(option) {
            case 1:
                net.handleNetwork();
                break;
            case 2:
                bill.handleBilling();
                break;
            .......
        }
    }
}
```

```
public class Client {
    public static void main(String[] args) {
        CallCenter c = new CallCenter();
        c.handleCalls(1);
        ......
    }
}
```



- Facade design to the rescue
  - Hiding the complexities of a large body of code by providing a simplified interface

Pattern: Template

Define the skeleton of an algorithm in an operation, deferring some steps to client subclasses

Acknowledgements for slides on template pattern: Informatics 122 Software Design II, Bren School (UCI)

Let’s Build a Café Simulator

- Coffee
  - Boil Water
  - Brew Coffee in boiling water
  - Pour in cup
  - Add sugar and milk

Inheritance?

- Tea
  - Boil Water
  - Steep tea in boiling water
  - Pour in cup
  - Add sugar and lemon

Let’s See the Code

```
public abstract class Cafe {
    public void boilWater() {
        System.out.println(“Boil Water”);
    }
    public void pourInCup() {
        System.out.println(“Pour in Cup”);
    }
    public abstract void prepare();
}
```

```
public class Coffee extends Cafe {
    public void prepare() {
        boilWater();
        brewCoffee();
        pourInCup();
        addSugarAndMilk();
    }
    private void brewCoffee() {
        System.out.println(“Brew Coffee”);
    }
    private void addSugarAndMilk() {
        System.out.println(“Add Sugar and
Milk”);
    }
}
```

```
public class Tea extends Cafe {
    public void prepare() {
        boilWater();
        steepTeaBag();
        pourInCup();
        addSugarAndLemon();
    }
    private void steepTeaBag() {
        System.out.println(“Steep Tea Bag”);
    }
    private void addSugarAndLemon() {
        System.out.println(“Add Sugar and
Lemon”);
    }
}
```

- Do you see any issues here?
  - Similar algorithms in `prepare` !!
    - How about doing the following?
      - Replace brewCoffee() and steepTeaBag() with brew()
      - Replace addSugarAndMilk() and addSugarAndLemon() with addCondiments()

Template Pattern

- The Template Method pattern defines the skeleton of an algorithm in a method, deferring some steps to subclasses
- Template Method lets subclasses redefine certain steps of an algorithm without changing the algorithm’s structure
- Usage
  1. Define the algorithm in superclass and ensure that subclasses cannot change the structure of this algorithm
  2. Each step of the algorithm is represented by a method
  3. Steps (methods) handled by subclasses are declared abstract
  4. Shared steps (concrete methods) are placed in the superclass

The Fixed Code

```
public abstract class Cafe {
    public void boilWater() {
        System.out.println(“Boil Water”);
    }
    public void pourInCup() {
        System.out.println(“Pour in Cup”);
    }
    // “final” ensures that the person
preparing
    // the beverage sticks to the recipe of
this
    // Café instead of generating his own
    public final void prepare() {
        boilWater();
        brew();
        pourInCup();
        addCondiments();
    }
    public abstract void brew();
    public abstract void addCondiments();
}
```

```
public class Coffee extends Cafe {
    private void brew() {
        System.out.println(“Brew Coffee”);
    }
    private void addCondiments() {
        System.out.println(“Add Sugar and
Milk”);
    }
}
```

```
public class Tea extends Cafe {
    private void brew() {
        System.out.println(“Steep Tea Bag”);
    }
    private void addCondiments() {
        System.out.println(“Add Sugar and
Lemon”);
    }
}
```

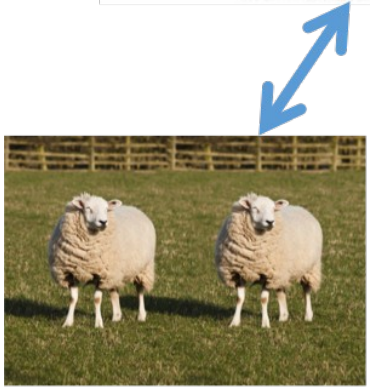
Pattern: Prototype

An object that serves as a basis for creation of others

Source of this slide: CSE331, Washington University

Let’s Build a Cloning Laboratory Simulator

- We are going to **clone** following Animals in our lab
  - Sheep
    - **“Is an”** Animal but has wool
  - Chicken
    - **“Is an”** Animal but lay eggs
- Which concepts we will be using?
  - Inheritance
  - Object cloning



Cloning Lab Simulator

```
public class Animal {
    private String name;
    public Animal(String n) { name=n; }
    public void sayHello() {
        System.out.println("I am a " + name);
    }
}
```

```
public class Sheep extends Animal implements Cloneable
{
    private String wool;
    public Sheep() { super("Sheep"); wool ="10KG"; }
    public void sayHello() {
        super.sayHello();
        System.out.println("I have "+wool+" wool");
    }
    public Sheep clone() throws
CloneNotSupportedException {
        return (Sheep) super.clone();
    }
}
```

```
public class Chicken extends Animal implements
Cloneable {
    private int eggs;
    public Chicken() { super("Chicken"); eggs=3; }
    public void sayHello() {
        super.sayHello();
        System.out.println("I have "+eggs+" eggs");
    }
   public Chicken clone() throws
CloneNotSupportedException{
        return (Chicken) super.clone();
    }
}
```

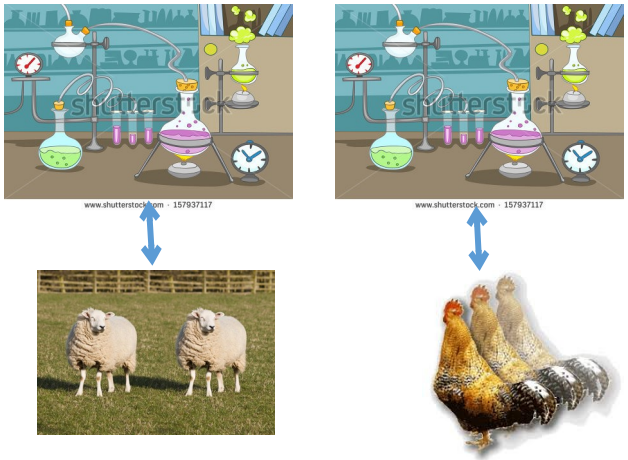
```
public class Lab1 {
    public static Sheep getClone(Sheep s)
           thrown
CloneNotSupportedException {
        return s.clone();
    }
}
```

```
public class Lab2 {
    public static Chicken getClone(Chicken
s)
           thrown
CloneNotSupportedException {
        return s.clone();
    }
}
```

```
public class Client {
  public static void main(String[] args) throws
CloneNotSupportedException{
        Sheep s1 = new Sheep(); Chicken c1 = new Chicken();
        Sheep s2 = Lab1.getClone(s1);
        Chicken c2 = Lab2.getClone(c2);
    }
}
```

What are the Issues?

- Instead of having just one laboratory for all Animal types, we ended up creating individual Animal specific laboratory
  - No use of polymorphism!
- Client has to ensure he requests the laboratory suited for his Animal type
- Code duplication!
  - More serious when we need to code some more Animal types (Cow, Dog, etc.)



Prototype Pattern

- **Problem:** Client wants another object similar to an existing one, but doesn't care about the details of the state of that object
  - Creating an instance of a class is time-consuming or complex in some way

- **Solution**
  - Decouple product creation from system behavior
  - Avoid subclasses of an object creator in the client application

The Fixed Version

```
public class Animal implements Cloneable {
    private String name;
    public Animal(String n) { name=n; }
    public void sayHello() {
        System.out.println("I am a " + name);
    }
    public Animal clone() throws
CloneNotSupportedException {
        return (Animal) super.clone();
    }
}
```

```
public class Lab {
    public static Animal getClone(Animal s)
{
        return s.clone();
    }
}
```

```
public class Sheep extends Animal {
    private String wool;
    public Sheep() { super("Sheep"); wool ="10KG"; }
    public void sayHello() {
        super.sayHello();
        System.out.println("I have "+wool+" wool");
    }
    public Sheep clone() throws
CloneNotSupportedException {
        return (Sheep) super.clone();
    }
}
```

```
public class Chicken extends Animal {
    private int eggs;
    public Chicken() { super("Chicken"); eggs=3; }
    public void sayHello() {
        super.sayHello();
        System.out.println("I have "+eggs+" eggs");
    }
   public Chicken clone() throws
CloneNotSupportedException{
        return (Chicken) super.clone();
    }
}
```

Sheep and Chicken also requires clone() implementation to enable deep copy (if any such fields are there in class)

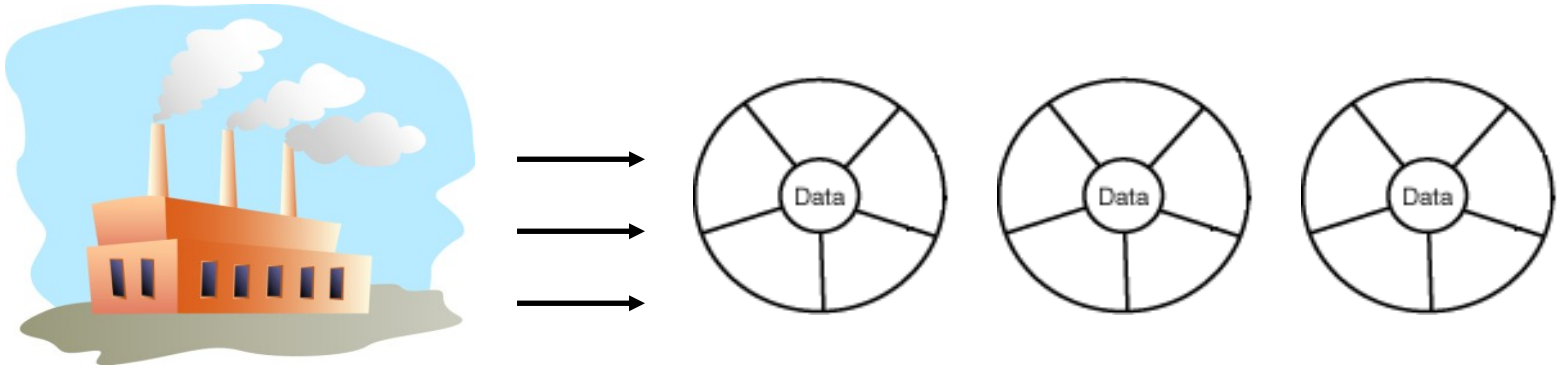
```
public class Client {
  public static void main(String[] args) throws
CloneNotSupportedException{
        Animal s1 = new Sheep(); Animal c1 = new Chicken();
        Animal s2 = Lab.getClone(s1);
        Animal c2 = Lab.getClone(c2);
    }
}
```

Drawback of Prototype Pattern

- It is built on the method `clone()`, which could be complicated sometimes in terms of shallow copy and deep copy

Pattern: Factory

A method or object that creates other objects



Source of this slide: CSE331, Washington University

Let’s Revisit our Client from Cloning Laboratory

```
public class Client {
  public static void main(String[] args) throws
CloneNotSupportedException{
        String need = args[0];
        Animal animal;
        if(need.equals(“wool”) {
            animal = new Sheep();
        }
        else if(need.equals(“eggs”) {
            animal = new Chicken();
        }
        else if(need.equals(“milk”) {
            animal = new Cow();
        }
        else System.exit(-1);
        // Our client is too greedy
        Animal[] cloned = new Animal[100];
        for(int i=0; i<cloned.length; i++) {
            cloned[i] = Lab.getClone(animal);
        }
    }
}
```

- We have got more funding and our lab now support some more Animals!
  - Our client now has options to choose Animals based on his requirements
- What is the issue here?
  - Mixing two events in same place (or method)
    - Animal creation
    - Cloning of Animal

The Issue with “new”

```
public class Client {
  public static void main(String[] args) throws
CloneNotSupportedException{
        String need = args[0];
        Animal animal;
        if(need.equals(“wool”) {
            animal = new Sheep();
        }
        else if(need.equals(“eggs”) {
            animal = new Chicken();
        }
        else if(need.equals(“milk”) {
            animal = new Cow();
        }
        else if(need.equals(“protection”) {
            animal = new Dog();
        }
        else if(need.equals(“riding”) {
            animal = new Horse();
        }
        ........
    }
}
```

- When we have several related classes, that’s an indication that they might change in future
  - We might expand our Lab to support cloning of several other Animals…
- What is the issue?
  - Client code needs to be recompiled:
    - Every time we **add** the support for a new Animal in our Lab
    - Every time if we **remove** the support for an existing Animal in our Lab

Factory Pattern

- **Factory**: A method or object whose primary purpose is to manage the creation of other objects (usually of a different type)

- **Problem:** Object creation is cumbersome or heavily coupled for a given client. Client needs to create but doesn't want the details.

- **Solution:** A helper method that creates and returns the object(s)

The Fix: Encapsulate Creation Code

```
public class AnimalFactory {
    public Animal createAnimal(String need) {
        if(need.equals(“wool”) {
            return new Sheep();
        }
        else if(need.equals(“eggs”) {
            return new Chicken();
        }
        .......
    }
}
```

```
public class Client {
  public static void main(String[] args) throws
CloneNotSupportedException{
        String need = args[0];
        AnimalFactory factory = new AnimalFactory();
        Animal animal = factory.createAnimal(need);
        // Our client is too greedy
        Animal[] cloned = new Animal[100];
        for(int i=0; i<cloned.length; i++) {
            cloned[i] = Lab.getClone(animal);
        }
    }
}
```

- What are the benefits?
  - Client need not recompile if support for Animals are added or removed in our Lab
  - Easy to serve some other Client class
  - Ensure consistent object initialization

We Have Another Problem Now…

```
public class AnimalFactory {
    public Animal createAnimal(String need) {
        if(need.equals(“wool”) {
            return new Sheep();
        }
        else if(need.equals(“eggs”) {
            return new Chicken();
        }
        .......
    }
}
```

```
public class Client {
  public static void main(String[] args) throws
CloneNotSupportedException{
        String need = args[0];
        AnimalFactory factory = new AnimalFactory();
        Animal animal = factory.createAnimal(need);
        // Our client is too greedy
        Animal[] cloned = new Animal[100];
        for(int i=0; i<cloned.length; i++) {
            cloned[i] = Lab.getClone(animal);
        }
    }
}
```

- Our cloning Lab is in very high demand and we have started cloning almost every Animal (*except ourselves…*)
- Supporting creation of so many Animals in just `AnimalFactory` class is becoming a bottleneck

Abstract Factory Pattern

- A superclass factory that can be extended to provide different sub-factories, each with different features
- Used when we have **multiple families of object** components

Cat Family

Dog Family

The Fix: Abstract Factory Pattern

```
public abstract class AnimalFactory {
    public abstract Animal createAnimal(String need);
}
```

```
public class CatFactory extends AnimalFactory {
    public Animal createAnimal(String need) {
        if(need.equals("pet") {
            return new HouseCat();
        }
        else if(need.equals("zoo") {
            return new Lion();
        }
    }
}
```

```
public class DogFactory extends AnimalFactory {
    public Animal createAnimal(String need) {
        if(need.equals("kids") {
            return new Poodle();
        }
        else if(need.equals("hunting") {
            return new Greyhound();
        }
    }
}
```

```
public class ClientForCats {
  public static void main(String[] args) throws
CloneNotSupportedException{
        String need = args[0];
        AnimalFactory factory = new CatFactory();
        Animal animal = factory.createAnimal(need);
        // Our client is too greedy
        Animal[] cloned = new Animal[100];
        for(int i=0; i<cloned.length; i++) {
            cloned[i] = Lab.getClone(animal);
        }
    }
}
```

```
public class ClientForDogs {
  public static void main(String[] args) throws
CloneNotSupportedException{
        String need = args[0];
        AnimalFactory factory = new DogFactory();
        Animal animal = factory.createAnimal(need);
        // Our client is too greedy
        Animal[] cloned = new Animal[100];
        for(int i=0; i<cloned.length; i++) {
            cloned[i] = Lab.getClone(animal);
        }
    }
}
```

Next Lecture

- Remaining 6 more design patterns