Design Patterns – Creational

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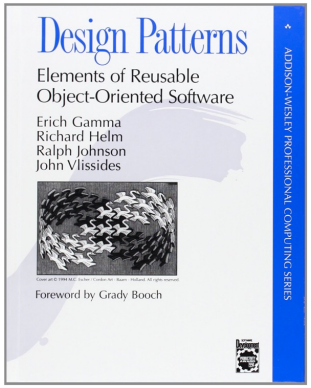
Resources

- Design Patterns – Elements of Reusable Object-Oriented Software; Gamma, et. al.



- *Design Patterns Explained Simply (sourcemaking.com)*

Creational patterns

Class

- Factory Method

Object

- Abstract Factory
- Builder
- Singleton
- Object Pool
- Prototype

Creational Patterns

- Problem: constructors in Java (and other OO languages) are inflexible
  - 1. Can't return a subtype of the type they belong to
  - 2. Always return a fresh new object, can't reuse
- "Factory" creational patterns present a solution to the first problem
  - Factory method, Factory object, Prototype
- "Sharing" creational patterns present a solution to the second problem
  - Singleton

Factory Method

Class

- Factory Method

Object

- Abstract Factory
- Builder
- Singleton
- Object Pool
- Prototype

Motivation

- Intent
  - Define an interface for creating an object, but let subclasses decide which class to instantiate. Factory Method lets a class defer instantiation to subclasses.
  - Define a "virtual" constructor.
  - The new operator considered harmful.
- Problem
  - A framework needs to standardize the architectural model for a range of applications, but allow for individual applications to define their own domain objects and provide for their instantiation.

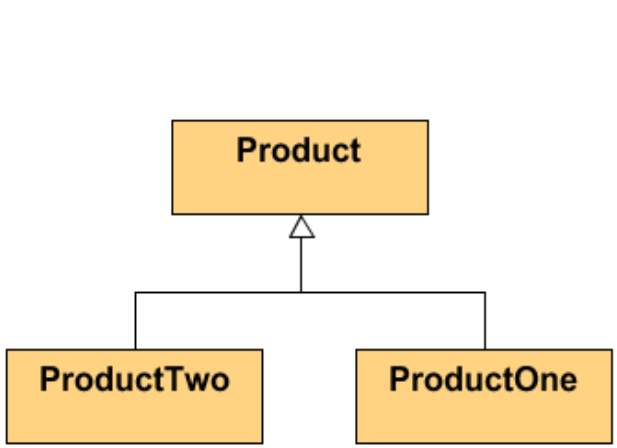
Solution (simple example)

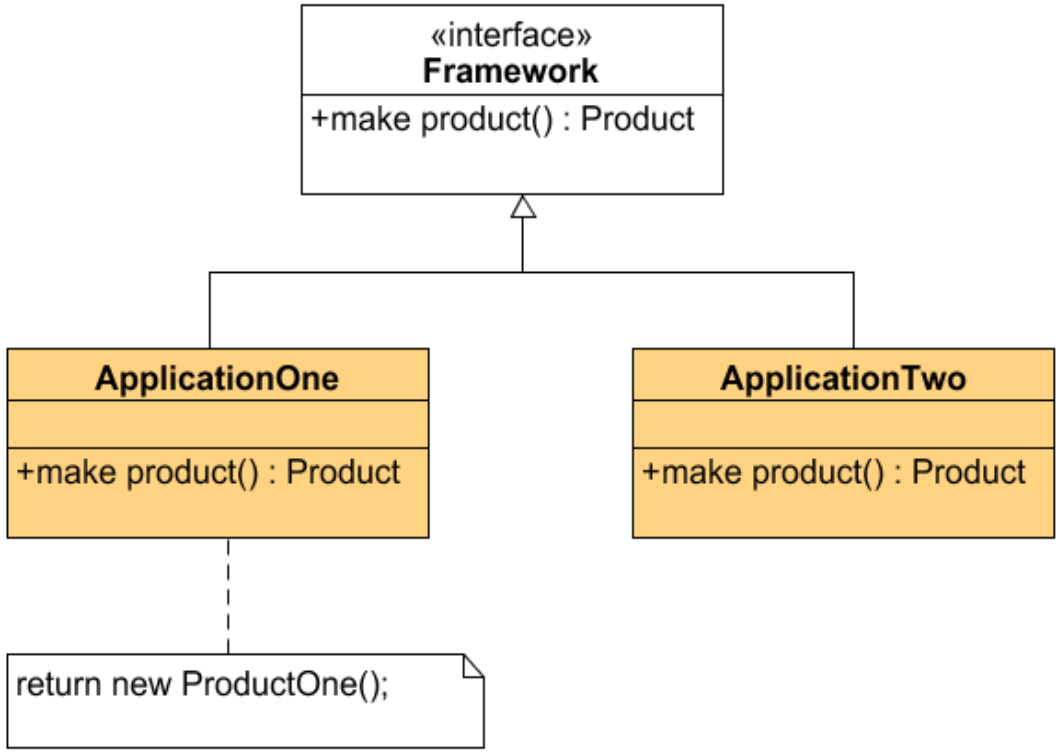
```
public final class ComplexNumber {

        // Static factory method returns an object of this class.
    public static ComplexNumber valueOf(double aReal, double aImaginary) {
        return new ComplexNumber(aReal, aImaginary);
    }
        // Caller cannot see this private constructor.
    private ComplexNumber(double aReal, double aImaginary) {
        fReal = aReal;
        fImaginary = aImaginary;
    }
        //…
    private double fReal;
    private double fImaginary;
}
```

Solution

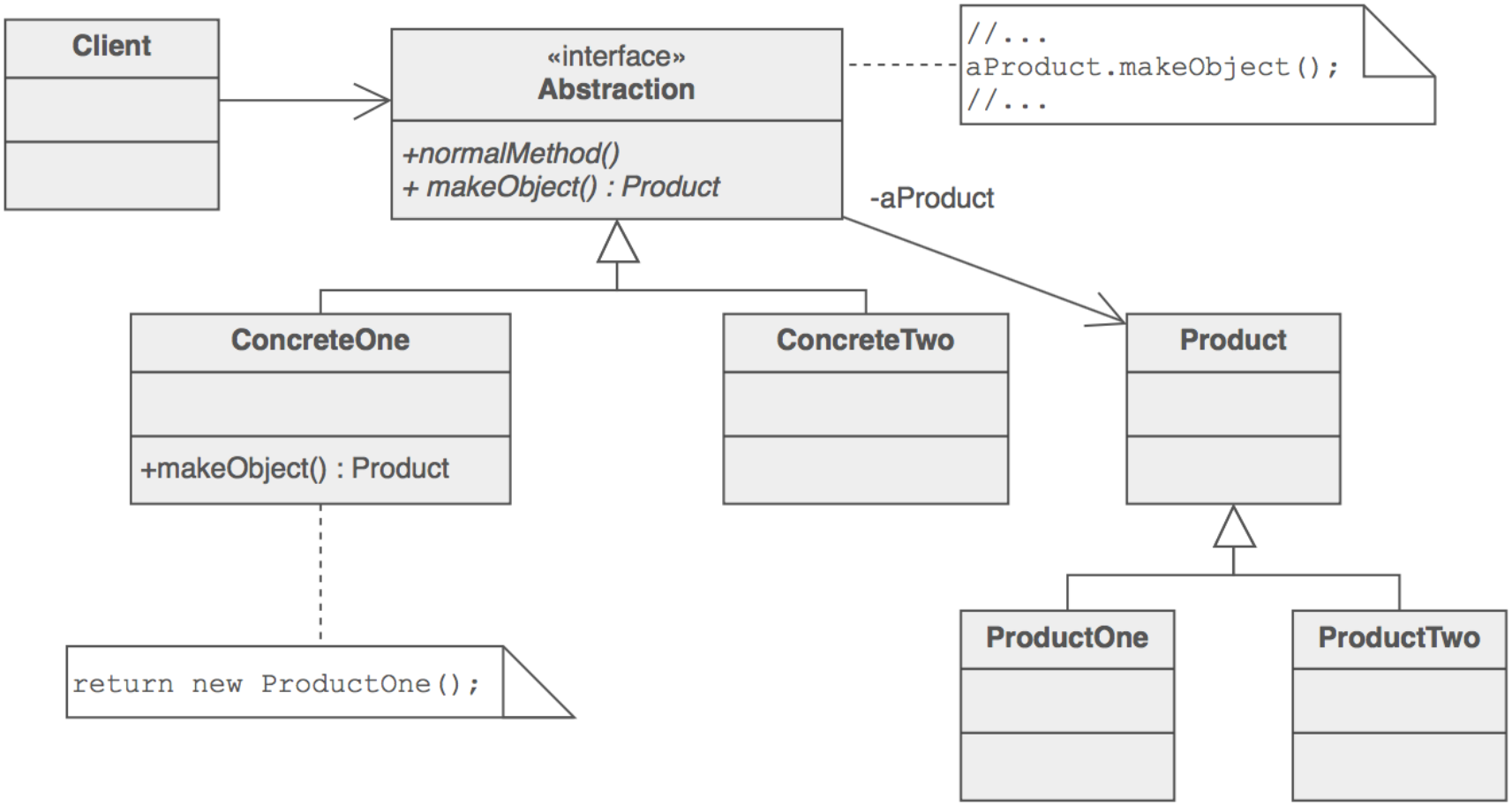
- An increasingly popular definition of factory method is a static method of a class that returns an object of that class' type.
  - But unlike a constructor, the actual object it returns might be an instance of a subclass.
  - Unlike a constructor, an existing object might be reused, instead of a new object created.
  - Unlike a constructor, factory methods can have different and more descriptive names
    - Color.make_RGB_color(float red, float green, float blue)
    - Color.make_HSB_color(float hue, float saturation, float brightness)

Structure

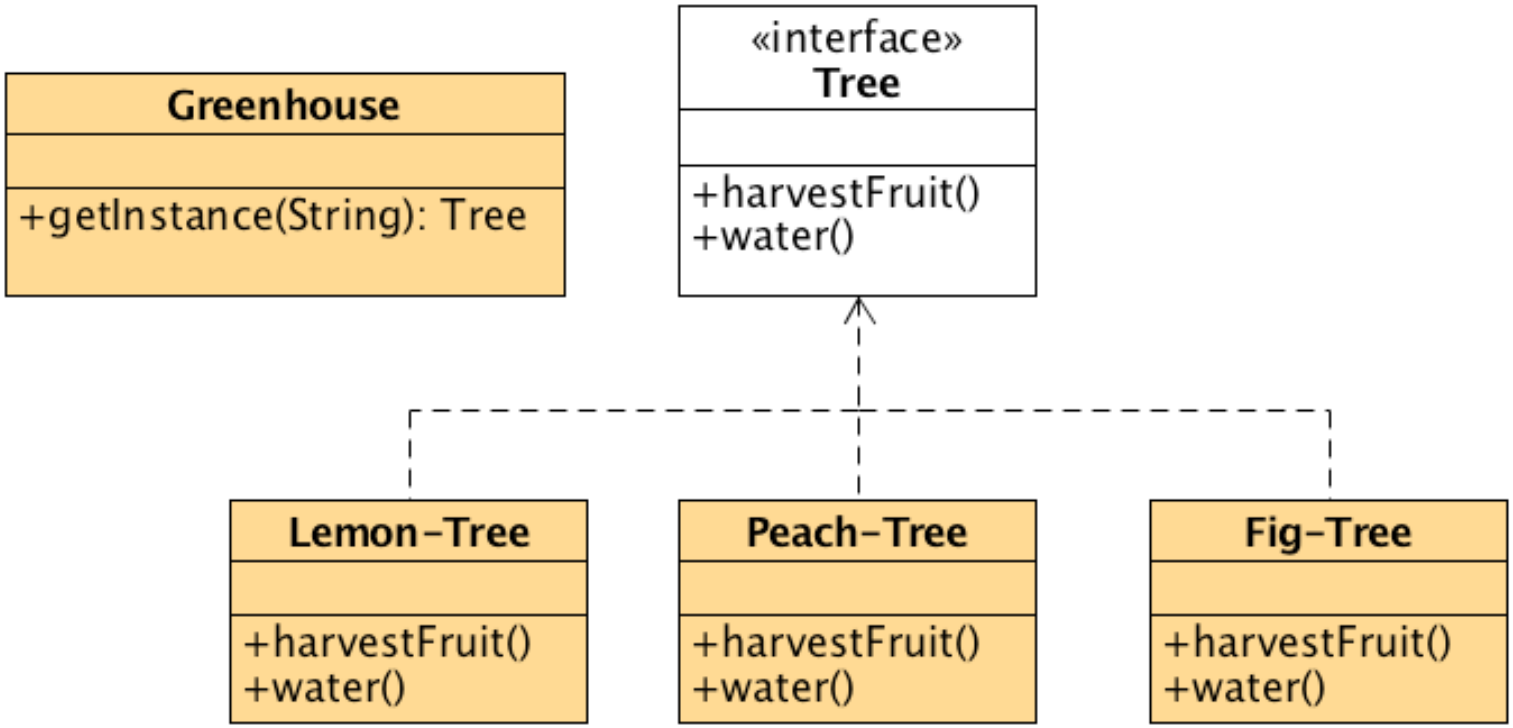

Product
ProductTwo
ProductOne


«interface»
Framework
+make product() : Product
ApplicationOne
+make product() : Product
ApplicationTwo
+make product() : Product
return new ProductOne();

Structure


Client
«interface»
Abstraction
+normalMethod()
+ makeObject() : Product
//...
aProduct.makeObject();
//...
-aProduct
ConcreteOne
+makeObject() : Product
ConcreteTwo
Product
ProductOne
ProductTwo
return new ProductOne();

Example


Greenhouse
+getInstance(String): Tree
«interface»
Tree
+harvestFruit()
+water()
Lemon-Tree
+harvestFruit()
+water()
Peach-Tree
+harvestFruit()
+water()
Fig-Tree
+harvestFruit()
+water()

Example

```
interface Arvore {
    void regar();
    void colherFruta();
}

class Figueira implements Arvore {
    protected Figueira() {System.out.println("Figueira plantada."); }
    public void regar() { System.out.println("Figueira: Regar muito pouco"); }
    public void colherFruta() { System.out.println("Hum.. figos!"); }
}

class Pessegueiro implements Arvore {
    protected Pessegueiro() {System.out.println("Pessegueiro plantado."); }
    public void regar() { System.out.println("Pessegueiro: Regar normal"); }
    public void colherFruta() { System.out.println("Boa.. pessegos!"); }
}

class Limoeiro implements Arvore {
    protected Limoeiro() {System.out.println("Limoeiro plantada."); }
    public void regar() { System.out.println("Limoeiro: Regar pouco"); }
    public void colherFruta() { System.out.println("Ahh.. Caipirinha!"); }
}
```

Example

```
class Viveiro {
    public static Arvore factory(String pedido){
        if (pedido.equalsIgnoreCase("Figueira"))
            { return new Figueira(); }
        if (pedido.equalsIgnoreCase("Pessegueiro"))
            { return new Pessegueiro(); }
        if (pedido.equalsIgnoreCase("Limoeiro"))
            { return new Limoeiro(); }
        else
            throw new IllegalArgumentException(pedido +" não existente!");
    }
    //...
}
```

```
// or with Java Reflection
  public static Arvore factory2(String pedido) {
     Arvore arv = null;
     try {
        arv = (Arvore) Class.forName("Factory."+pedido).newInstance();
     } catch(Exception e) {
        throw new IllegalArgumentException(pedido +" nao existente!");
     }
     return arv;
  }
```

Example

```
public static void main(String[] args) {
    Arvore pomar[] = {
        Viveiro.factory("Figueira"),
        Viveiro.factory("Pessegueiro"),
        Viveiro.factory("Limoeiro")
    };
    for (Arvore a: pomar)
        a.regar();
    for (Arvore a: pomar)
        a.colherFruta();
}
```

```
Figueira plantada.
Pessegueiro plantado.
Limoeiro plantada.
Figueira: Regar muito pouco
Pessegueiro: Regar normal
Limoeiro: Regar pouco
Hum.. figos!
Boa.. pessegos!
Ahh.. Caipirinha!
```

Another Example

```
class Race {
   Race createRace() {
      Bicycle bike1 = new Bicycle();
      Bicycle bike2 = new Bicycle(); //...
   }
}
class TourDeFrance extends Race {
   Race createRace() {
      Bicycle bike1 = new RoadBicycle();
      Bicycle bike2 = new RoadBicycle(); //...
   }
}
class Cyclocross extends Race {
   Race createRace() {
      Bicycle bike1 = new MountainBicycle();
      Bicycle bike2 = new MountainBicycle(); //...
   }
}
```

Problem with this code:
Code duplication!

createRace is very similar among the 3 classes.

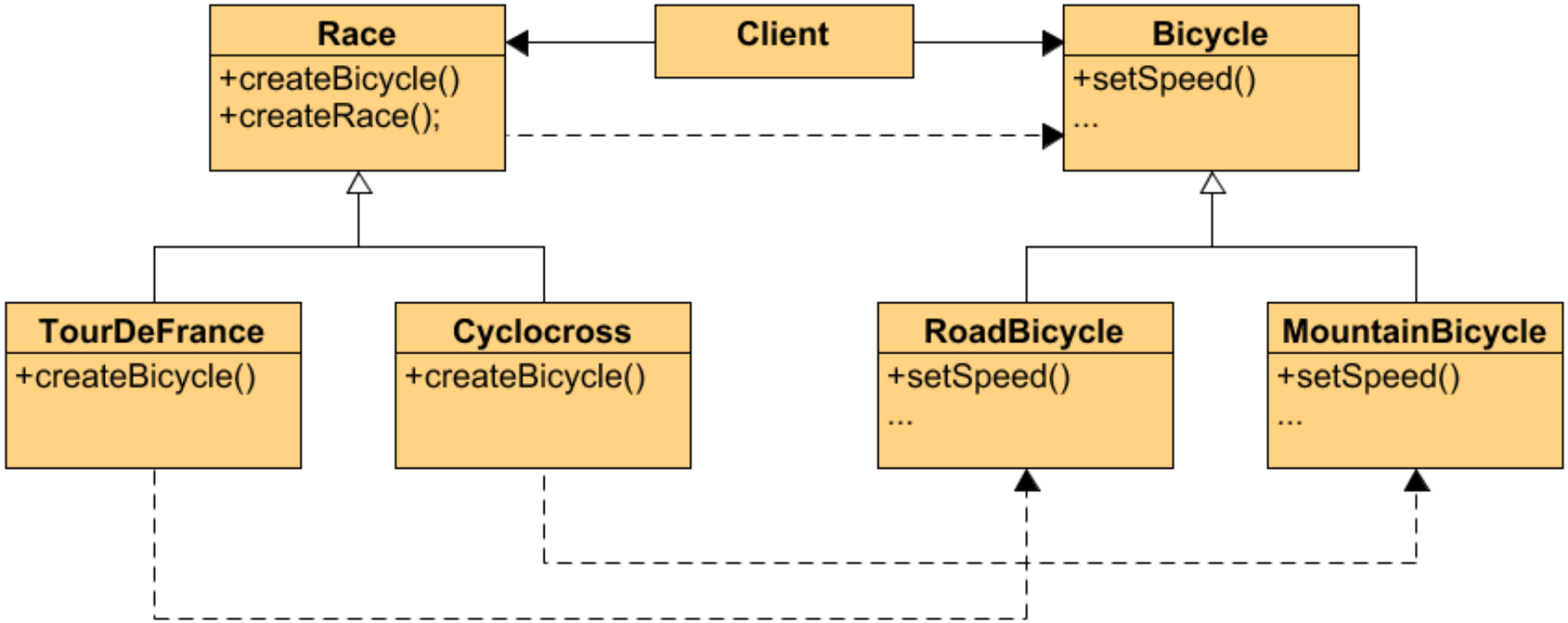
Why not have a single createRace in Race?

Using Factory Method

```
class Race {
   Bicycle createBicycle() {
      return new Bicycle();
   }
   Race createRace() {
      Bicycle bike1 = createBicycle();
      Bicycle bike2 = createBicycle(); //...
   }
}
class TourDeFrance extends Race {
   Bicycle createBicycle() {
      return new RoadBicycle();
   }
}
class Cyclocross extends Race {
   Bicycle createBicycle() {
      return new MountainBicycle();
   }
}
```

Parallel Hierarchies

- Can extend with new Races and Bikes with no modification (generally) to Client



Factory Methods in the JDK

- Calendar replaced Date (JDK1.0)
- DateFormat encapsulates knowledge on how to format a Date
  - Options: Just date? Just time? date+time?

```
Calendar td = Calendar.getInstance();
Date today = td.getTime();

DateFormat df1 = DateFormat.getDateInstance();
DateFormat df2 = DateFormat.getTimeInstance();
DateFormat df3 = DateFormat.getDateInstance(DateFormat.FULL);

System.out.println(df1.format(today));  // "9/jan/2015"
System.out.println(df2.format(today));  // "10:01:24"
System.out.println(df3.format(today));  // "Sexta-feira, 9 de Janeiro de 2015"
```

Check list

- If you have an inheritance hierarchy that exercises polymorphism, consider adding a polymorphic creation capability by defining a static factory method in the base class.
- Design the arguments to the factory method. What qualities or characteristics are necessary and sufficient to identify the correct derived class to instantiate?
- Consider designing an internal "object pool" that will allow objects to be reused instead of created from scratch.
- Consider making all constructors private or protected.

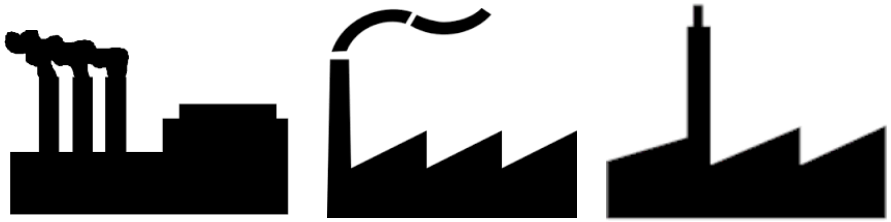
Abstract Factory

Class

- Factory Method

Object

- Abstract Factory
- Builder
- Singleton
- Object Pool
- Prototype

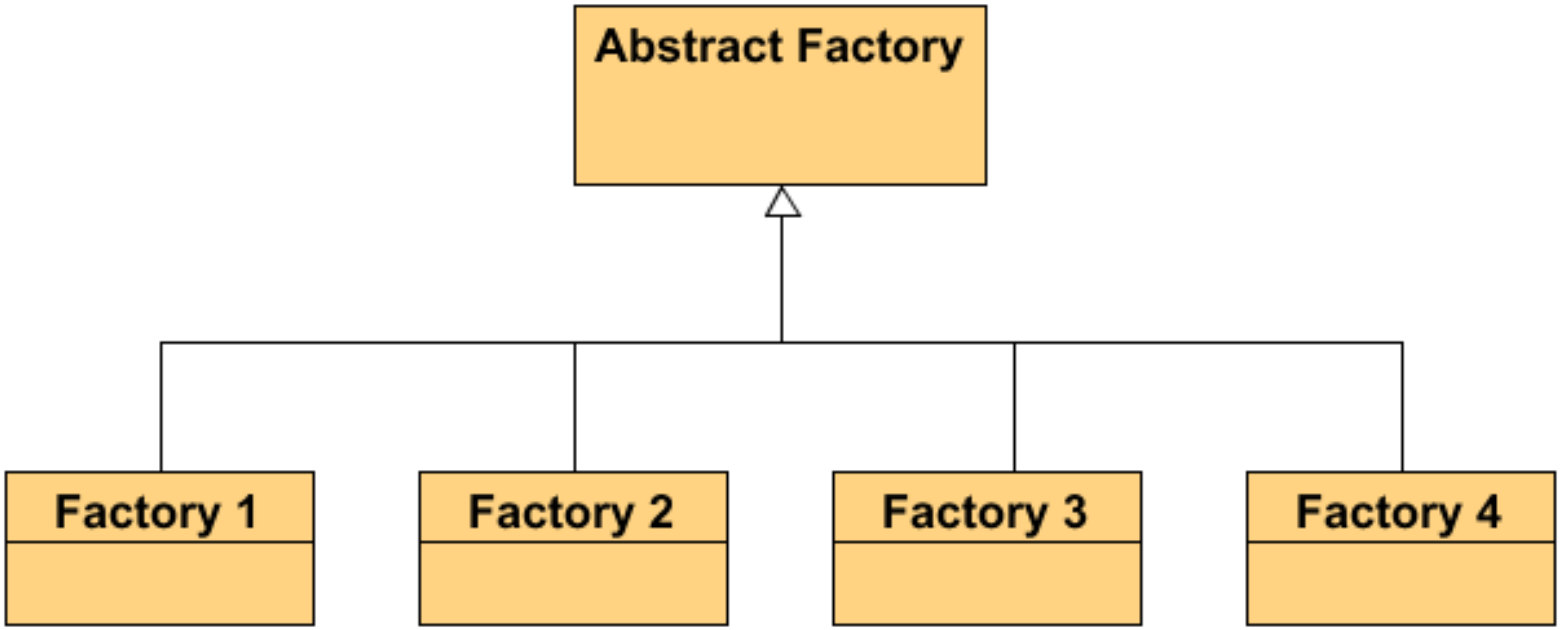


Motivation

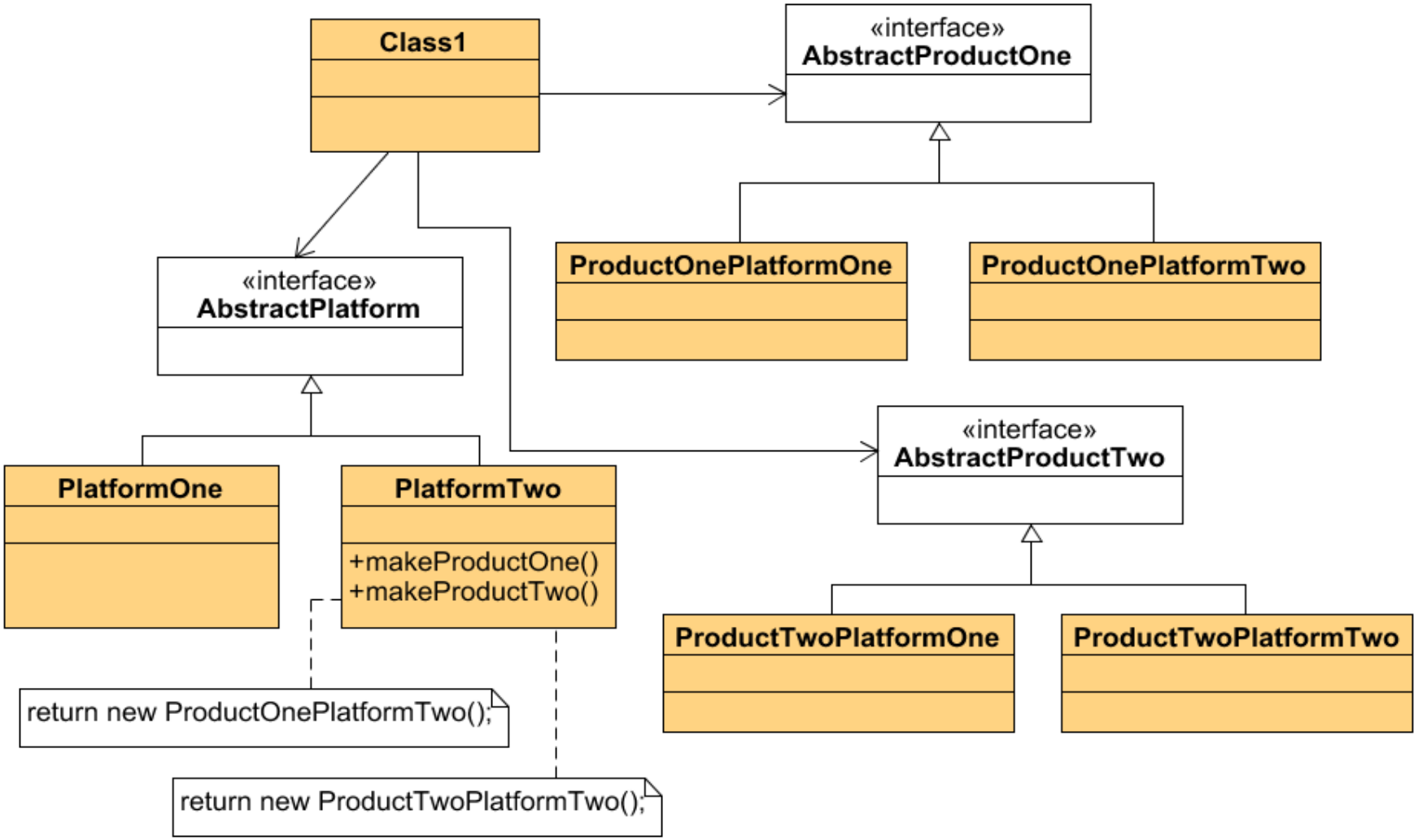
- Intent
  - Provide an interface for creating families of related or dependent objects without specifying their concrete classes.
  - A hierarchy that encapsulates many possible "platforms", and the construction of a suite of "products".
  - The *new* operator considered harmful.
- Problem
  - If an application is to be portable, it needs to encapsulate platform dependencies.
  - These "platforms" might include: windowing system, operating system, database, etc.

Solution

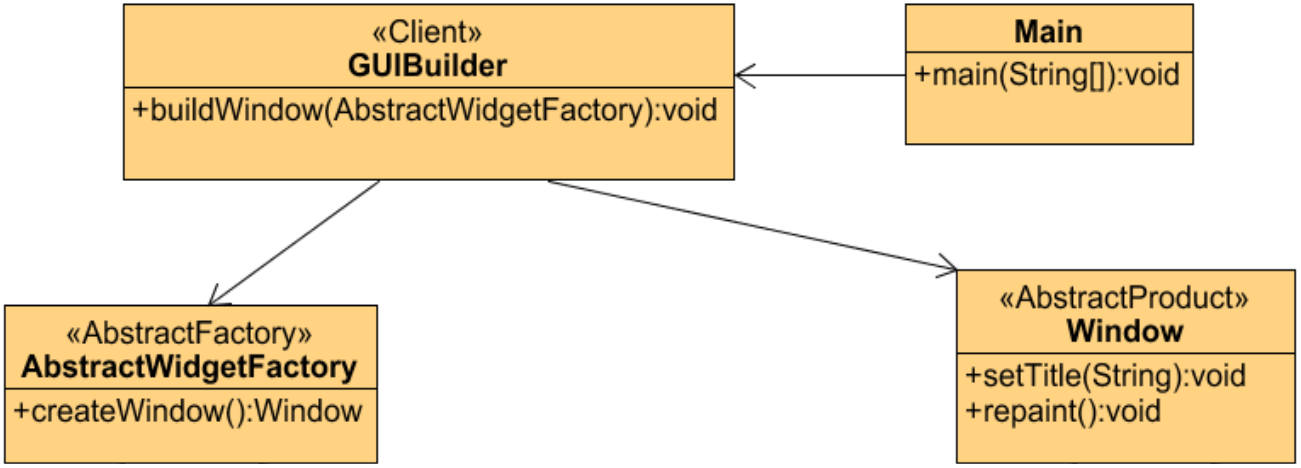
- The Abstract Factory defines a Factory Method per product



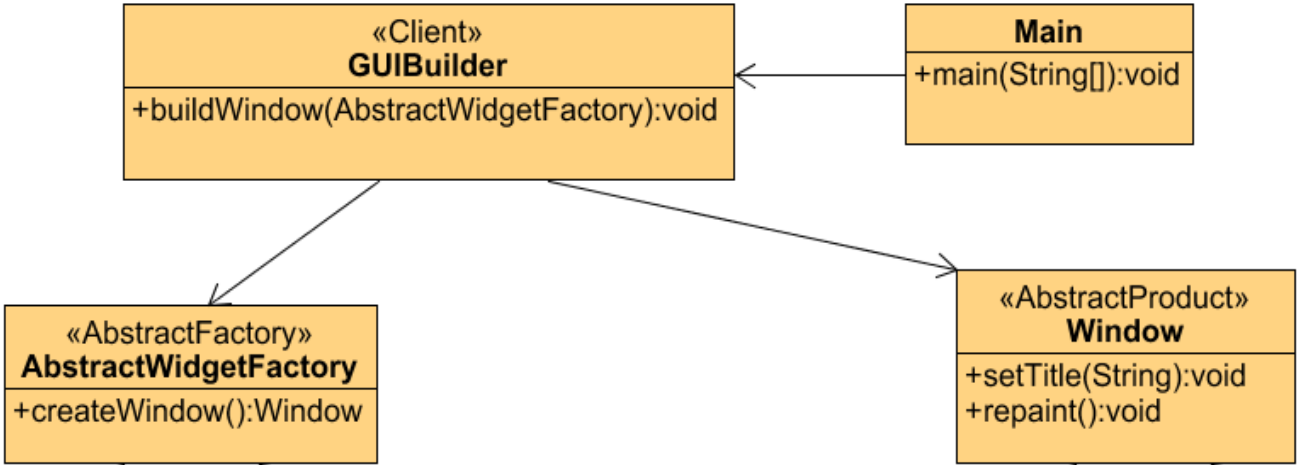
Structure


Class1
«interface»
AbstractProductOne
«interface»
AbstractPlatform
ProductOnePlatformOne
ProductOnePlatformTwo
«interface»
AbstractProductTwo
PlatformOne
PlatformTwo
+makeProductOne()
+makeProductTwo()
ProductTwoPlatformOne
ProductTwoPlatformTwo
return new ProductOnePlatformTwo();
return new ProductTwoPlatformTwo();

Example

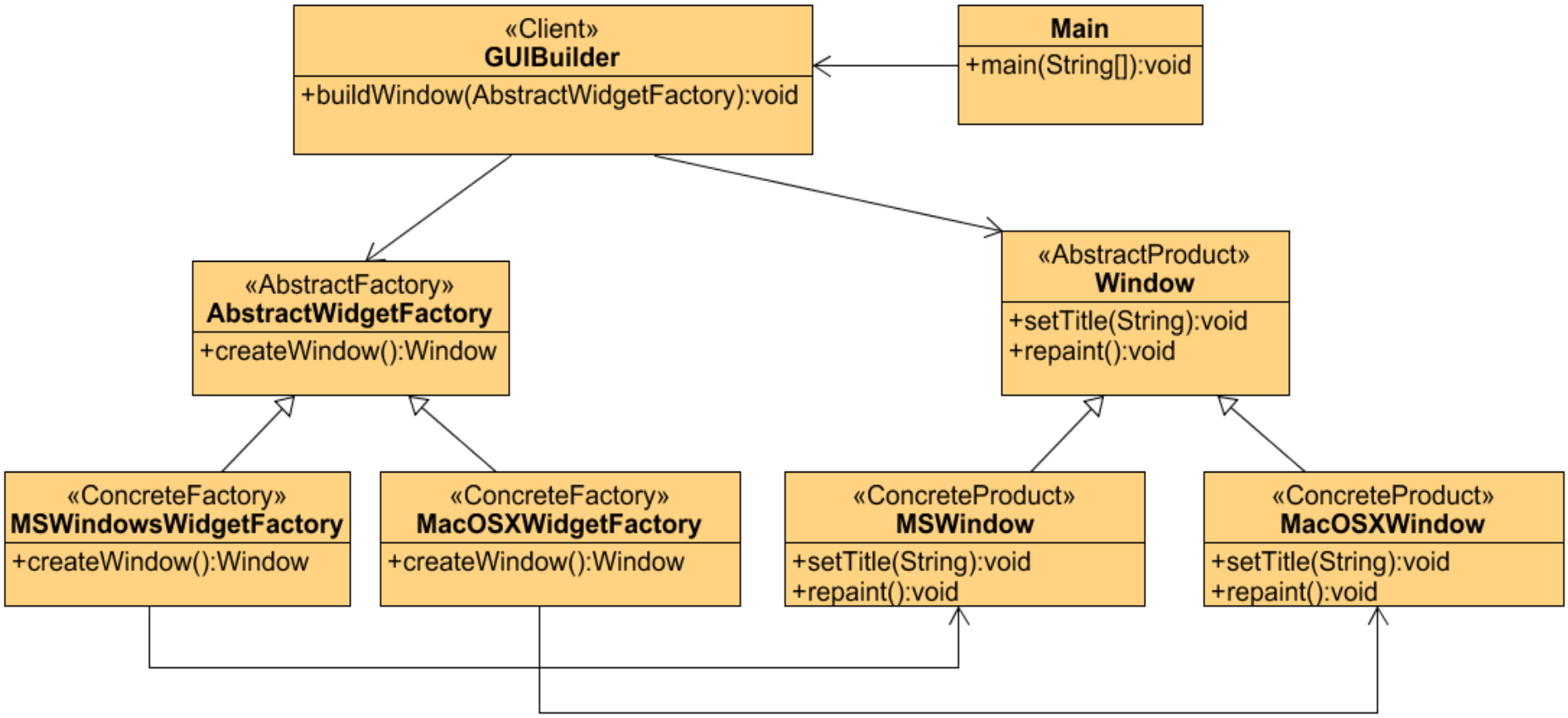

«Client»
GUIBuilder
+buildWindow(AbstractWidgetFactory):void
Main
+main(String[]):void
«AbstractFactory»
AbstractWidgetFactory
+createWindow():Window
«AbstractProduct»
Window
+setTitle(String):void
+repaint():void

Example




```
public class GUIBuilder {
    public void buildWindow(AbstractWidgetFactory widgetFactory) {
        Window window = widgetFactory.createWindow();
        window.setTitle("New Window");
    }
}
```

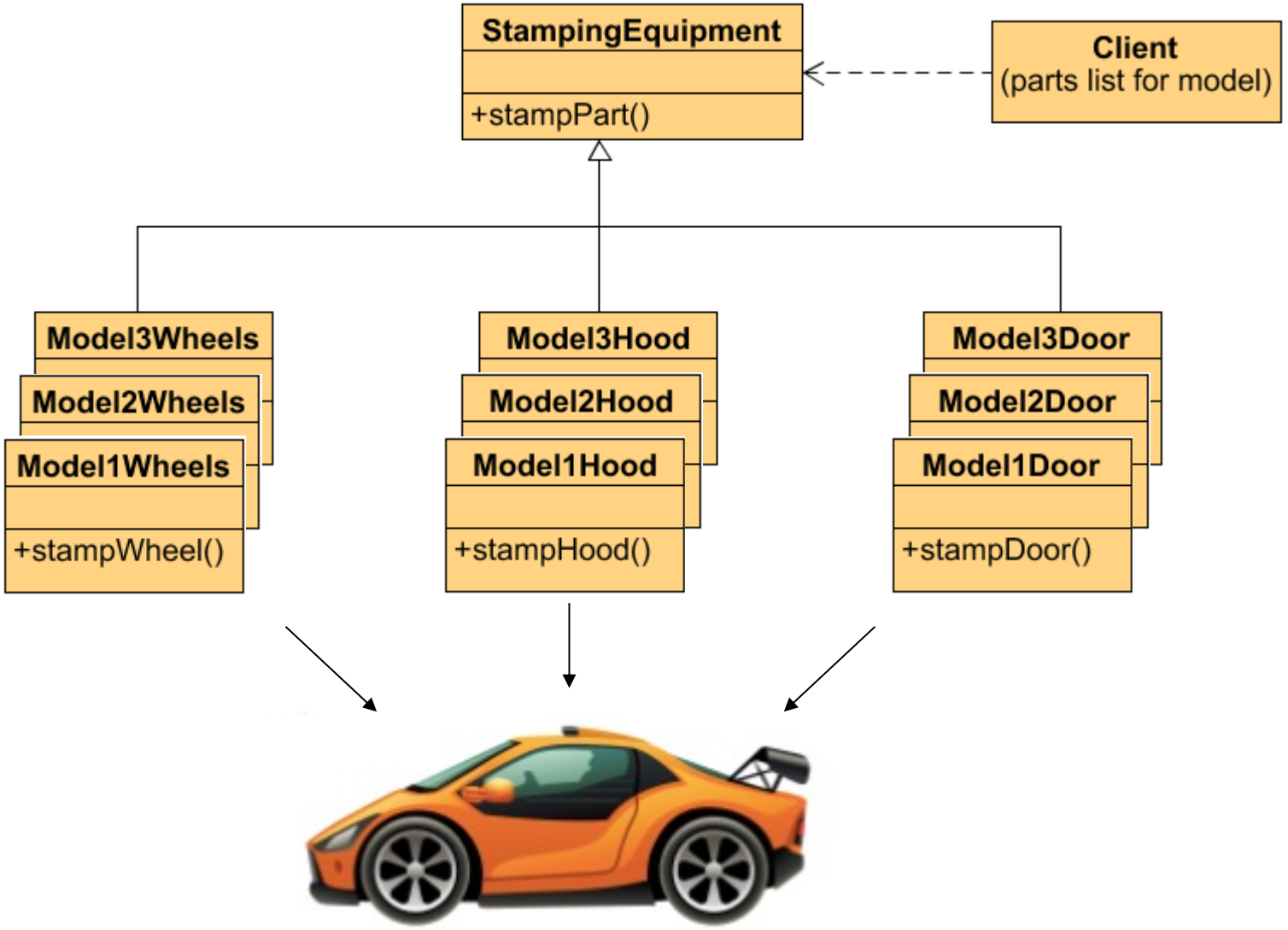
Example


«Client»
GUIBuilder
+buildWindow(AbstractWidgetFactory):void
Main
+main(String[]):void
«AbstractFactory»
AbstractWidgetFactory
+createWindow():Window
«AbstractProduct»
Window
+setTitle(String):void
+repaint():void
«ConcreteFactory»
MSWindowsWidgetFactory
+createWindow():Window
«ConcreteFactory»
MacOSXWidgetFactory
+createWindow():Window
«ConcreteProduct»
MSWindow
+setTitle(String):void
+repaint():void
«ConcreteProduct»
MacOSXWindow
+setTitle(String):void
+repaint():void

Example

```
public class MainTest {
   public static void main(String[] args) {
      GUIBuilder builder = new GUIBuilder();
      if (Platform.currentPlatform()=="MACOSX")
         builder.buildWindow(new MacOSXWidgetFactory());
      else if (Platform.currentPlatform()=="WIN")
         builder.buildWindow(new MsWindowsWidgetFactory());
      else //...
   }
}
public class GUIBuilder {
   public void buildWindow(AbstractWidgetFactory widgetFactory) {
      Window window = widgetFactory.createWindow();
      window.setTitle("New Window");
   }
}
```

Another example



Check list

- Decide if "platform independence" and creation services are the current source of pain.
- Map out a matrix of "platforms" versus "products".
- Define a factory interface that consists of a factory method per product.
- Define a factory derived class for each platform that encapsulates all references to the new operator.
- The client should retire all references to new, and use the factory methods to create the product objects.

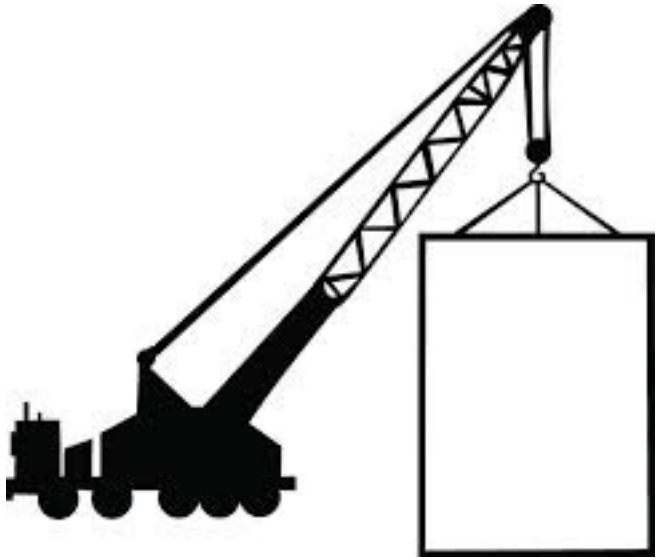
Builder

Class

- Factory Method

Object

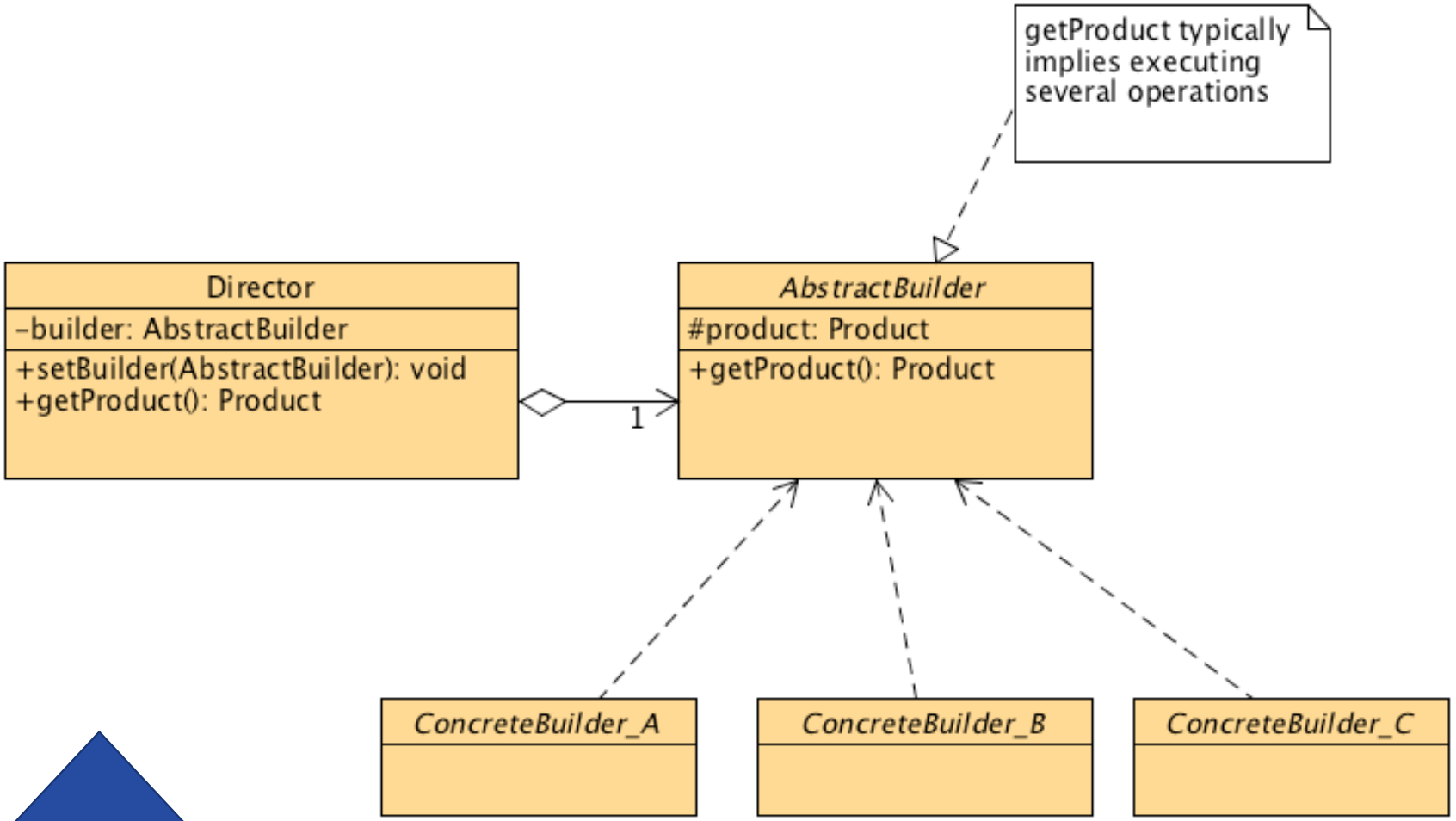
- Abstract Factory
- Builder
- Singleton
- Object Pool
- Prototype



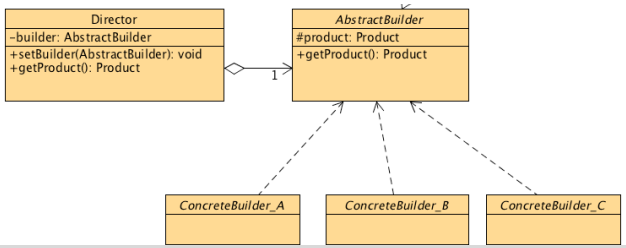
Motivation

- Intent
  - Separate the construction of a complex object from its representation so that the same construction process can create different representations.
  - Parse a complex representation, create one of several targets.
- Problem
  - An application needs to create the elements of a complex aggregate. The specification for the aggregate exists on secondary storage and one of many representations needs to be built in primary storage.

Structure

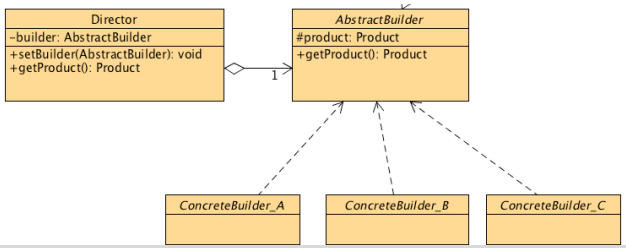

getProduct typically implies executing several operations
Director
-builder: AbstractBuilder
+setBuilder(AbstractBuilder): void
+getProduct(): Product
1
AbstractBuilder
#product: Product
+getProduct(): Product
ConcreteBuilder_A
ConcreteBuilder_B
ConcreteBuilder_C

Example (1)



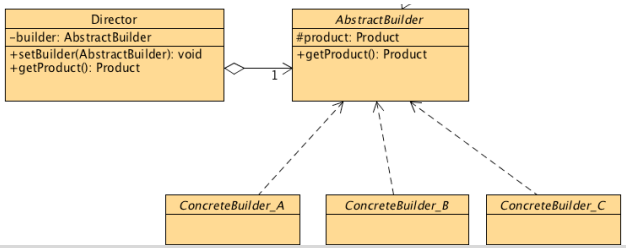

```
class Pizza {    /* "Product" */
  private String dough;
  private String sauce;
  private String topping;
  public void setDough(String dough)     { this.dough = dough; }
  public void setSauce(String sauce)     { this.sauce = sauce; }
  public void setTopping(String topping) { this.topping = topping; }
}

abstract class PizzaBuilder {   /* "Abstract Builder" */
  protected Pizza pizza;

  public Pizza getPizza() { return pizza; }
  public void createNewPizzaProduct() { pizza = new Pizza(); }

  public abstract void buildDough();
  public abstract void buildSauce();
  public abstract void buildTopping();
}
```

Example (2)



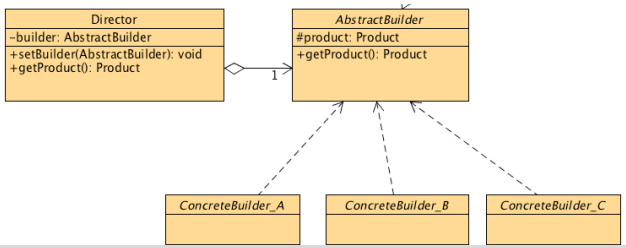

```
/* "ConcreteBuilder" */
class HawaiianPizzaBuilder extends PizzaBuilder {
  public void buildDough()   { pizza.setDough("cross"); }
  public void buildSauce()   { pizza.setSauce("mild"); }
  public void buildTopping() { pizza.setTopping("ham+pineapple"); }
}

/* "ConcreteBuilder" */
class SpicyPizzaBuilder extends PizzaBuilder {
  public void buildDough()   { pizza.setDough("pan baked"); }
  public void buildSauce()   { pizza.setSauce("hot"); }
  public void buildTopping() { pizza.setTopping("pepperoni+salami"); }
}
```

Example (3)




```
class Waiter {    /* "Director" */
    private PizzaBuilder pizzaBuilder;

    public void setPizzaBuilder(PizzaBuilder pb) {
        pizzaBuilder = pb;
    }
    public Pizza getPizza() {
        return pizzaBuilder.getPizza();
    }

    public void constructPizza() {
        pizzaBuilder.createNewPizzaProduct();
        pizzaBuilder.buildDough();
        pizzaBuilder.buildSauce();
        pizzaBuilder.buildTopping();
    }
}
```

Example (4)




```
/* A customer ordering a pizza. */
class BuilderExample {
  public static void main(String[] args) {
    Waiter waiter = new Waiter();
    PizzaBuilder hawaiian_pizzabuilder = new HawaiianPizzaBuilder();
    PizzaBuilder spicy_pizzabuilder = new SpicyPizzaBuilder();

    waiter.setPizzaBuilder( hawaiian_pizzabuilder );
    waiter.constructPizza();
    Pizza pizza = waiter.getPizza();

    waiter.setPizzaBuilder( spicy_pizzabuilder );
    waiter.constructPizza();
    pizza = waiter.getPizza();
  }
}
```

Another example – slightly different

- Consider a builder when faced with many constructors
- Use a builder inner class

Another example

```
public class NutritionFacts {
     private final int servingSize;     // (mL) required
     private final int servings;        // (per container)
     private final int calories;        // optional
     private final int fat;             // (g) optional
     private final int sodium;          // (mg) optional
     private final int carbohydrate;    // (g)  optional

     public NutritionFacts(int servingSize, int servings,
                           int calories, int fat, int sodium,
                           int carbohydrate) {
       this.servingSize = servingSize;
       this.servings = servings;
       this.calories = calories;
       this.fat = fat;
       this.sodium = sodium;
       this.carbohydrate = carbohydrate;
     }
   }
```

What's wrong?

Example – more constructors

```
public NutritionFacts(int servingSize, int servings) {
  this(servingSize, servings, 0);
}

public NutritionFacts(int servingSize, int servings,
                      int calories) {
  this(servingSize, servings, calories, 0);
}

public NutritionFacts(int servingSize, int servings,
                      int calories, int fat) {
  this(servingSize, servings, calories, fat, 0);
}

public NutritionFacts(int servingSize, int servings,
                      int calories, int fat, int sodium) {
  this(servingSize, servings, calories, fat, sodium, 0);
}
```

Still wrong?

Example – with Builder (1)

```
public class NutritionFacts { // Builder Pattern
    private final int servingSize;
    private final int servings;
    private final int calories;
    private final int fat;
    private final int sodium;
    private final int carbohydrate;

    public static class Builder {
        // Required parameters
        private final int servingSize;
        private final int servings;
        // Optional parameters - initialized to default values
        private int calories = 0;
        private int fat = 0;
        private int carbohydrate = 0;
        private int sodium = 0;

        //...
```

Example – with Builder (2)

```
        public Builder(int servingSize, int servings) {
            this.servingSize = servingSize;  this.servings = servings;
        }
        public Builder calories(int val) {
            calories = val;
            return this;
        }
        public Builder fat(int val) {
            fat = val;
            return this;
        }
        public Builder carbohydrate(int val) {
            carbohydrate = val;
            return this;
        }
        public Builder sodium(int val) {
            sodium = val;
            return this;
        } //...
```

Example – with Builder (3)

```
        public NutritionFacts build() {
            return new NutritionFacts(this);
        }
    } // end of class Builder

    private NutritionFacts(Builder builder) {
        servingSize = builder.servingSize;
        servings = builder.servings;
        calories = builder.calories;
        fat = builder.fat;
        sodium = builder.sodium;
        carbohydrate = builder.carbohydrate;
    }
}
```

We can now use this static inner class as follows:

```
NutritionFacts sodaDrink = new NutritionFacts.Builder(240, 8).
      calories(100).sodium(35).carbohydrate(27).build();
```

Builders in the JDK

- All implementations of java.lang.Appendable are good example of use of Builder pattern in java.

```
public static void main(String[] args) {
    String data = new StringBuilder("Exemplo de builder_")
        .append(1)
        .append(true)
        .append("_para_fechar")
        .toString();
    System.out.println(data);
}
```

```
Exemplo de builder_1true_para_fechar
```

Check list

- Decide if a common input and many possible representations (or outputs) is the problem at hand.
- Encapsulate the parsing of the common input in a Reader class (*the Director*).
- Design a standard protocol for creating all possible output representations. Capture the steps of this protocol in a Builder interface.
- Define a Builder derived class for each target representation.
- The client creates a Reader object and a Builder object, and registers the latter with the former.
- The client asks the Reader to "construct".
- The client asks the Builder to return the result.

Singleton

Class

- Factory Method

Object

- Abstract Factory
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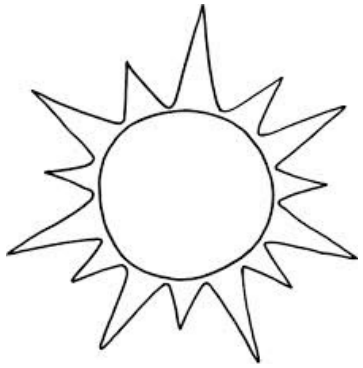


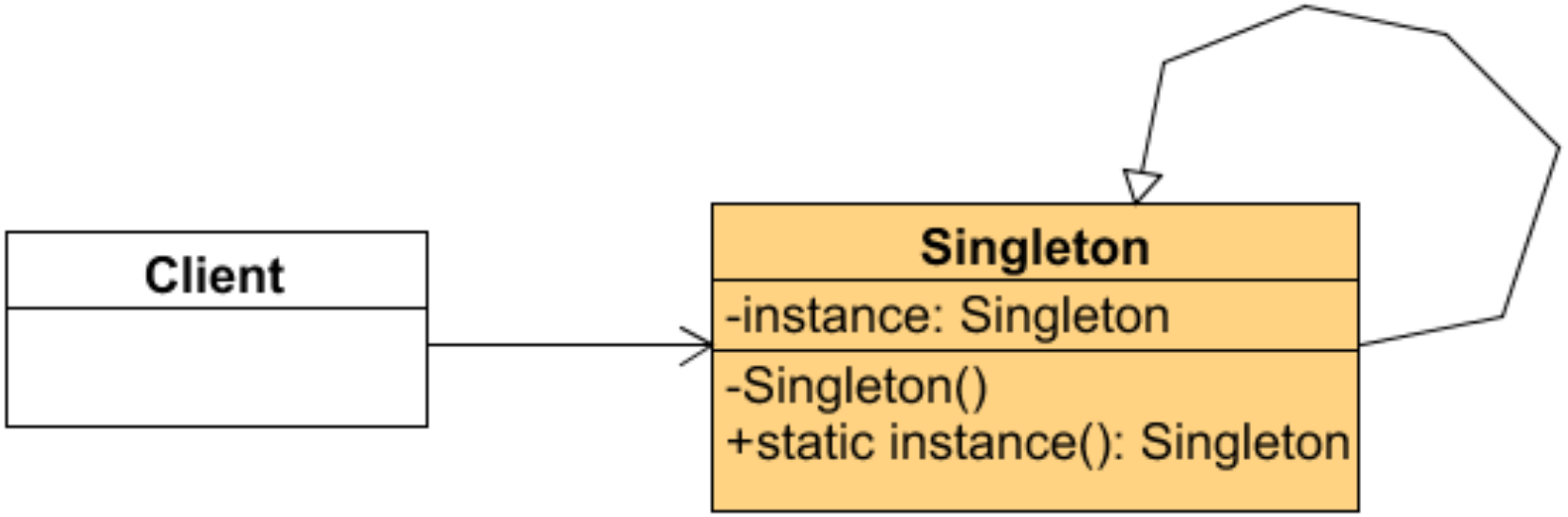
Motivation

- Intent
  - Ensure a class has only one instance, and provide a global point of access to it.
  - Encapsulated "just-in-time initialization" or "initialization on first use".
- Problem
  - Application needs one, and only one, instance of an object. Additionally, lazy initialization and global access are necessary.

Solution

- Define the constructor as private (or protected))
  - private Singleton(String name)
- Define a private static reference to the single class object
  - static private Singleton instance
- Define a acessor method to that instance
  - static public Singleton getInstance ()
  - Customers can access only the singleton object through this method

Structure


Client
Singleton
-instance: Singleton
-Singleton()
+static instance(): Singleton

Example

```
class Singleton {

    private String name;

    static private Singleton instance = new Singleton("Ermita");

    private Singleton(String name) {
        this.name = name;
    }

    static public Singleton getInstance() {
        return instance;
    }
    @Override
    public String toString() {
        return name;
    }
}
```

Example – lazy initialization

```
class LazySingleton {

    private String name;

    static private LazySingleton instance=null;

    private LazySingleton(String name) {
        this.name = name;
    }
    static public synchronized LazySingleton getInstance() {
        if (instance == null) {
            instance = new LazySingleton("Ermita");
        }
        return instance;
    }
    @Override
    public String toString() {
        return name;
    }
}
```

Check list

- Define a private static attribute in the "single instance" class.
- Define a public static accessor function in the class.
- Do "lazy initialization" (creation on first use) in the accessor function.
- Define all constructors to be protected or private.
- Clients may only use the accessor function to manipulate the Singleton.

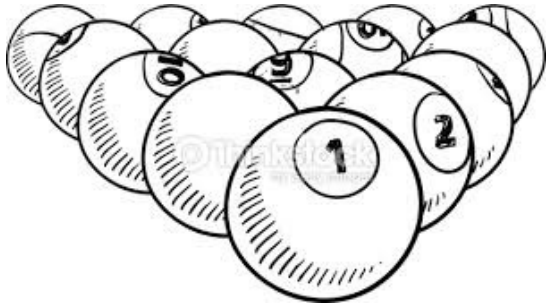
Object Pool

Class

- Factory Method

Object

- Abstract Factory
- Builder
- Singleton
- Object Pool
- Prototype



Motivation

- Intent
  - Object pooling can offer a significant performance boost; it is most effective in situations where:
    - the cost of initializing a class instance is high,
    - the rate of instantiation of a class is high, and
    - the number of instantiations in use at any one time is low.
- Problem
  - Object are used to manage the object caching. A client with access to a Object pool can avoid creating a new Object by simply asking the pool for one that has already been instantiated instead.
  - It is desirable to keep all Reusable objects that are not currently in use in the same object pool so that they can be managed by one coherent policy.

Solution

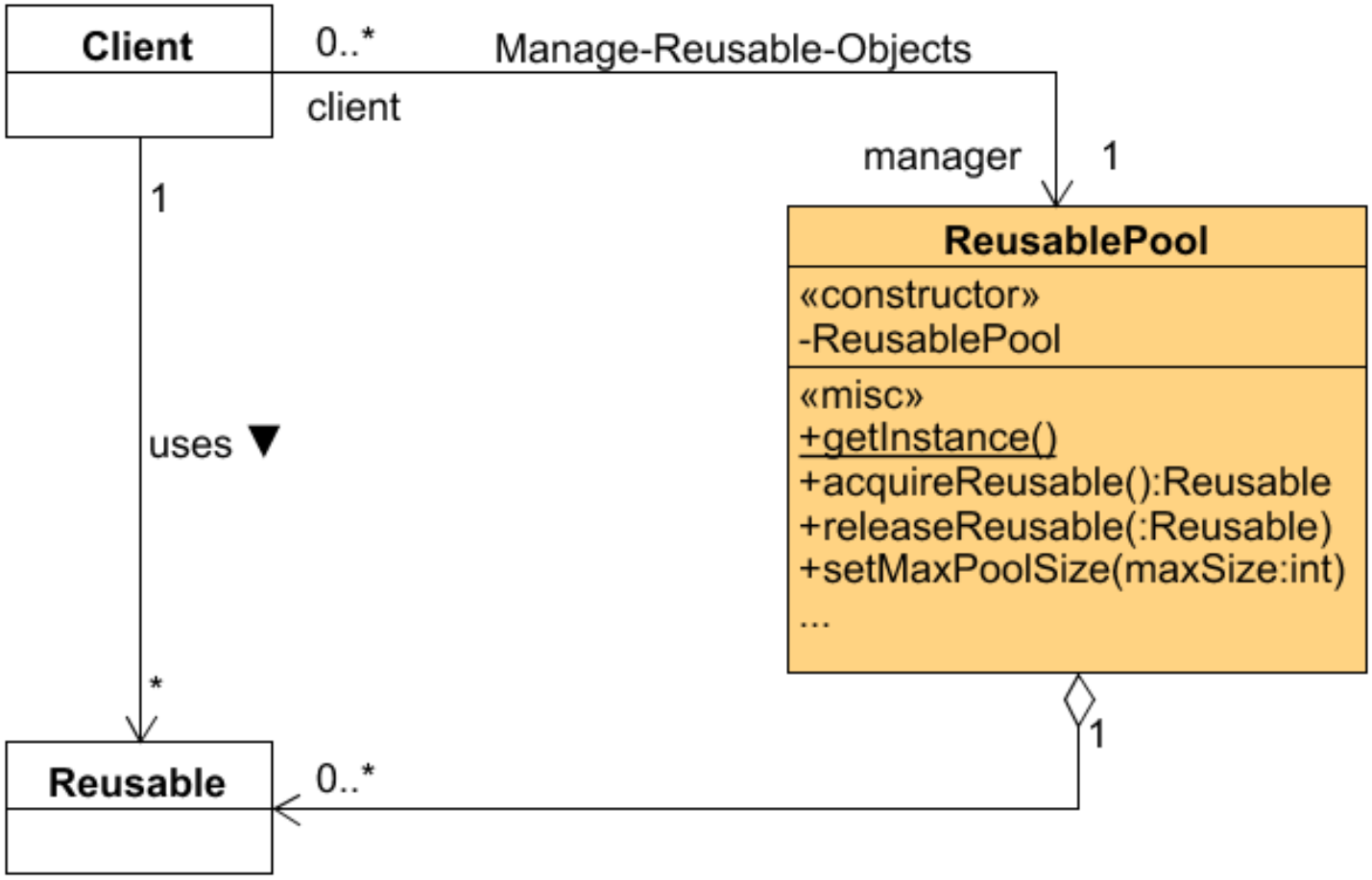
(1) redShoes = Shelf.acquireShoes();

(2) client.wear(redShoes);

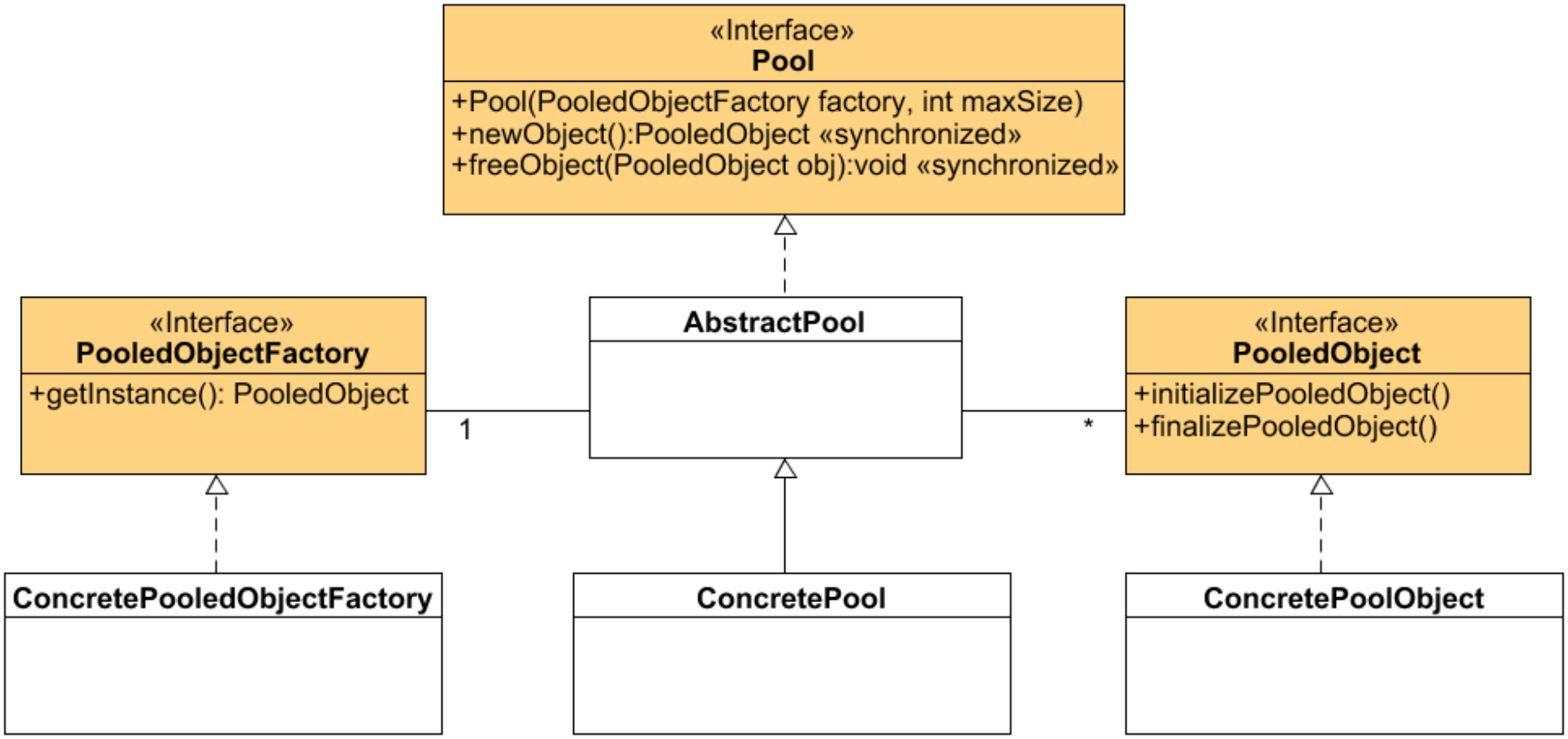
(4) Shelf.releaseShoes(redShoes);

(3) client.play();

Structure


Client
0..*
Manage-Reusable-Objects
client
manager
1
1
ReusablePool
«constructor»
-ReusablePool
«misc»
+getInstance()
+acquireReusable():Reusable
+releaseReusable(:Reusable)
+setMaxPoolSize(maxSize:int)
...
uses
*
1
Reusable
0..*

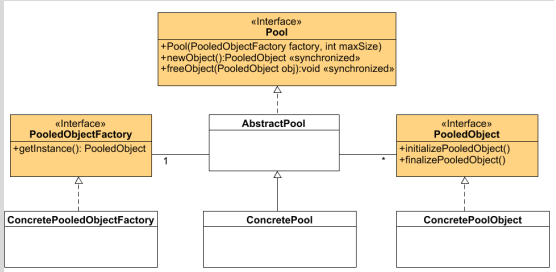
A more complete Structure



Example - *PooledObject*

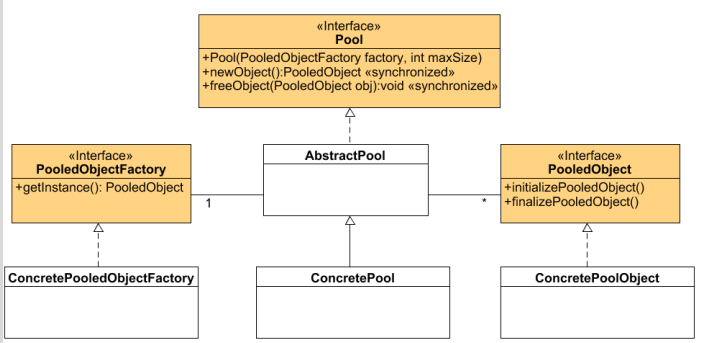
```
/**
 * Interface that has to be implemented by an object that can be
 * stored in an object pool through the Pool class.
 * http://www.devahead.com
 */
public interface PooledObject
{
    /**
     * Initialization method. Called when an object is retrieved
     * from the object pool or has just been created.
     */
    public void initializePooledObject();

    /**
     * Finalization method. Called when an object is stored in
     * the object pool to mark it as free.
     */
    public void finalizePooledObject();
}
```



Example - *PooledObjectFactory*

```
/**
 * Interface that has to be implemented by every class that allows
 * the creation of objects for an object pool through the
 * Pool class.
*/
public interface PooledObjectFactory
{
        /**
         * Creates a new object for the object pool.
         *
         * @return new object instance for the object pool
         */
        public PooledObject getInstance();
}
```

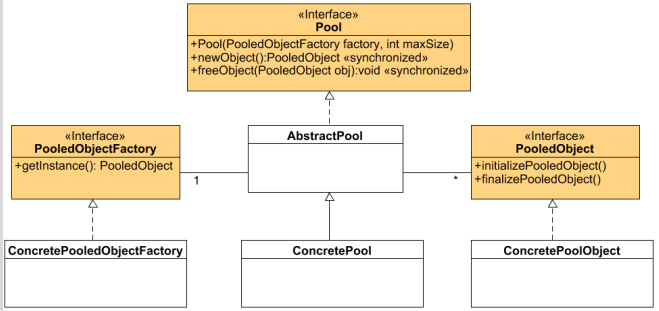


Example - *AbstractPool*

```
public class AbstractPool implements Pool
{
    protected final int MAX_FREE_OBJECT_INDEX;

    protected PooledObjectFactory factory;
    protected PooledObject[] freeObjects;
    protected int freeObjectIndex = -1;

    /**
     * @param factory the object pool factory instance
     * @param maxSize the maximum number of instances stored in the pool
     */
    public AbstractPool(PooledObjectFactory factory, int maxSize)
    {
        this.factory = factory;
        this.freeObjects = new PooledObject[maxSize];
        MAX_FREE_OBJECT_INDEX = maxSize - 1;
    }
```



Example – *AbstractPool.newObject*

```
/**
 * Creates a new object or returns a free object from the pool.
 * @return a PooledObject instance already initialized
 */
public synchronized PooledObject newObject() {
    PooledObject obj = null;

    if (freeObjectIndex == -1) {
        // There are no free objects so I just
        // create a new object that is not in the pool.
        obj = factory.getInstance();
    } else {
        // Get an object from the pool
        obj = freeObjects[freeObjectIndex];
        freeObjectIndex--;
    }
    obj.initializePooledObject();
    return obj;
}
```

Example - *AbstractPool.freeObject*

```
    /**
     * Stores an object instance in the pool to make it available for a subsequent
     * call to newObject() (the object is considered free).
     * @param obj the object to store in the pool and that will be finalized
     */
    public synchronized void freeObject(PooledObject obj)
    {
        if (obj != null)   {
            // Finalize the object
            obj.finalizePooledObject();
            // put an object in the pool only if there is still room for it
            if (freeObjectIndex < MAX_FREE_OBJECT_INDEX) {
                freeObjectIndex++;
                // Put the object in the pool
                freeObjects[freeObjectIndex] = obj;
            }
        }
    }
}
```

Check list

- Create the *Pool* class with a collection of *PooledObjects*
- Create *acquire* and *release* methods in *Pool* class

Important remarks

- The creation and destruction of short lived objects (i.e. memory allocation and GC) is more efficient in modern JVMs.
- Object Pool must only be used for special objects whose creation is relatively costly, like DB / network connections, threads etc.

Prototype

Class

- Factory Method

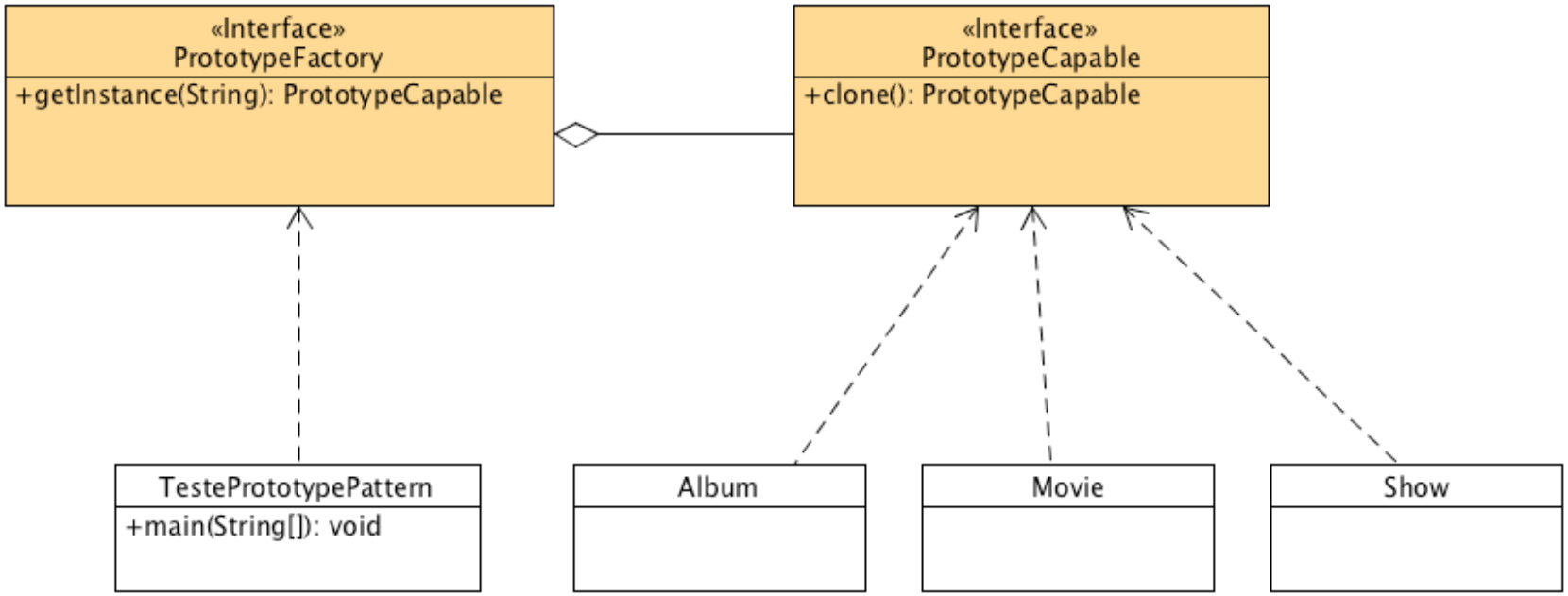
Object

- Abstract Factory
- Builder
- Singleton
- Object Pool
- Prototype

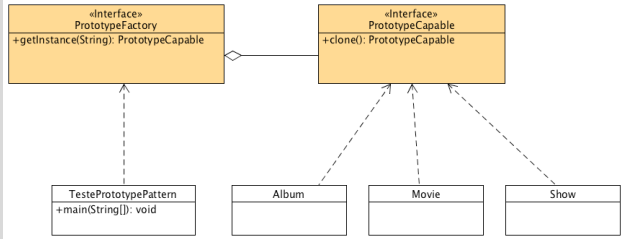
Motivation

- Intent
  - Specify the kinds of objects to create using a prototypical instance, and create new objects by copying this prototype.
  - Co-opt one instance of a class for use as a breeder of all future instances.
  - The new operator considered harmful.
- Problem
  - Application "hard wires" the class of object to create, in each "new" expression.

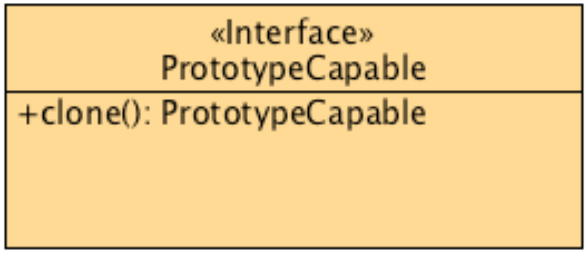
Structure


«Interface»
PrototypeFactory
+getInstance(String): PrototypeCapable
«Interface»
PrototypeCapable
+clone(): PrototypeCapable
TestePrototypePattern
+main(String[]): void
Album
Movie
Show

Example – *the contract*

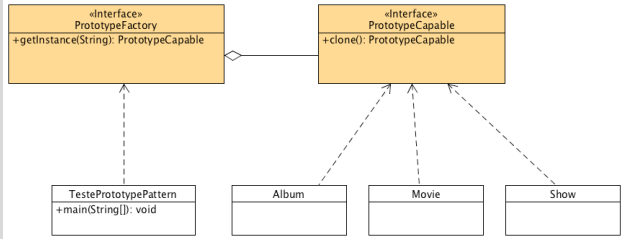



```
public interface PrototypeCapable extends Cloneable
{
    public PrototypeCapable clone() throws CloneNotSupportedException;
}
```



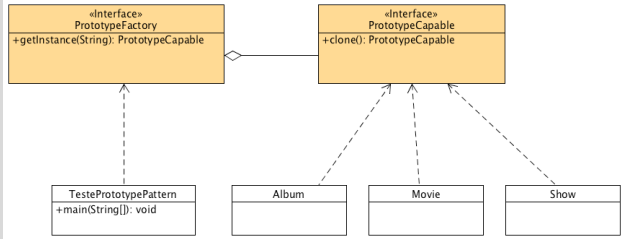
Example – *the model*

```
public class Album implements PrototypeCapable
{
    private String name = null;
    public String getName() {
        return name;
    }
    public void setName(String name) {
        this.name = name;
    }
    @Override
    public Album clone() throws CloneNotSupportedException {
        System.out.println("Cloning Album object..");
        return (Album) super.clone();
    }
    @Override
    public String toString() {
        return "Album";
    }
}
```



the same for Movie, Show, ..

Example – *the factory*

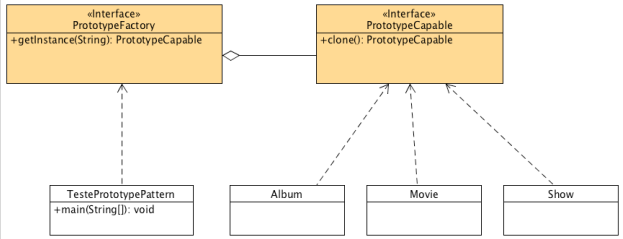



```
public class PrototypeFactory  {
    public static enum ModelType   {
        MOVIE, ALBUM, SHOW;
    }

    private static Map<ModelType, PrototypeCapable> prototypes =
        new HashMap<>();
    static {
        prototypes.put(ModelType.MOVIE, new Movie());
        prototypes.put(ModelType.ALBUM, new Album());
        prototypes.put(ModelType.SHOW, new Show());
    }

    public static PrototypeCapable getInstance(ModelType s)
                  throws CloneNotSupportedException {
        return (prototypes.get(s)).clone();
    }
}
```

Example – *the client*




```
public class TestPrototypePattern {
    public static void main(String[] args)  {
        try {

            PrototypeCapable proto;
            proto = PrototypeFactory.getInstance(ModelType.MOVIE);
            System.out.println(proto);

            proto = PrototypeFactory.getInstance(ModelType.ALBUM);
            System.out.println(albumPrototype);

            proto = PrototypeFactory.getInstance(ModelType.SHOW);
            System.out.println(proto);
        }
        catch (CloneNotSupportedException e)
            e.printStackTrace();
        }
    }
}
```

```
Cloning Movie object..
Movie
Cloning Album object..
Album
Cloning Show object..
Show
```

Check list

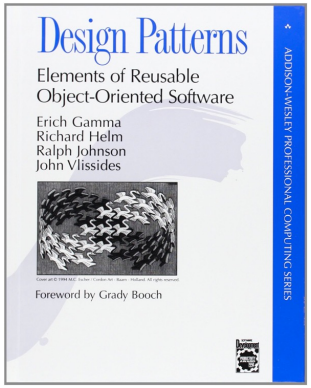
- Add a clone() method to the existing "product" hierarchy.
- Design a "registry" that maintains a cache of prototypical objects. The registry could be encapsulated in a new Factory class, or in the base class of the "product" hierarchy.
- Design a factory method that: may (or may not) accept arguments, finds the correct prototype object, calls clone() on that object, and returns the result.
- The client replaces all references to the new operator with calls to the factory method.

Creational patterns – Summary

- Abstract Factory
  - Creates an instance of several families of classes
- Builder
  - Separates object construction from its representation
- Factory Method
  - Creates an instance of several derived classes
- Singleton
  - A class of which only a single instance can exist
- Object Pool
  - Avoid expensive acquisition and release of resources by recycling objects that are no longer in use
- Prototype
  - A fully initialized instance to be copied or cloned

Resources

- Design Patterns – Elements of Reusable Object-Oriented Software; Gamma, et. al.



- *Design Patterns Explained Simply (sourcemaking.com)*