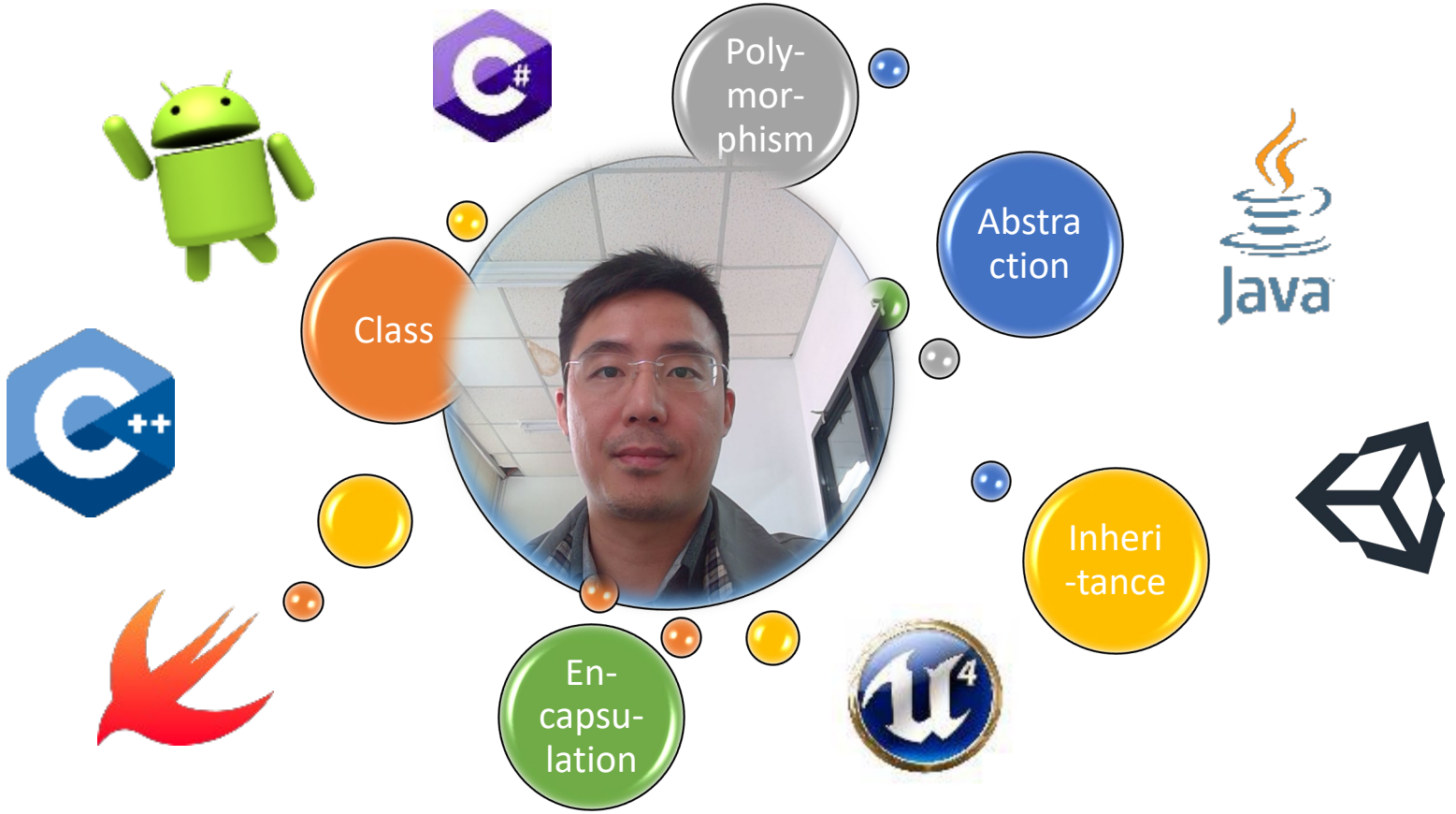


Creational Design Patterns

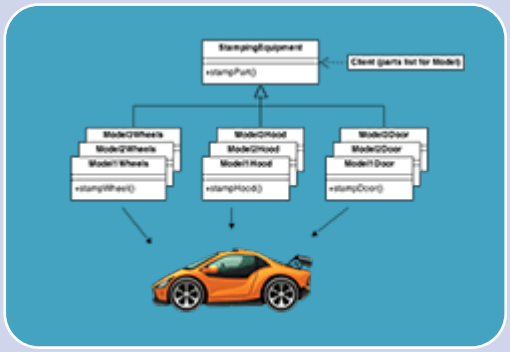
Kuan-Ting Lai

2023/4/8

Design Patterns

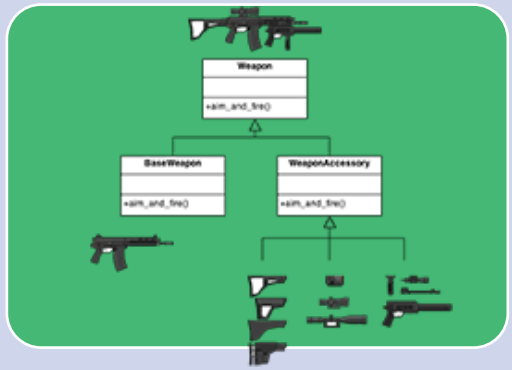
Creational Design Patterns

Initialize objects or create new classes



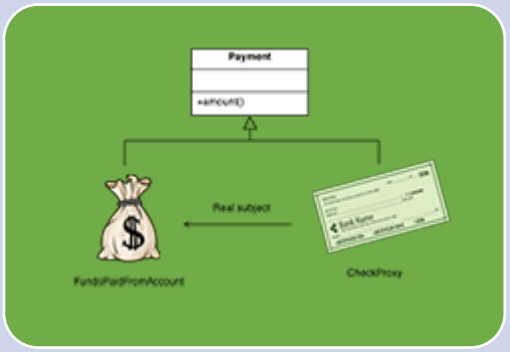
Structural Design Patterns

Compose objects to get new functions



Behavioral Design Patterns

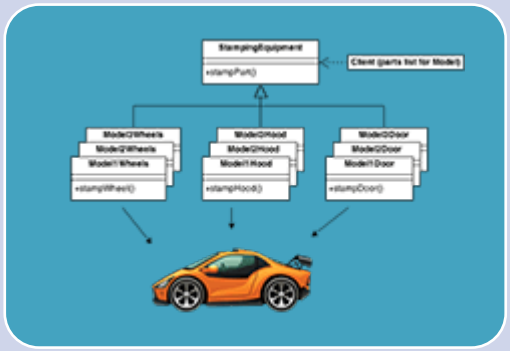
Communication between objects



Creational Design Patterns

Creational Design Patterns

Initialize objects or create new classes

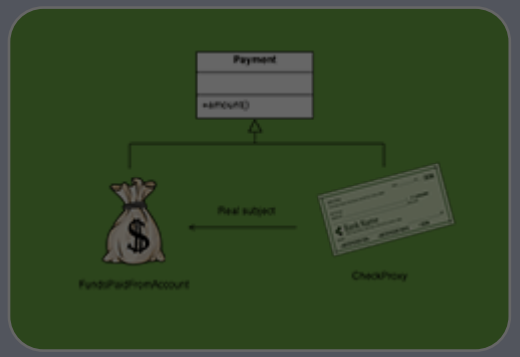


Structural Design Patterns

Compose objects to get new functions

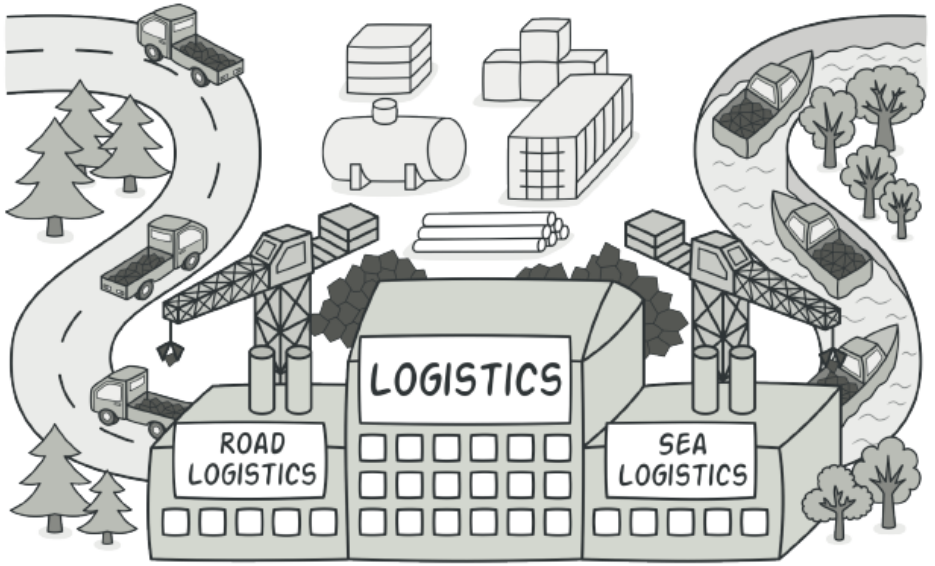
Behavioral Design Patterns

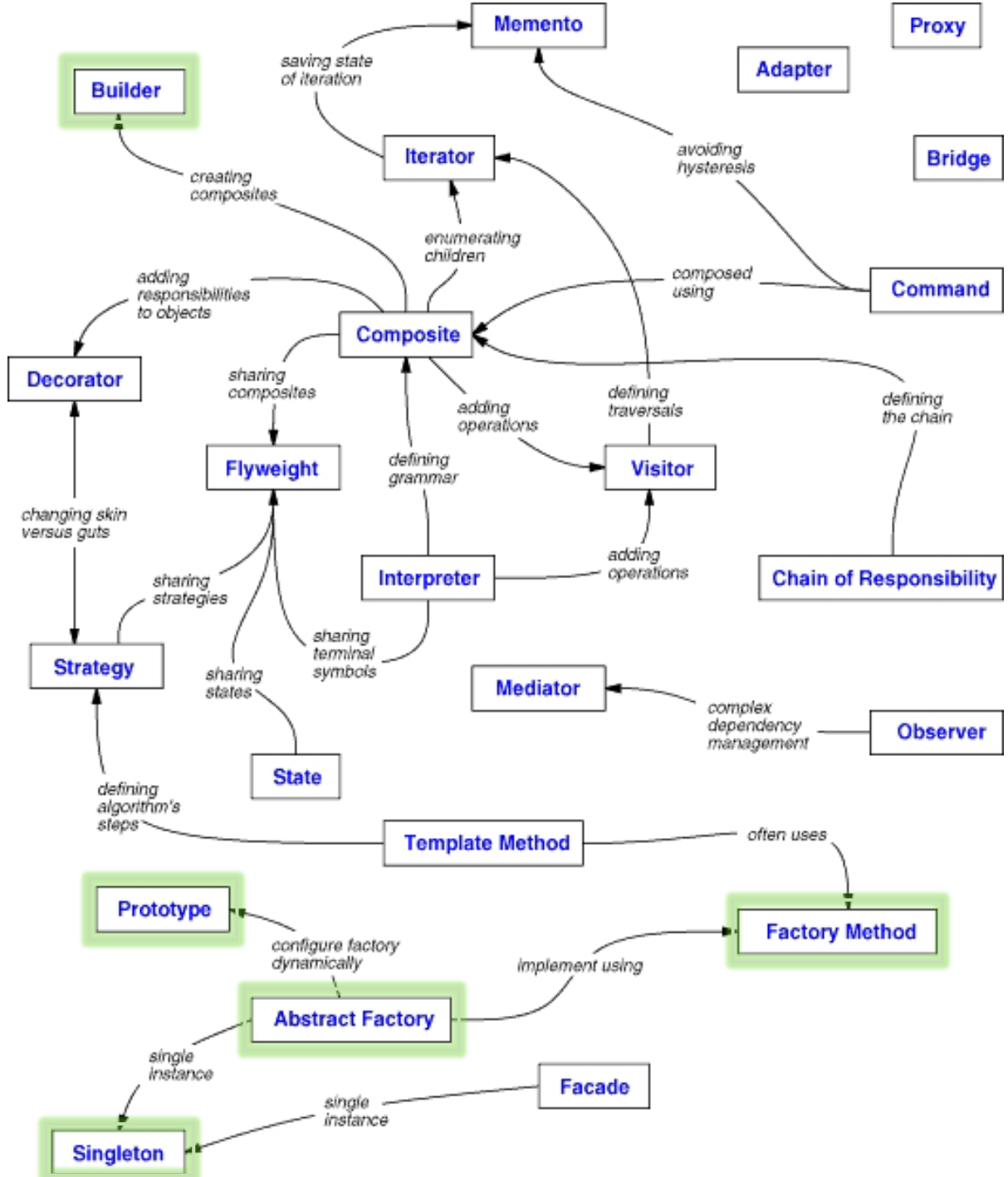
Communication between objects



Creational Design Patterns

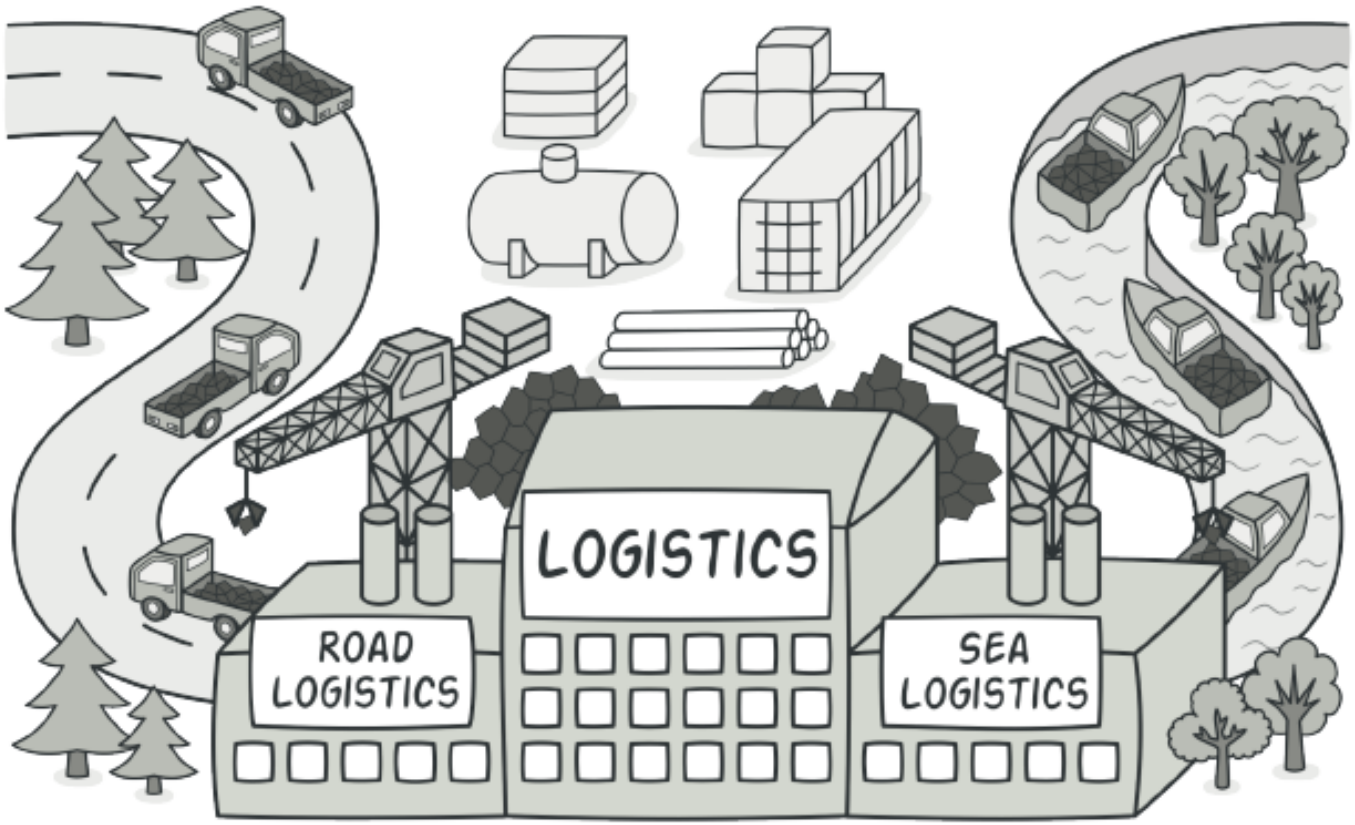
1. Factory Method
2. Abstract Factory
3. Builder
4. Prototype
5. Singleton




Memento
Proxy
saving state of iteration
Builder
Adapter
Iterator
avoiding hysteresis
Bridge
creating composites
enumerating children
adding responsibilities to objects
composed using
Command
Composite
Decorator
sharing composites
adding operations
defining traversals
defining the chain
Flyweight
defining grammar
Visitor
changing skin versus guts
sharing strategies
Interpreter
adding operations
Chain of Responsibility
sharing terminal symbols
Strategy
sharing states
Mediator
complex dependency management
Observer
State
defining algorithm's steps
Template Method
often uses
Prototype
Factory Method
configure factory dynamically
implement using
Abstract Factory
single instance
Facade
single instance
Singleton

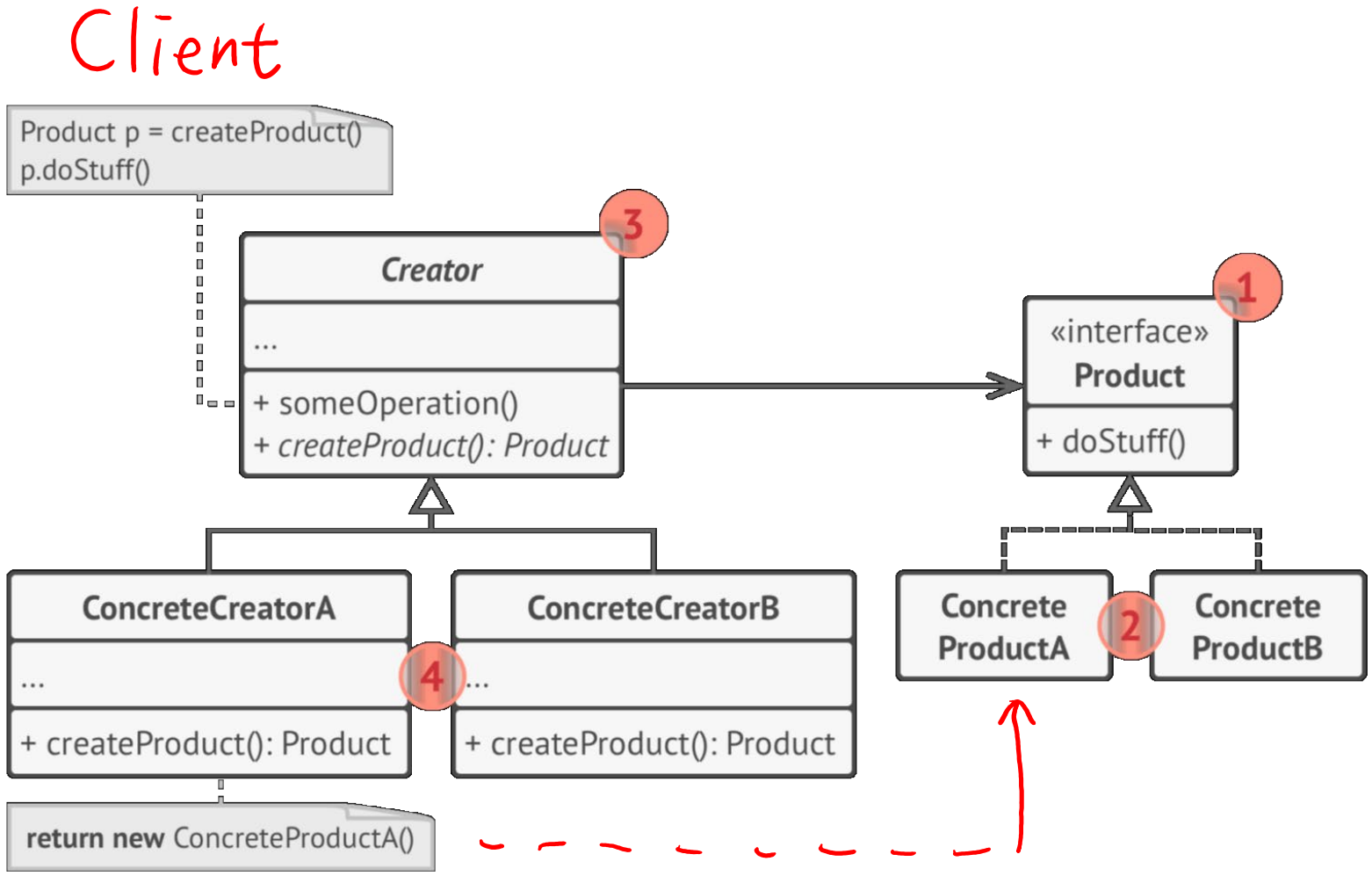
1. Factory Method

- Factory Method provides an interface for creating objects in a superclass, but allows subclasses to alter the type of objects that will be created.

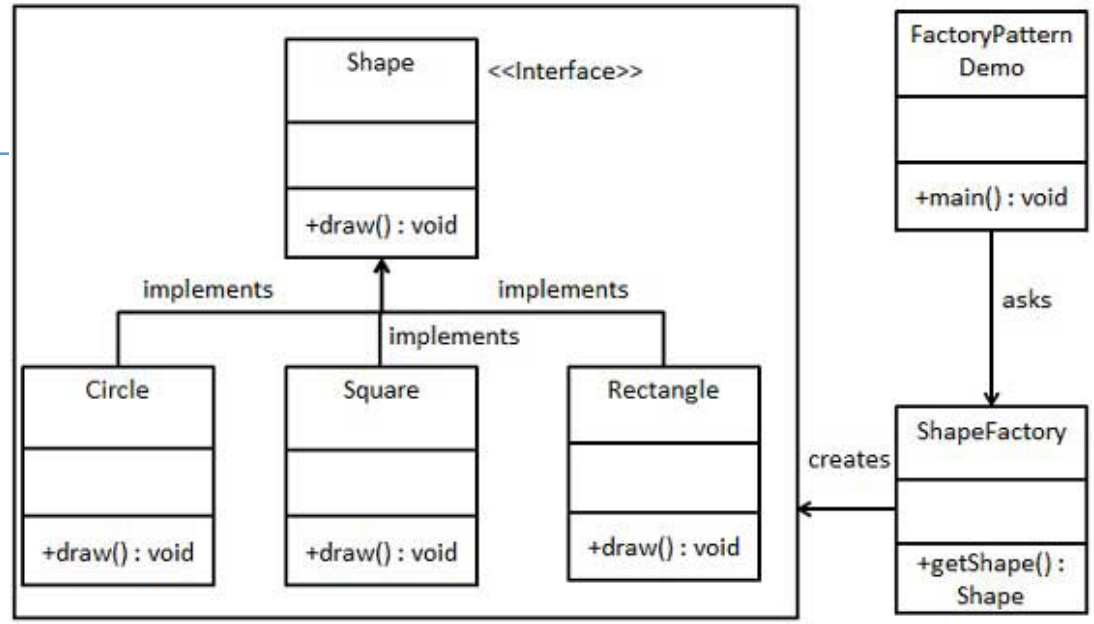


Structure of Factory Method

1. **Product** declares the interface.
2. **Concrete Products** implements the product interface.
3. **Creator** declares factory method
4. **Concrete Creators** override the base factory method



Example: Shape Factory




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

public class Circle implements Shape {
   @Override
    public void draw() {
        System.out.println("Inside Circle::draw() method.");
    }
}
public class Square implements Shape {
    @Override
    public void draw() { System.out.println("Inside Square::draw() method."); }
}
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("SQUARE") ){ return new Square(); }

            return null;
        }
}
```

https://www.tutorialspoint.com/design_pattern/factory_pattern.htm

Using ShapeFactory

```
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");
      shape1.draw();

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

C++ Factory Pattern: Creating Vehicles

```
enum VehicleType {VT_TwoWheeler, VT_ThreeWheeler};
// Library classes
class Vehicle {
public:
        virtual void printVehicle() = 0;
        static Vehicle* Create(VehicleType type);
};
class TwoWheeler : public Vehicle {
public:
        void printVehicle() {cout << "I am two wheeler" << endl;}
};
class ThreeWheeler : public Vehicle {
public:
        void printVehicle() { cout << "I am three wheeler" << endl;}
};
// Factory method to create objects of different types.
Vehicle* Vehicle::Create(VehicleType type) {
    if (type == VT_TwoWheeler)
        return new TwoWheeler();
    else if (type == VT_ThreeWheeler)
        return new ThreeWheeler();
    else return NULL;
}
```

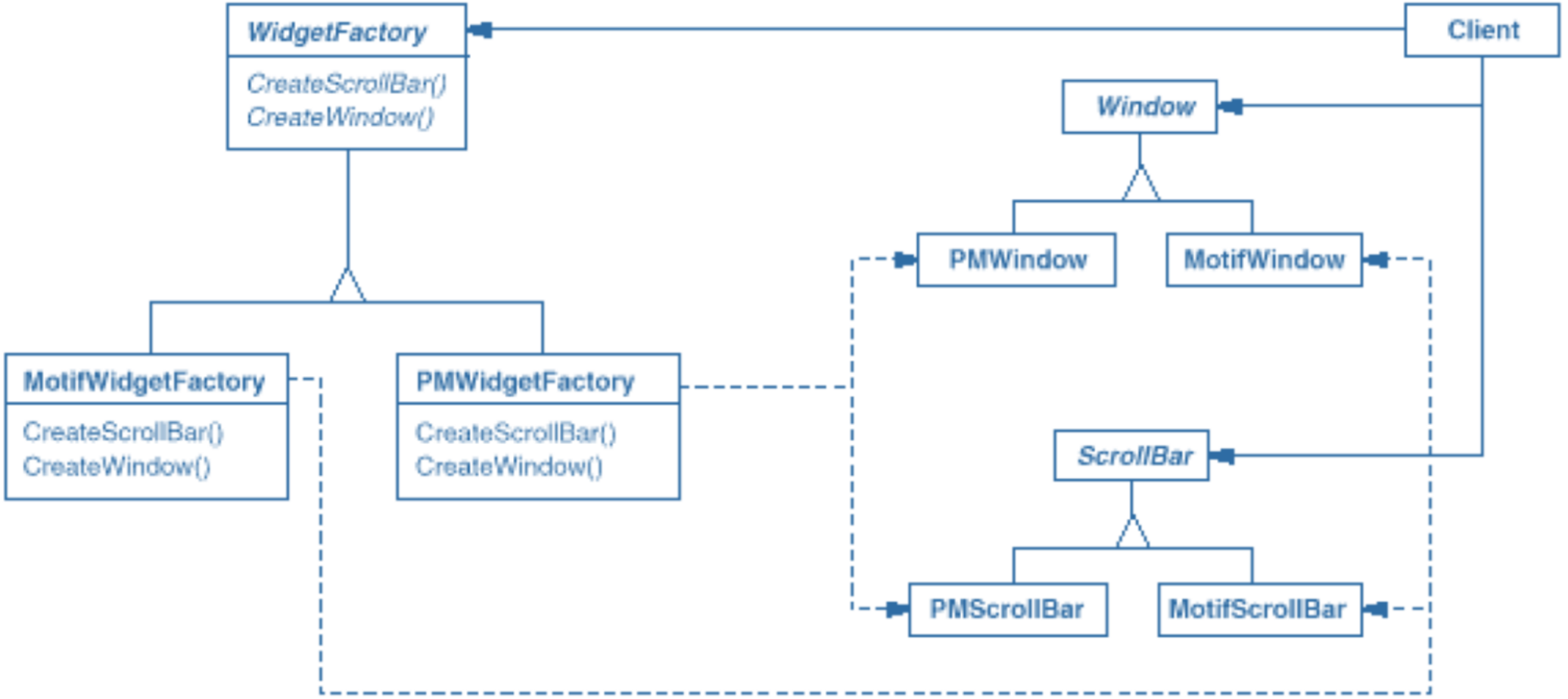
https://www.geeksforgeeks.org/design-patterns-set-2-factory-method/

2. Abstract Factory Pattern

- Just define an interface (abstract class) for creating families of related objects, but doesn’t specify their concrete sub-classes

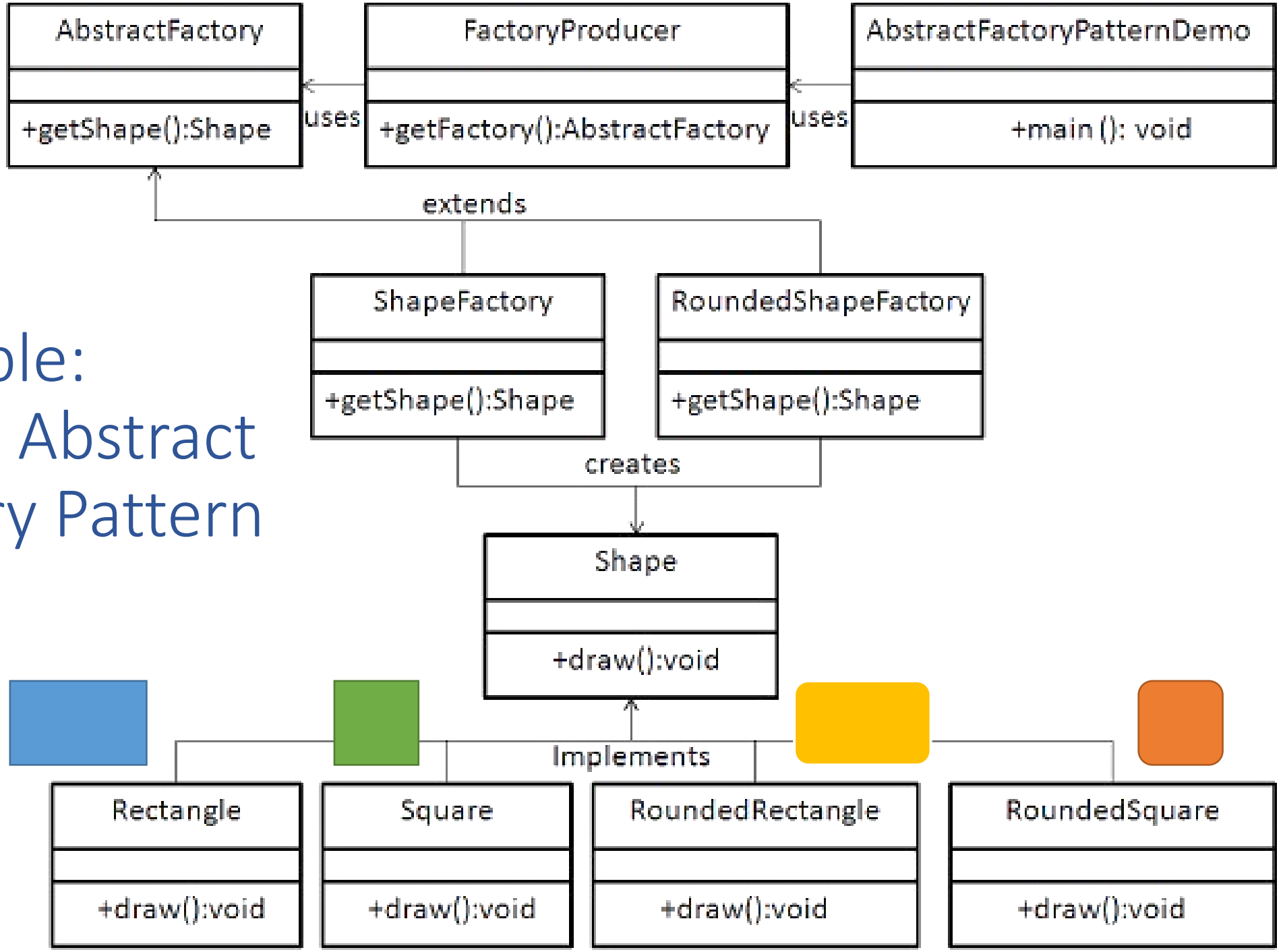
- Abstract factory is also called as factory of factories

Structure of Abstract Factory



Erich Gamma et al., “Design Patterns,” 1994, pg. 87

Example: Shape Abstract Factory Pattern



```
public class FactoryProducer {
    public static AbstractFactory getFactory(boolean rounded) {
        if (rounded) {
                return new RoundedShapeFactory();
        }
        else {
                return new ShapeFactory();
        }
    }
}
public abstract class AbstractFactory {
        abstract Shape getShape(String shapeType);
}
// Extend Abstract Factory
public class RoundedShapeFactory extends AbstractFactory {
    @Override
    public Shape getShape(String shapeType) {
        if (shapeType.equalsIgnoreCase("RECTANGLE")) {
                return new RoundedRectangle();
        }
        else if (shapeType.equalsIgnoreCase("SQUARE")) {
                return new RoundedSquare();
        }
        return null;
    }
}
```

.....

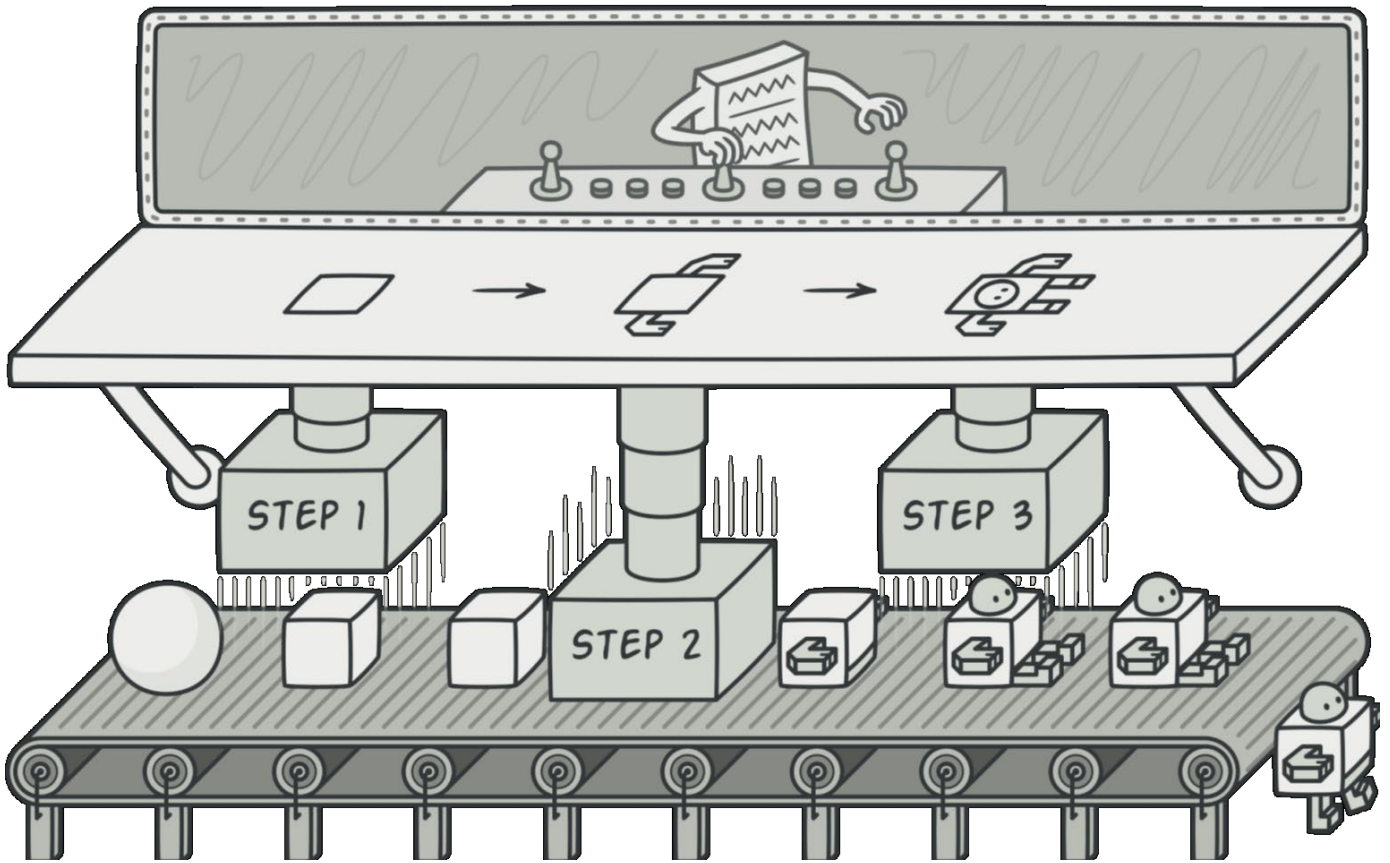
https://www.tutorialspoint.com/design_pattern/abstract_factory_pattern.htm

Using AbstractFactory to Get Rounded Shape

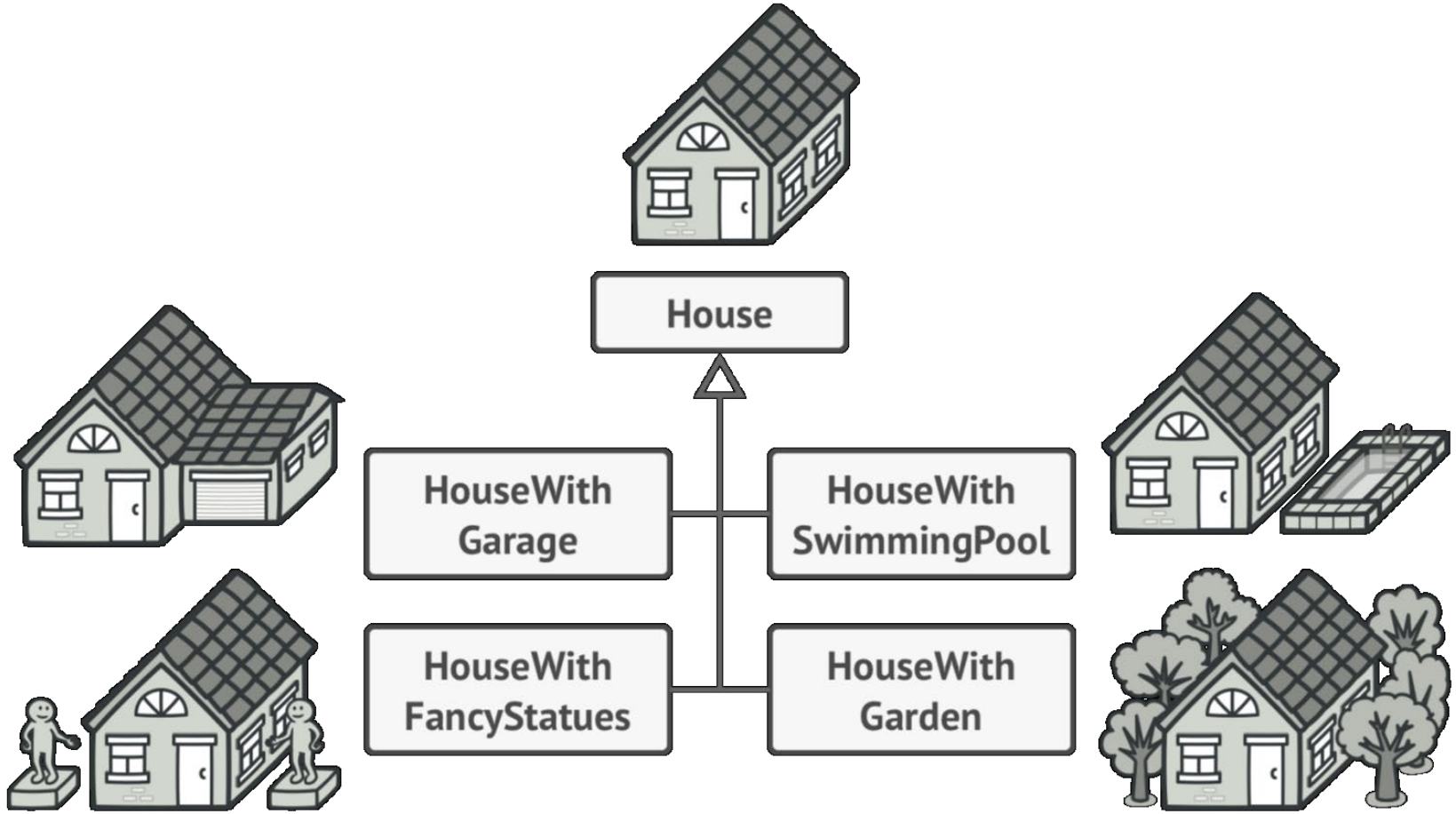
```
public class AbstractFactoryPatternDemo {

   public static void main(String[] args) {
      //get shape factory
      AbstractFactory shapeFactory = FactoryProducer.getFactory(false);
      Shape shape1 = shapeFactory.getShape("RECTANGLE");
      shape1.draw();

      //get rounded shape factory
      AbstractFactory shapeFactory1 = FactoryProducer.getFactory(true);
      //get rounded rectangle
      Shape shape2 = shapeFactory1.getShape("RECTANGLE");
      shape2.draw();
   }
}
```

3. Builder

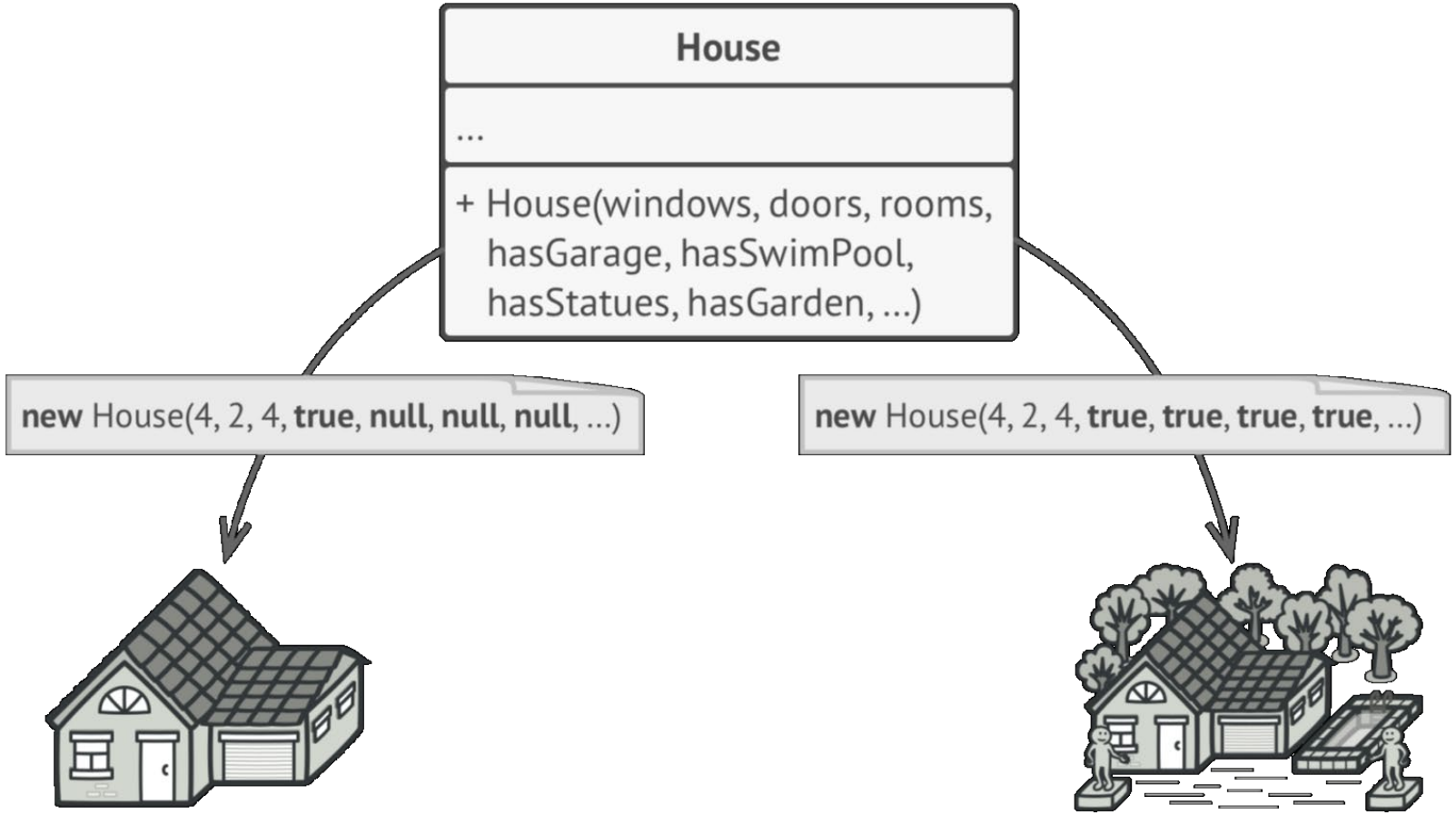
- Construct complex objects step by step.



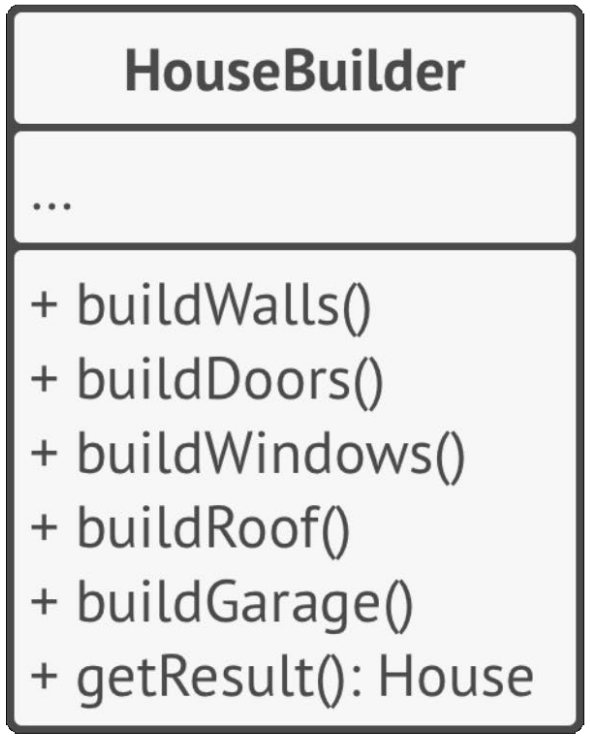
Example: Building a House

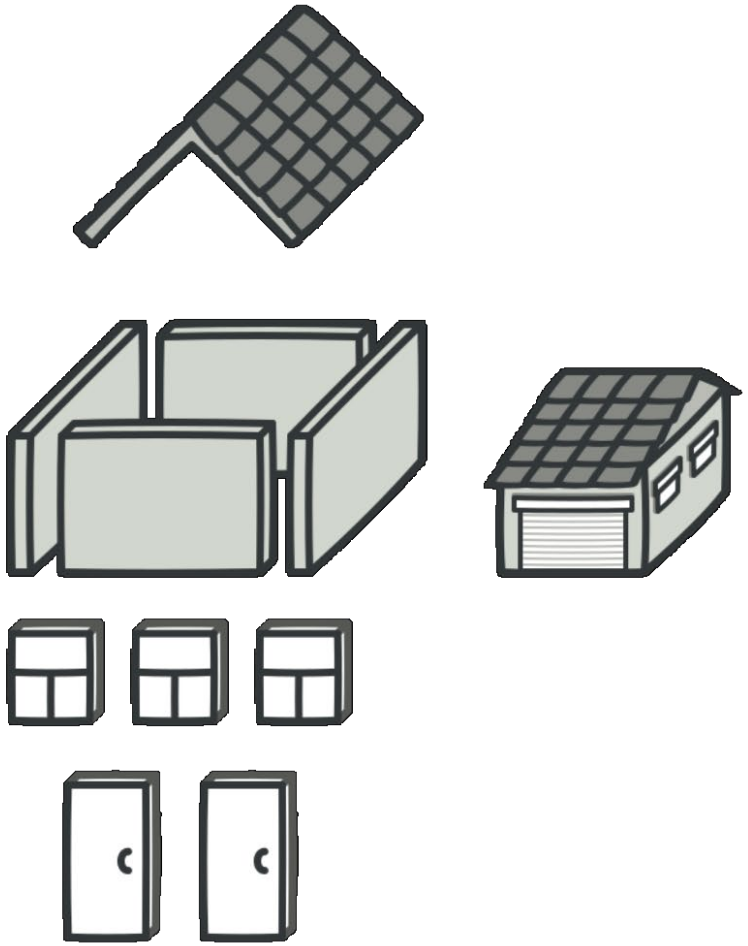


Solution 1: constructers with many parameters?

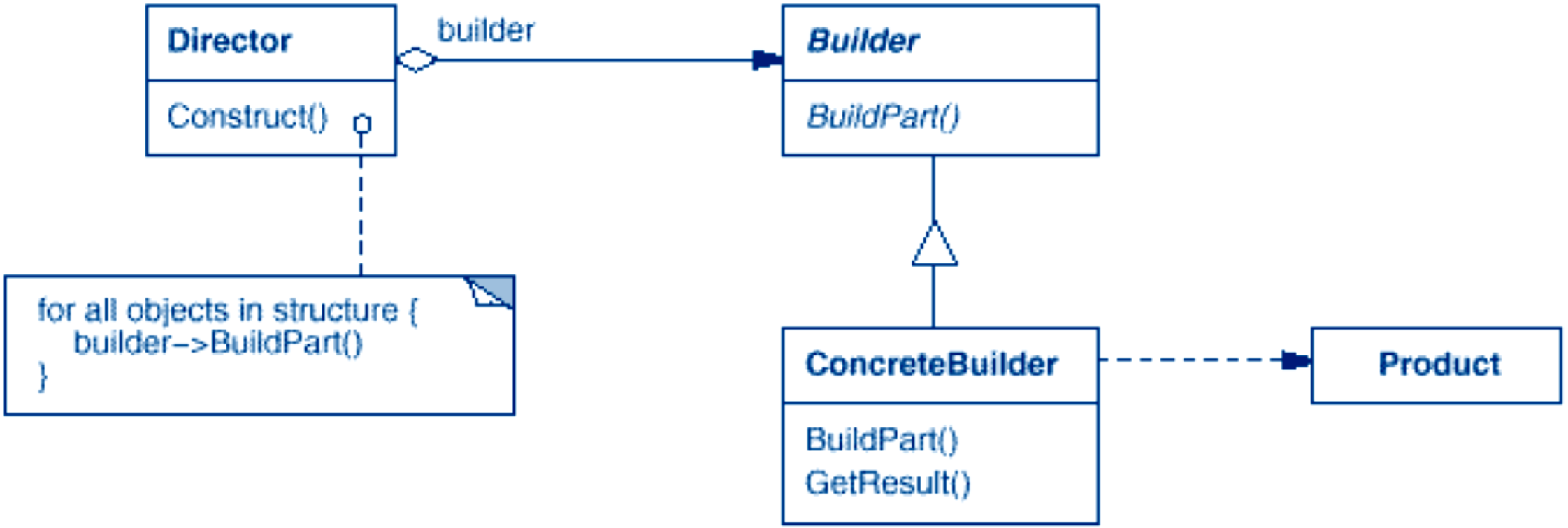


Solution 2: Using Builder Design Pattern

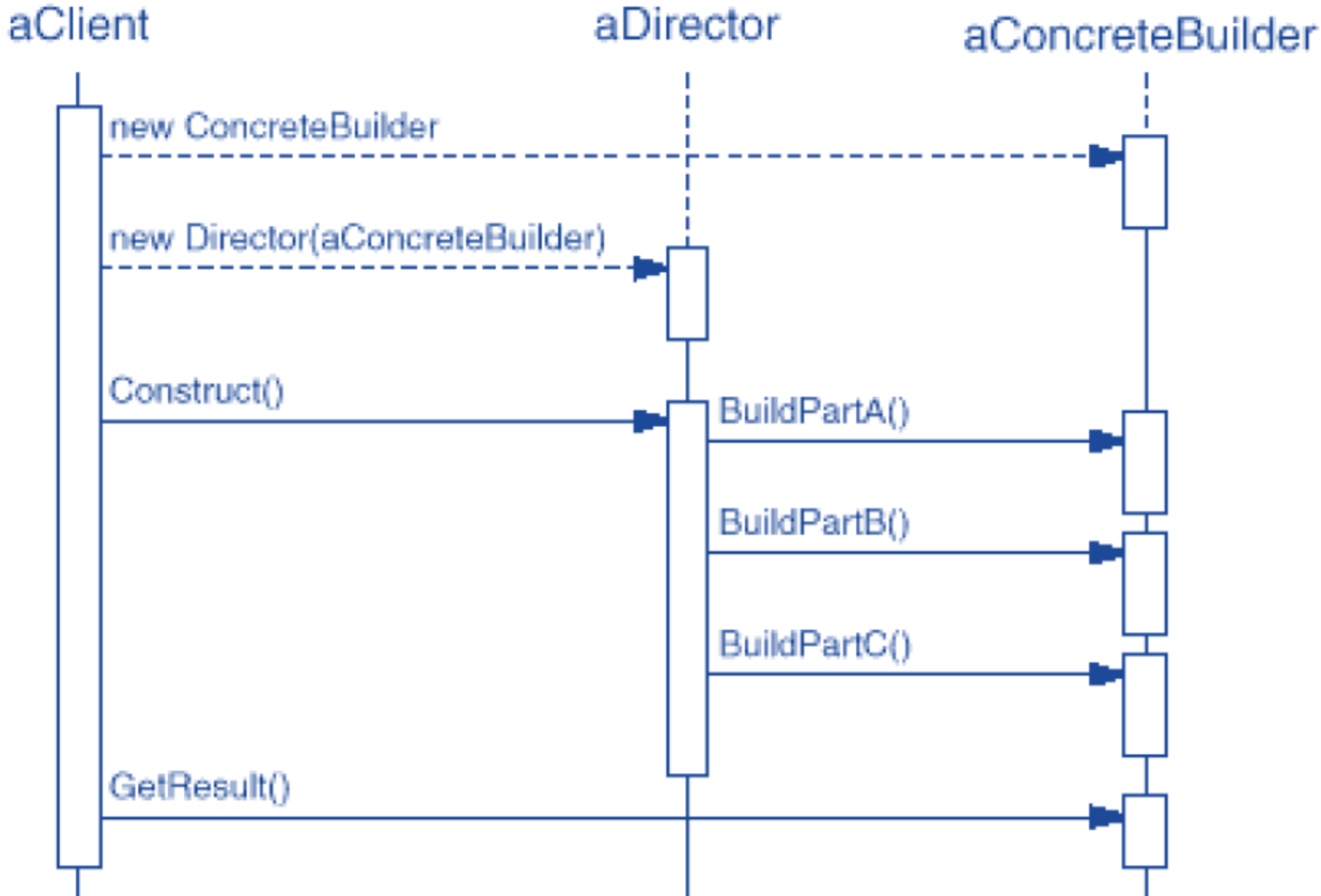




Structure of Builder



Erich Gamma et al., “Design Patterns,” 1994, pg. 98



Erich Gamma et al., “Design Patterns,” 1994, pg. 99

Real Builder in Java

- Create a `class UserBuilder` to initialize `class User`

```
public class User
{
    private String firstName;
    private String lastName;
    private int age;
    private String phone;
    private String address;

    private User(UserBuilder builder) {
        this.firstName = builder.firstName;
        this.lastName = builder.lastName;
        this.age = builder.age;
        this.phone = builder.phone;
        this.address = builder.address;
    }
}
```

https://howtodoinjava.com/design-patterns/creational/builder-pattern-in-java/

UserBuilder

- Provide functions to initialize different member variables
- Provide build() to return initialized User object

```
public class UserBuilder
{
    private final String firstName;
    private final String lastName;
    private int age;
    private String phone;
    private String address;

    public UserBuilder(String firstName, String lastName) {
        this.firstName = firstName;
        this.lastName = lastName;
    }
    public UserBuilder age(int age) {
        this.age = age;
        return this;
    }
    public UserBuilder phone(String phone) {
        this.phone = phone;
        return this;
    }
    public UserBuilder address(String address) {
        this.address = address;
        return this;
    }
    //Return the finally consrcuted User object
    public User build() {
        User user = new User(this);
        return user;
    }
}
```

Test UserBuilder

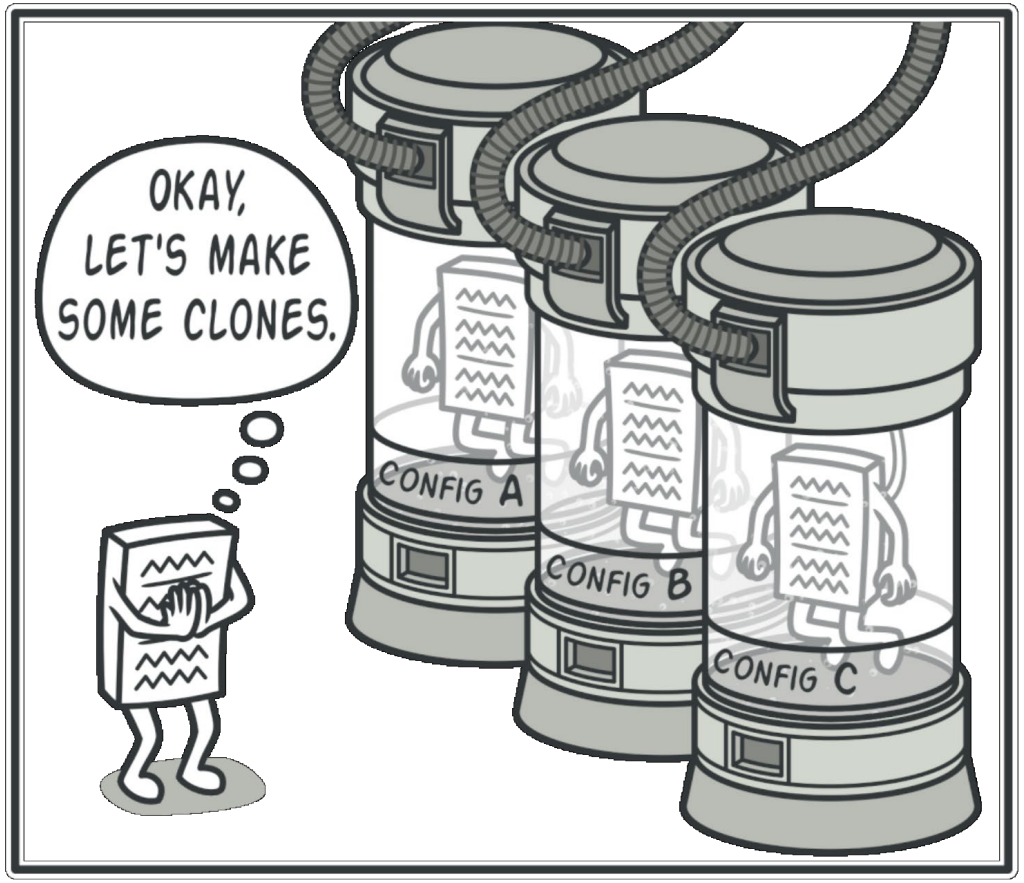
- Avoid telescoping constructors problem

```
public static void main(String[] args)
{
    User user1 = new User.UserBuilder("Lokesh", "Gupta")
    .age(30)
    .phone("1234567")
    .address("Fake address 1234")
    .build();

    User user2 = new User.UserBuilder("Super", "Man")
    //No age
    //No phone
    //no address
    .build();
}
```

https://howtodoinjava.com/design-patterns/creational/builder-pattern-in-java/

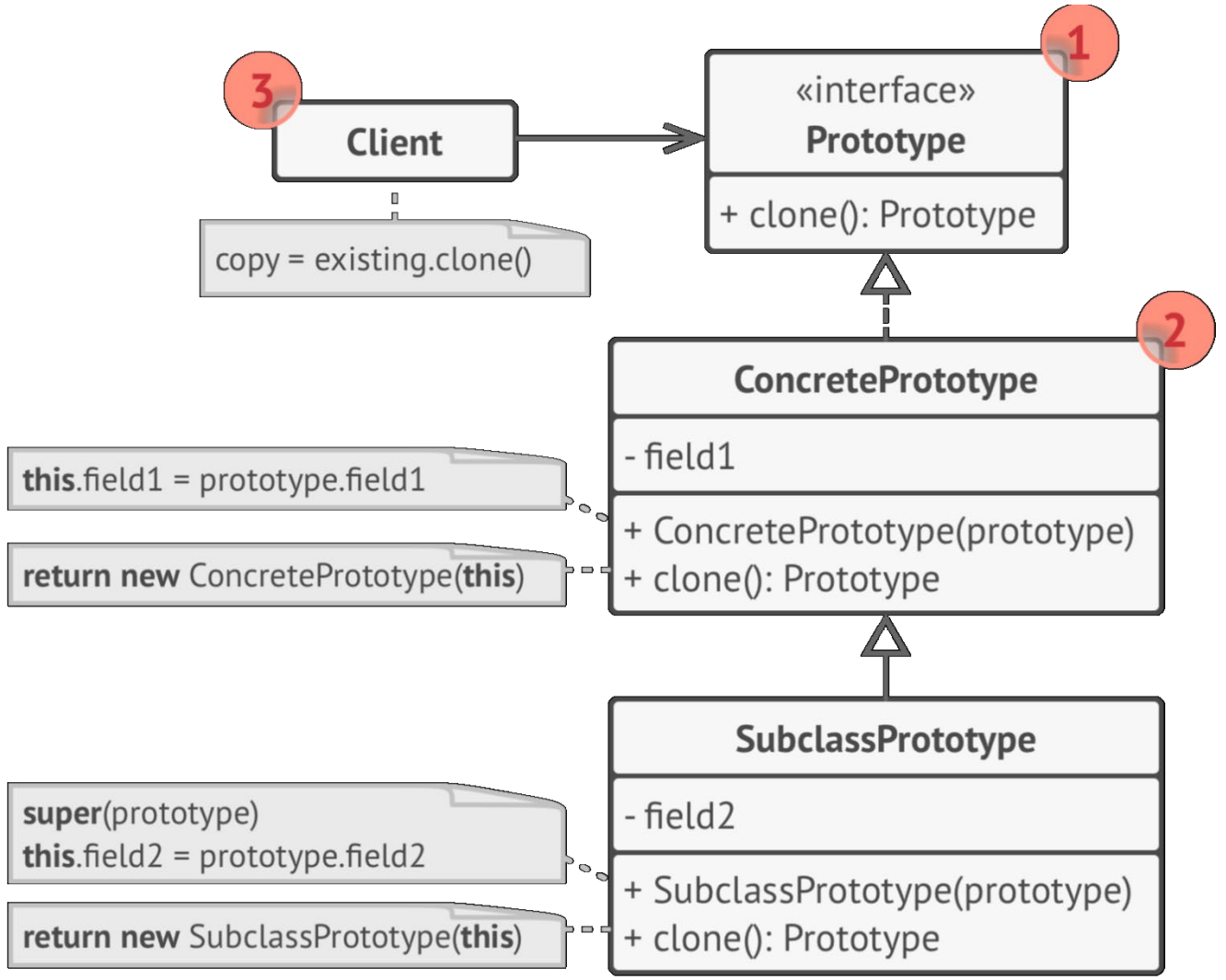
4. Prototype

- Allow copying existing objects without making your code dependent on their classes



Prototype Structure

1. Define clone() method.
2. **Concrete Prototype** class implements the cloning method.
3. The **Client** can produce a copy of any object that follows the prototype interface.

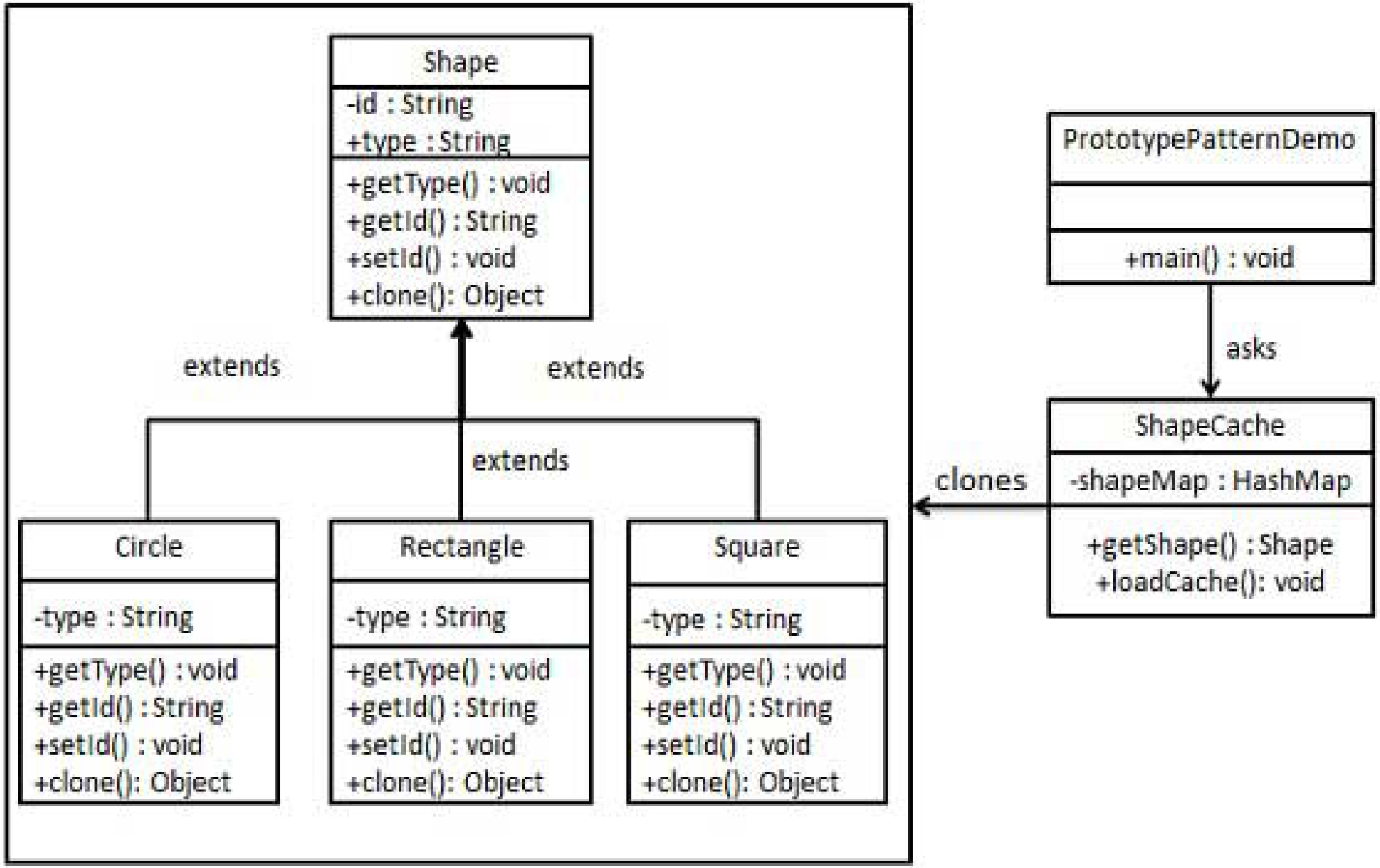


Java Cloneable Interface

- A class implements the Cloneable interface to indicate that Object.clone() can be used to make a field-for-field copy of instances

```
public class DogName implements Cloneable {
    public String dname;
    // Overriding clone() method of Object class
    public Object clone()throws CloneNotSupportedException {
        return (DogName)super.clone();
    }
    public static void main(String[] args) {
        DogName obj1 = new DogName("Tommy");
        try {
            DogName obj2 = (DogName)obj1.clone();
            System.out.println(obj2.getName());
        }
        catch (CloneNotSupportedException e) {
                e.printStackTrace();
        }
    }
}
```

Example: Shape Prototype



https://www.tutorialspoint.com/design_pattern/prototype_pattern.htm

```
public abstract class Shape implements Cloneable {
    private String id;
    protected String type;

    abstract void draw();

    public String getType() { return type; }
    public String getId() { return id; }
    public void setId(String id) { this.id = id; }

    public Object clone() {
        Object clone = null;

        try {
                clone = super.clone();
        }
        catch (CloneNotSupportedException e) {
                e.printStackTrace();
        }
        return clone;
    }
}
```

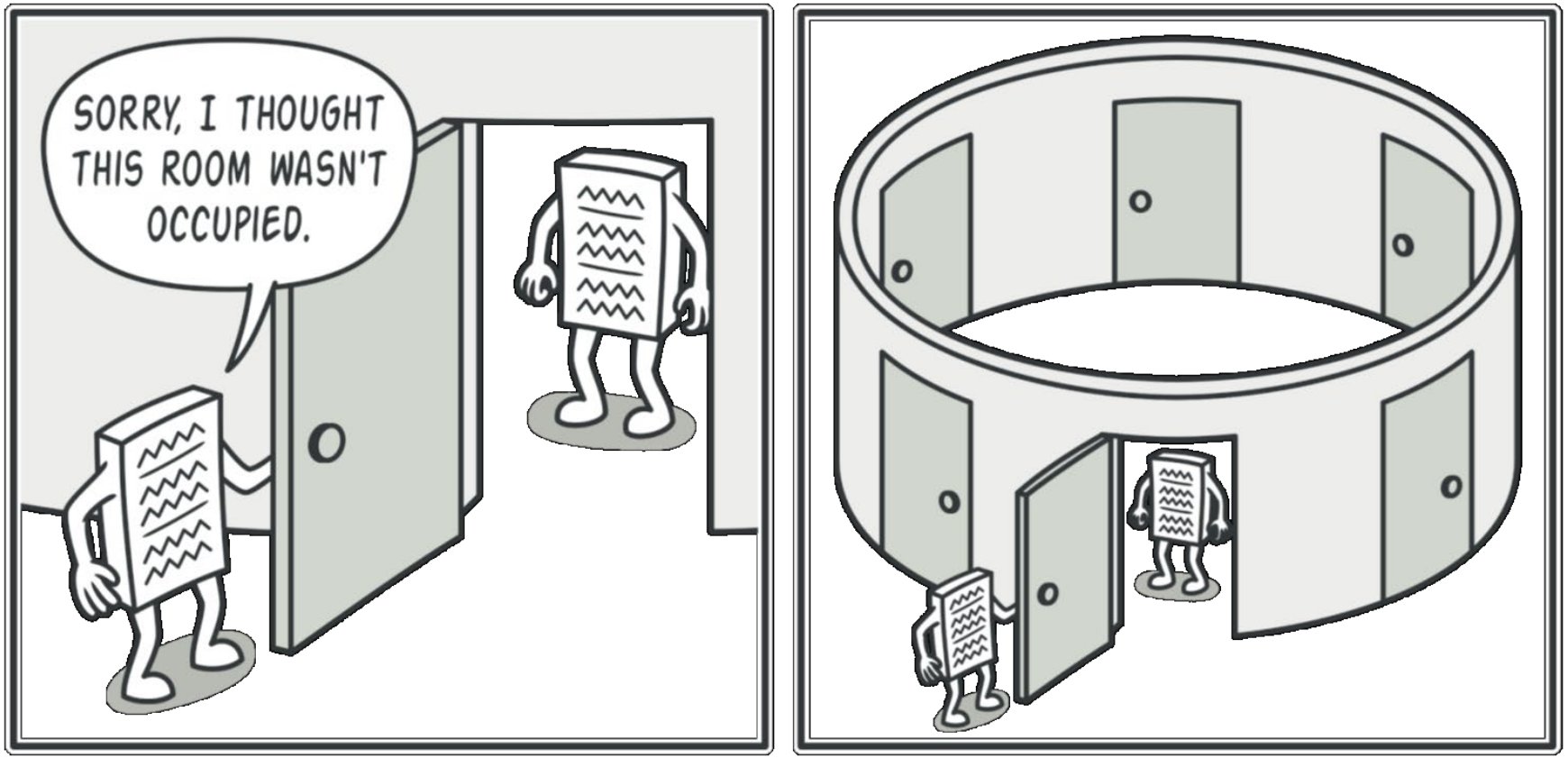
Shallow Copy vs. Deep Copy

- Shallow Copy
  - Copy all fields of Object A to Object B, including pointers
  - Changes in referenced objects in Object A also reflect in Object B

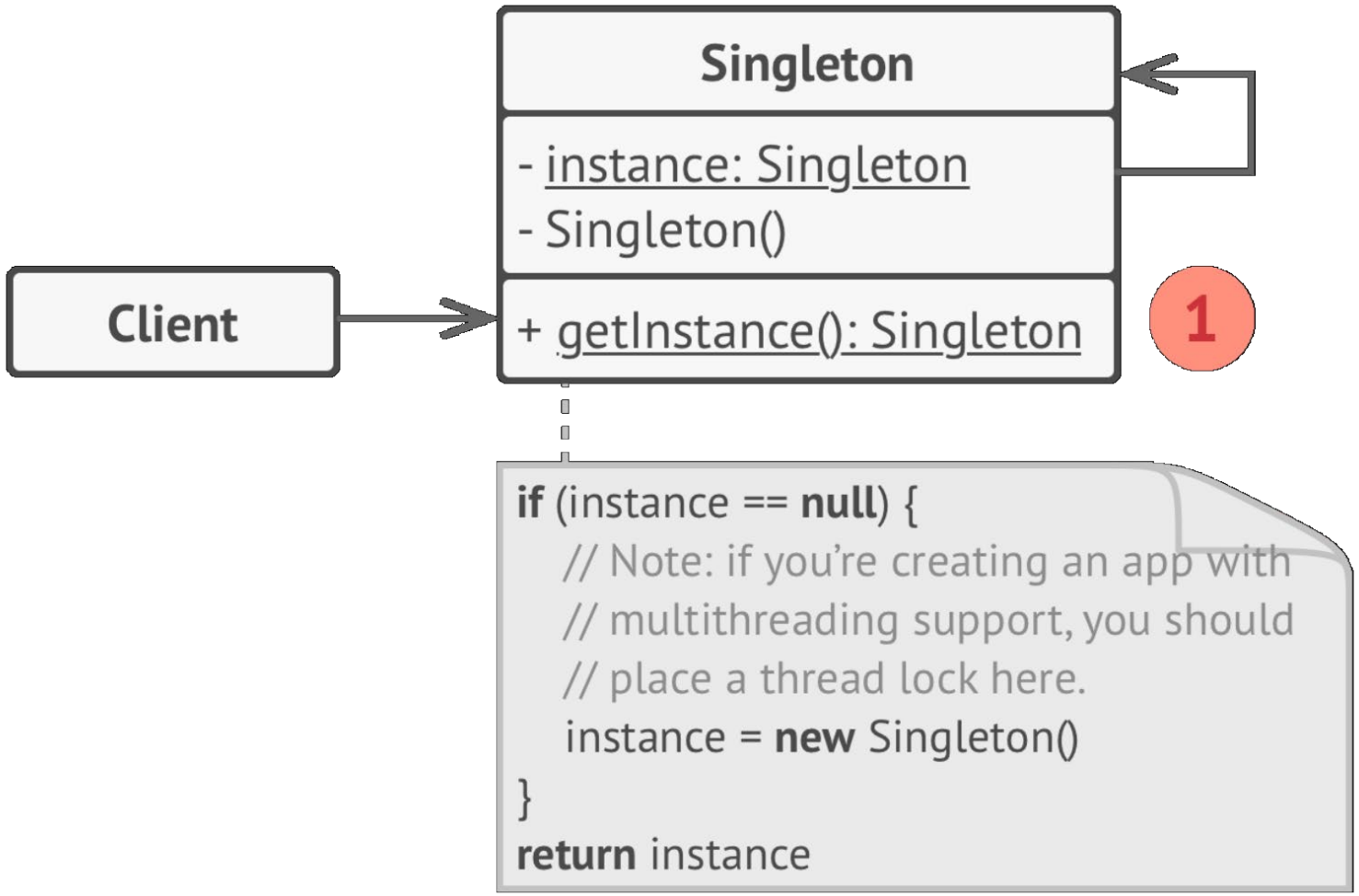
- Deep Copy
  - For pointers in Object A, create new instances for Object B, and then copy the contents
  - Changes in referenced objects in Object A **don't reflect** in Object B

5. Singleton

- **Singleton** is a creational design pattern that lets you ensure that a class has only one instance



5. Singleton Structure



C++ Singleton Example

```
class Singleton
{
public:
    static Singleton* getInstance();

private:
    static Singleton* instance; // Here will be the instance stored.

    Singleton(); // Private constructor to prevent instancing.
};

/* Null, because instance will be initialized on demand. */
Singleton* Singleton::instance = 0;

Singleton* Singleton::getInstance()
{
    if (instance == 0)
        instance = new Singleton();

    return instance;
}
```

Java Singleton Example

```
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!");
    }
}
```

https://www.tutorialspoint.com/design_pattern/singleton_pattern.htm

Summary

- Many designs start by using **Factory Method** and evolve toward **Abstract Factory**, **Prototype**, or **Builder**
- **Builder** focuses on constructing complex objects step by step.
- **Abstract Factory** specializes in creating families of related objects.
- **Prototype** is used to clone (copy) objects
- **Singleton** ensures that a class has only one instance

Dive into Design Patterns

- Alexander Shvets

References

- Alexander Shvets, “Dive into Design Patterns,” 2018
- https://howtodoinjava.com/design-patterns/
- https://www.tutorialspoint.com/design_pattern/index.htm