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OOP Concept for Beginners: What is Encapsulation

THORBEN JANSSEN | NOVEMBER 30, 2017 |

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Encapsulation is one of the fundamental concepts in object-oriented programming (https://stackify.com/oops-concepts-in-java/) (OOP). It describes the idea of bundling data and methods that work on that data within one unit, e.g., a class in Java.

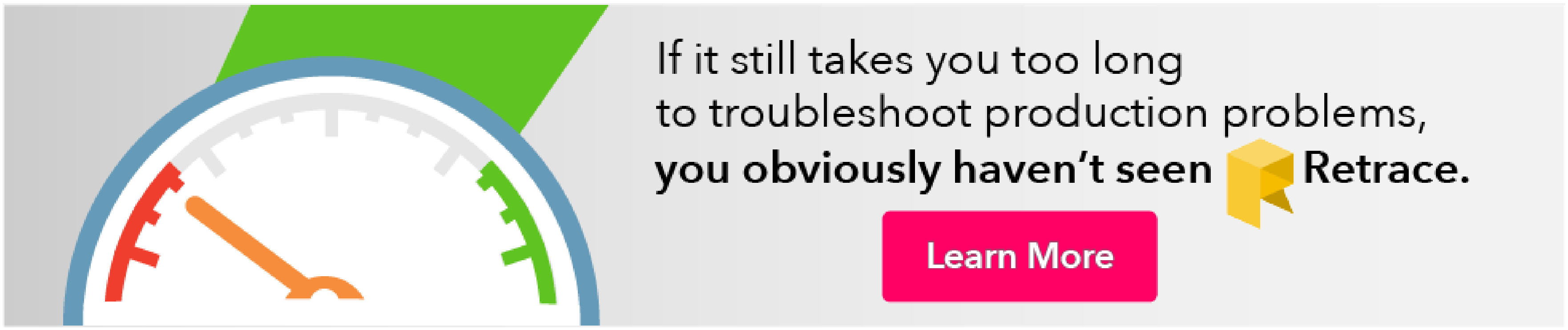
This concept is also often used to hide the internal representation, or state, of an object from the outside. This is called information hiding (https://en.wikipedia.org/wiki/Encapsulation_(computer_programming)#An_information-hiding_mechanism). The general idea of this mechanism is simple. If you have an attribute that is not visible from the outside of an object, and bundle it with methods that provide read or write access to it, then you can hide specific information and control access to the internal state of the object.

If you're familiar with any object-oriented programming language, you probably know that these methods as getter and setter methods. As the names indicate, a getter method retrieves an attribute, and a setter method changes it. Depending on the methods that you implement, you can decide if an attribute can be read and changed, or if it's read-only, or if it is not visible at all. As I will show you later, you can also use the setter method to implement additional validation rules to ensure that your object always has a valid state.

Let's take a look at an example that shows the concept of encapsulation and how you can use it to implement information hiding and apply additional validation before changing the values of your object attributes.

Encapsulation in Java

If you've read my previous post about abstraction (https://stackify.com/oop-concept-abstraction/), you already saw several examples for encapsulation. It's such a basic concept that most Java developers use it without thinking about it. It's simply how you design a Java class. You bundle a set of attributes that store the current state of the object with a set of methods using these attributes.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The *CoffeeMachine* example

I did that, for example, when I created the *CoffeeMachine* class. The attributes *configMap*, *beans*, *grinder*, and *brewingUnit* store the current state of the *CoffeeMachine* object. The methods *brewCoffee*, *brewEspresso*, *brewFilterCoffee* and *addBeans* implement a set of operations on these attributes.

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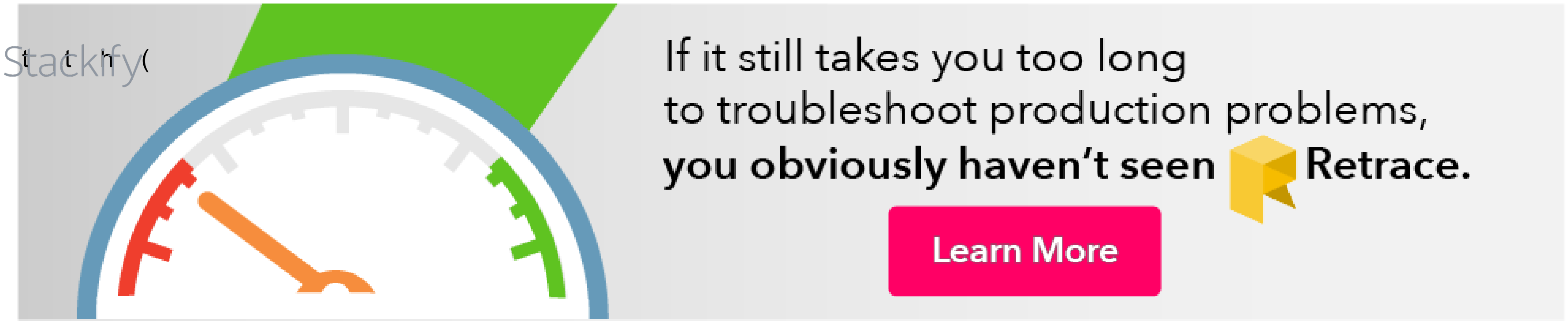
You can clone this and all other classes of the *CoffeeMachine* example project at https://github.com/thjanssen/Stackify-OopAbstraction (https://github.com/thjanssen/Stackify-OopAbstraction).

```
import java.util.HashMap;
import java.util.Map;

public class CoffeeMachine {
    private Map configMap;
    private Map beans;
    private Grinder grinder;
    private BrewingUnit brewingUnit;

    public CoffeeMachine(Map beans) {
        this.beans = beans;
        this.grinder = new Grinder();
        this.brewingUnit = new BrewingUnit();
        this.configMap = new HashMap();
        this.configMap.put(CoffeeSelection.ESPRESSO, new Configuration(8, 28));
        this.configMap.put(CoffeeSelection.FILTER_COFFEE, new Configuration(30, 480));
    }

    public Coffee brewCoffee(CoffeeSelection selection) throws CoffeeException {
        switch (selection) {
            case FILTER_COFFEE:
                return brewFilterCoffee();
            case ESPRESSO:
                return brewEspresso();
            default:
                throw new CoffeeException("CoffeeSelection [" + selection + "] not supported!"
);
        }
    }

    private Coffee brewEspresso() {
        Configuration config = configMap.get(CoffeeSelection.ESPRESSO);

        // grind the coffee beans
        GroundCoffee groundCoffee = this.grinder.grind(
            this.beans.get(CoffeeSelection.ESPRESSO), config.getQuantityCoffee());

        // brew an espresso
        return this.brewingUnit.brew(CoffeeSelection.ESPRESSO,
            groundCoffee, config.getQuantityWater());
    }

    private Coffee brewFilterCoffee() {
        Configuration config = configMap.get(CoffeeSelection.FILTER_COFFEE);

        // grind the coffee beans
        GroundCoffee groundCoffee = this.grinder.grind(
            this.beans.get(CoffeeSelection.FILTER_COFFEE), config.getQuantityCoffee());

        // brew a filter coffee
        return this.brewingUnit.brew(CoffeeSelection.FILTER_COFFEE,
            groundCoffee, config.getQuantityWater());
    }

    public void addBeans(CoffeeSelection sel, CoffeeBean newBeans) throws CoffeeException {
        CoffeeBean existingBeans = this.beans.get(sel);
        if (existingBeans != null) {
            if (existingBeans.getName().equals(newBeans.getName())) {
                existingBeans.setQuantity(existingBeans.getQuantity() + newBeans.getQuantity
());
            } else {
                throw new CoffeeException("Only one kind of beans supported for each CoffeeSele
ction.");
            }
        } else {
            this.beans.put(sel, newBeans);
        }
    }
}
```

Information hiding in Java

As explained at the beginning, you can use the encapsulation concept to implement an information-hiding mechanism. Similar to the abstraction concept, this is one of the most commonly used mechanisms in Java. You can find examples of it in almost all well-implemented Java classes.

You implement this information-hiding mechanism by making your class attributes inaccessible from the outside and by providing getter and/or setter methods for attributes that shall be readable or updatable by other classes.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Access Modifiers

Java supports four access modifiers (https://docs.oracle.com/javase/tutorial/java/javaOO/accesscontrol.html) that you can use to define the visibility of classes, methods, and attributes. Each of them specifies a different level of accessibility, and you can only use one modifier per class, method or attribute. As a rule of thumb, you should always use the most restrictive modifier that still allows you to implement your business logic.

These modifiers are, starting from the most to the least restrictive one:

- private
- no modifier

- protected
- public

Let’s take a closer look at each of these modifiers and discuss when you should use them.

Private

This is the most restrictive and most commonly used access modifier. If you use the *private* modifier with an attribute or method, it can only be accessed within the same class. Subclasses or any other classes within the same or a different package can’t access this attribute or method.

As a rule of thumb, the *private* modifier should be your default choice for all attributes and internal methods that shouldn’t be called from external classes. You might need to make an exception to this rule when you’re using inheritance, and some of the subclasses need direct access to an attribute or internal method. In that case, you should use the *protected* modifier instead of *private*.

No modifier

When you don’t provide any access modifier for your attribute or method, you can access it within your class and from all classes within the same package. That’s why it’s often called package-private.

I use the *private* modifier to restrict access to all attributes as well as the *brewEspresso* and *brewFilterCoffee* methods in the *CoffeeMachine* example. These attributes and methods should only be used within the *CoffeeMachine* class and are not part of the public API.

That might seem a bit confusing in the beginning, but it's very useful when the classes in your package implement a well-defined set of logic, and you want to control the API that's available to classes outside of this package. You can then use package visibility to implement a method that can only be used by classes within this package. That allows you to create a package internal and an external API.

Protected

Attributes and methods with the access modifier *protected* can be accessed within your class, by all classes within the same package, and by all subclasses within the same or other packages.

The *protected* modifier gets mostly used for internal methods that need to be called or overridden by subclasses. You can also use it to allow subclasses to access internal attributes of a superclass directly.

Public

This is the least restrictive access modifier. Methods and attributes that use the *public* modifier can be accessed within your current class and by all other classes.

Public methods and attributes become part of the public API of your class and of any component in which you include them. That is almost never a good idea for any attribute, and you should think twice before you use this modifier on a method.

If a method is publicly available, you need to make sure that it's well documented and that it robustly handles any input values. Also keep in mind, that sooner or later this method will be used by some part of your application that will make it hard to change or remove it.

In general, your public API should be as lean as possible and only include the methods which are intended to be used by other parts of the application or by external clients.

That’s the case for the *CoffeeMachine* class, its constructor, and the *brewCoffee* and *addBeans* methods. The *CoffeeMachine* class has to be public because it represents the interface of the coffee machine. It is intended to be used by other classes that don’t have to be part of the same package. The constructor and the *brewCoffee* and *addBeans* methods can be called by other classes to create a new instance of the *CoffeeMachine* and to interact with it by adding coffee beans or by brewing a fresh cup of coffee.

The *brewCoffee* method shows another benefit of the different access modifiers. You can not only use it to hide information, but you can also use to support abstraction. The public *brewCoffee* method abstracts the internal details of the *brewFilterCoffee* and *brewEspresso* methods, which are both private. The access modifiers ensure that an external class can only call the abstraction provided by the *brewCoffee* method, but not the internal methods.

Accessibility matrix

Here you can see an overview of the different access modifiers and the accessibility of the attributes or methods.

The *Coffee* example

The *Coffee* class provides a good example of the information-hiding mechanism. It represents a drink that was brewed by the *CoffeeMachine*.

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```
public class Coffee {
    private CoffeeSelection selection;
    private double quantity;

    public Coffee (CoffeeSelection selection, double quantity) {
        this.selection = selection;
        this.quantity = quantity;
    }

    public CoffeeSelection getSelection() {
        return selection;
    }

    public double getQuantity() {
        return quantity;
    }

    public void setQuantity(double quantity) throws CoffeeException {
        if (quantity >= 0.0) {
            this.quantity = quantity;
        } else {
            throw new CoffeeException("Quantity has to be >= 0.0.");
        }
    }
}
```

The class uses two *private* attributes to store information about the *CoffeeSelection* and the *quantity* of the drink. The access modifier private makes both attributes inaccessible for other classes within the same or other packages. If you want to get information about the current state of the object, you need to call one of the *public* methods.

The *getSelection* method provides read access to the *selection* attribute. It represents the kind of coffee that was brewed by the *CoffeeMachine*, e.g., a filter coffee or an espresso. As you can see in the code snippet, I didn't implement a setter method for this attribute because you can't change the kind of coffee after it was brewed. At least I don't know of any way to change a boring filter coffee into a strong and tasty espresso.

The available quantity of a drink changes over time. After every sip you take, your cup contains a little bit less. Therefore, I implemented a getter and setter method for the *quantity* attribute.

If you take a closer look at the *setQuantity* method, you can see that I also implemented an additional validation. If the coffee is especially delicious, you might drink it until your cup is empty. When you did that, your coffee is gone, and you can't drink any more of it. So the quantity of the *Coffee* has to be greater or equal to zero.

Summary

Encapsulation is one of the core concepts in object-oriented programming (https://stackify.com/oops-concepts-in-java/). It describes the bundling of data and methods operating on this data into one unit.

It is often used to implement an information-hiding mechanism. This mechanism reduces the accessibility of attributes to the current class and uses public getter and setter methods to control and restrict external access to these attributes. These methods not only allow you to define which attributes can be read or updated, but it also enables you to validate the new value before changing the attribute.

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About Thorben Janssen

Thorben is an independent trainer and author of the Amazon bestselling book *Hibernate Tips - More than 70 solutions to common Hibernate problems*.He writes about Java EE related topics on his blog Thoughts on Java (https://www.thoughts-on-java.org).

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