1. Overview

In this tutorial, we'll be discussing **the SOLID principles of object-oriented design.**

First, we'll start by **exploring the reasons they came about and why we should consider them** when designing software. Then we'll outline each principle alongside some example code.

2. The Reason for SOLID Principles

The SOLID principles were introduced by Robert C. Martin in his 2000 paper "Design Principles and Design Patterns." These concepts were later built upon by Michael Feathers, who introduced us to the SOLID acronym. And in the last 20 years, these five principles have revolutionized the world of object-oriented programming, changing the way that we write software.

So, what is SOLID and how does it help us write better code? Simply put, Martin and Feathers' **design principles encourage us to create more maintainable, understandable, and flexible software.** Consequently, **as our applications grow in size, we can reduce their complexity** and save ourselves a lot of headaches further down the road!

The following five concepts make up our SOLID principles:

1. **S**ingle Responsibility
2. **O**pen/Closed
3. **L**iskov Substitution
4. **I**nterface Segregation
5. **D**ependency Inversion

While these concepts may seem daunting, they can be easily understood with some simple code examples. In the following sections, we'll take a deep dive into these principles, with a quick Java example to illustrate each one.

3. Single Responsibility

Let's begin with the single responsibility principle. As we might expect, this principle states that **a class should only have one responsibility. Furthermore, it should only have one reason to change.**

How does this principle help us to build better software? Let's see a few of its benefits:

1. **Testing** – A class with one responsibility will have far fewer test cases.
2. **Lower coupling** – Less functionality in a single class will have fewer dependencies.
3. **Organization** – Smaller, well-organized classes are easier to search than monolithic ones.

For example, let's look at a class to represent a simple book:

```java
public class Book {

    private String name;
    private String author;
    private String text;

    //constructor, getters and setters
}Copy
```

In this code, we store the name, author and text associated with an instance of a *Book*.

Let's now add a couple of methods to query the text:

```java
public class Book {

    private String name;
    private String author;
    private String text;

    //constructor, getters and setters

    // methods that directly relate to the book properties
    public String replaceWordInText(String word, String replacementWord){
        return text.replaceAll(word, replacementWord);
    }

    public boolean isWordInText(String word){
        return text.contains(word);
    }
}Copy
```

Now our *Book* class works well, and we can store as many books as we like in our application.

But what good is storing the information if we can't output the text to our console and read it?

Let's throw caution to the wind and add a print method:

```java
public class BadBook {
    //...

    void printTextToConsole(){
        // our code for formatting and printing the text
    }
}
```
Copy

However, this code violates the single responsibility principle we outlined earlier.

To fix our mess, we should implement a separate class that deals only with printing our texts:

```java
public class BookPrinter {

    // methods for outputting text
    void printTextToConsole(String text){
        //our code for formatting and printing the text
    }

    void printTextToAnotherMedium(String text){
        // code for writing to any other location..
    }
}
```
Copy

Awesome. Not only have we developed a class that relieves the *Book* of its printing duties, but we can also leverage our *BookPrinter* class to send our text to other media.

Whether it's email, logging, or anything else, we have a separate class dedicated to this one concern.

4. Open for Extension, Closed for Modification

It's now time for the O in SOLID, known as the **open-closed principle.** Simply put, **classes should be open for extension but closed for modification. In doing so, we stop ourselves from modifying existing code and causing potential new bugs** in an otherwise happy application.

Of course, the **one exception to the rule is when fixing bugs in existing code.**

Let's explore the concept with a quick code example. As part of a new project, imagine we've implemented a *Guitar* class.

It's fully fledged and even has a volume knob:

```java
public class Guitar {

    private String make;
    private String model;
    private int volume;

    //Constructors, getters & setters
}Copy
```

We launch the application, and everyone loves it. But after a few months, we decide the *Guitar* is a little boring and could use a cool flame pattern to make it look more rock and roll.

At this point, it might be tempting to just open up the *Guitar* class and add a flame pattern — but who knows what errors that might throw up in our application.

Instead, let's **stick to the open-closed principle and simply extend our *Guitar* class**:

```java
public class SuperCoolGuitarWithFlames extends Guitar {

    private String flameColor;

    //constructor, getters + setters
}Copy
```

By extending the *Guitar* class, we can be sure that our existing application won't be affected.

5. Liskov Substitution

Next on our list is Liskov substitution, which is arguably the most complex of the five principles. Simply put, **if class *A* is a subtype of class *B*, we should be able to replace *B* with *A* without disrupting the behavior of our program.**

Let's jump straight to the code to help us understand this concept:

```java
public interface Car {

    void turnOnEngine();
    void accelerate();
}Copy
```

Above, we define a simple *Car* interface with a couple of methods that all cars should be able to fulfill: turning on the engine and accelerating forward.

Let's implement our interface and provide some code for the methods:

```java
public class MotorCar implements Car {

    private Engine engine;

    //Constructors, getters + setters

    public void turnOnEngine() {
        //turn on the engine!
        engine.on();
    }

    public void accelerate() {
        //move forward!
        engine.powerOn(1000);
    }
}Copy
```

As our code describes, we have an engine that we can turn on, and we can increase the power.

But wait — we are now living in the era of electric cars:

```java
public class ElectricCar implements Car {

    public void turnOnEngine() {
        throw new AssertionError("I don't have an engine!");
    }

    public void accelerate() {
        //this acceleration is crazy!
    }
}Copy
```

By throwing a car without an engine into the mix, we are inherently changing the behavior of our program. This is **a blatant violation of Liskov substitution and is a bit harder to fix than our previous two principles.**

One possible solution would be to rework our model into interfaces that take into account the engine-less state of our *Car*.

6. Interface Segregation

The I in SOLID stands for interface segregation, and it simply means that **larger interfaces should be split into smaller ones. By doing so, we can ensure that implementing classes only need to be concerned about the methods that are of interest to them.**

For this example, we're going to try our hands as zookeepers. And more specifically, we'll be working in the bear enclosure.

Let's start with an interface that outlines our roles as a bear keeper:

```java
public interface BearKeeper {
    void washTheBear();
    void feedTheBear();
    void petTheBear();
}Copy
```

As avid zookeepers, we're more than happy to wash and feed our beloved bears. But we're all too aware of the dangers of petting them. Unfortunately, our interface is rather large, and we have no choice but to implement the code to pet the bear.

Let's **fix this by splitting our large interface into three separate ones**:

```java
public interface BearCleaner {
    void washTheBear();
}

public interface BearFeeder {
    void feedTheBear();
}

public interface BearPetter {
    void petTheBear();
}Copy
```

Now, thanks to interface segregation, we're free to implement only the methods that matter to us:

```java
public class BearCarer implements BearCleaner, BearFeeder {

    public void washTheBear() {
        //I think we missed a spot...
    }

    public void feedTheBear() {
        //Tuna Tuesdays...
    }
}Copy
```

And finally, we can leave the dangerous stuff to the reckless people:

```java
public class CrazyPerson implements BearPetter {

    public void petTheBear() {
        //Good luck with that!
    }
}Copy
```

Going further, we could even split our *BookPrinter* class from our example earlier to use interface segregation in the same way. By implementing a *Printer* interface with a single *print* method, we could instantiate separate *ConsoleBookPrinter* and *OtherMediaBookPrinter* classes.

7. Dependency Inversion

The principle of dependency inversion refers to the decoupling of software modules. This way, instead of high-level modules depending on low-level modules, both will depend on abstractions.

To demonstrate this, let's go old-school and bring to life a Windows 98 computer with code:

```java
public class Windows98Machine {}
```
Copy

But what good is a computer without a monitor and keyboard? Let's add one of each to our constructor so that every *Windows98Computer* we instantiate comes prepacked with a *Monitor* and a *StandardKeyboard*:

```java
public class Windows98Machine {

    private final StandardKeyboard keyboard;
    private final Monitor monitor;

    public Windows98Machine() {
        monitor = new Monitor();
        keyboard = new StandardKeyboard();
    }

}
```
Copy

This code will work, and we'll be able to use the *StandardKeyboard* and *Monitor* freely within our *Windows98Computer* class.

Problem solved? Not quite. **By declaring the *StandardKeyboard* and *Monitor* with the *new* keyword, we've tightly coupled these three classes together.**

Not only does this make our *Windows98Computer* hard to test, but we've also lost the ability to switch out our *StandardKeyboard* class with a different one should the need arise. And we're stuck with our *Monitor* class too.

Let's decouple our machine from the *StandardKeyboard* by adding a more general *Keyboard* interface and using this in our class:

```java
public interface Keyboard { }
```
Copy
```java
public class Windows98Machine{

    private final Keyboard keyboard;
    private final Monitor monitor;

    public Windows98Machine(Keyboard keyboard, Monitor monitor) {
        this.keyboard = keyboard;
        this.monitor = monitor;
    }
}
```
Copy

Here, we're using the dependency injection pattern to facilitate adding the *Keyboard* dependency into the *Windows98Machine* class.

Let's also modify our *StandardKeyboard* class to implement the *Keyboard* interface so that it's suitable for injecting into the *Windows98Machine* class:

```
public class StandardKeyboard implements Keyboard { }Copy
```

Now our classes are decoupled and communicate through the *Keyboard* abstraction. If we want, we can easily switch out the type of keyboard in our machine with a different implementation of the interface. We can follow the same principle for the *Monitor* class.

Excellent! We've decoupled the dependencies and are free to test our *Windows98Machine* with whichever testing framework we choose.

8. Conclusion

In this article, we've taken a **deep dive into the SOLID principles of object-oriented design.**

We **started with a quick bit of SOLID history and the reasons these principles exist**