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**Acronymns**

**POJO** – Plain Old Java Object

**JSON** – Javascript Object Notation

# **Keyboard Shortcuts**

**psvm + tab** – Generate the “public static void main“ method in intellij.

**sout + tab** – Generate “System.out.println()” method in intellij.

**sysout + ctrl + space** - Generate “System.out.println()” method in eclipse.

**Ctrl + shift + o** – To automatically import all the unknown classes in eclipse

**Alt + insert** – To open the generate (sources) tool in intellij

**Alt + enter** – To import a class or other automatically in intellij.

**Ctrl + Shift + A/ Shift \* 2** – Open the search bar (soft wrap/ reload projects etc) in intellij.

**Ctrl + Alt + S** – To Open settings in intellij.

**Alt + Shift + click** – Multi-line cursor in intellij

**Alt + click** – Multi-line cursor in eclipse/ vscode

**Escape** – End multi-line cursor in intellij/ eclipse. Clicking elsewhere also works in all the IDEs including eclipse.

**Ctrl \* 2** – To open the build manager’s (maven/ gradle) command interface in intellij

**Ctrl + Alt + O** – To organize imports in intellij

# **CORE JAVA**

## **Primitive Data Types**

long num = 1798798l; // You have to add the “l” (for “lucky”) as the end of integer values because the default data type for integers is “int”

float num = 5.6f; // You have to add the “f” at the end when using floats because the default data type for floating point values is “double”.

int num = 0b101; // This assigns the binary number “5” to the variable.

int num = 0x7E; // This assigns the hexadecimal number “126” to the variable.

int num = 10\_000\_000; // The underscores, ”\_”, help separate values but the value is stored as a regular number, “1000000”

double num = 12E10; // This assigns the exponent of 12 raised to the power 10 to the variable.

char c = 'e';

c++;         // This increment the character value to 'f'

System.out.println(c);

int a = 257;

byte b = (byte) a;

System.out.println(b);          // Returns "1" as it performs 257%256 (256 is the range of data type byte (-127,127))

byte a = 30;

byte b = 10;

byte resultB = a \* b;               // Type mismatch: cannot convert from int to byte

int result = a \* b;                 // Type Promotion

int a = 4;

int b = 5;

int c = 6;

int d = 7;

boolean result;

// result = a<b | c<d;

result = a<b || c<d;            // Similar to above, except this one allows for short circuiting

int i = 6;

do {

  System.out.println("Hi: " + i);

  i++;

} while(i < 5);         // The semicolon is necessary

* Class instances (objects) are stored in the heap memory and their references (addresses) stored in the stack memory of the methods that use them.
* Each method in a program has its own stack memory.
* These objects in the heap store the global variables as well as the method declarations

## **Arrays**

Arrays are stored in the heap memory.

int nums1[] = new int[4]; // Default value of 0

int nums[] = {1,2,3,4};         // Array initialisation using "{}" rather than "[]"

### **Multidimensional Arrays**

int nums[][] = new int[3][4];

for(int i=0; i<nums.length; i++) {

    for(int j=0; j<nums[i].length; j++) {

        nums[i][j] = (int)(Math.random()\*100);

    }

}

// New looping syntax for a multi-dimensional array

for(int n[] : nums) {       // The first variable is an array

    for(int m : n) {        // The second one is the element in the array being looped over

        System.out.print(m + " ");

    }

    System.out.println();

}

### **Jagged Arrays**

int nums[][] = new int[3][];

nums[0] = new int[3];       // Jagged Array

nums[1] = new int[4];

nums[2] = new int[2];

for(int i=0; i<nums.length; i++) {

  for(int j=0; j<nums[i].length; j++) {

     nums[i][j] = (int)(Math.random()\*100);

  }

}

### **Creating an array of objects**

class Student {

    int regNo;

    String name;

    int marks;

    public static void main(String args[]) {

        Student s1 = new Student();

        s1.regNo = 1;

        s1.name = "Daniel";

        s1.marks = 66;

        Student s2 = new Student();

        s2.regNo = 1;

        s2.name = "Victor";

        s2.marks = 77;

        Student s3 = new Student();

        s3.regNo = 1;

        s3.name = "Stellah";

        s3.marks = 63;

        Student students[] = new Student[3];        // An array of objects

        students[0] = s1;

        students[1] = s2;

        students[2] = s3;

        for(int i=0; i<students.length; i++) {

            System.out.println(students[i].name + " - Reg No: " + students[i].regNo + students[i].marks);

        }

    }

}

### **Copying Elements From one element to another**

This can be done using a for loop. However, java comes with an inbuilt method that allows you to do the same:

System.arraycopy(originalArray, startIndex, destinationArray, startIndex, numberOfValuesToCopy);

## **Enhanced For Loop/ foreach loop\***

Syntax:

for(<type of variables in array> <name of the variable holding the element being lterated over> : <source array>)

int nums[] = new int[4];

nums[0] = 4;

nums[1] = 3;

nums[2] = 2;

nums[3] = 1;

for(int n: nums) {          // There is no counter. You only need to specify the variable name of the element being looped over and the source array.

   System.out.println(n);

}

for(Student stud: students) {

   System.out.println(stud.name + " - Reg No: " + stud.regNo + stud.marks);

}

## **String is not a primitive data type. It is a class**

String name = new String("Daniel");         // Object creating

String name1 = "Karongo";                   // Java Shorthand for the above

String name2 = "Karongo";                   // Does not create a new object but instead assigns the address of the already existing "Karongo", in the String Constant Pool, in the heap memory, to "name2". In that case, both "name1" and "name2" refer to the same object.

name1 = name1 + "Kungu";                    // This creates a new object with the value "Karongo Kungu" and assigns its address to "name1", overwriting the address of the original "Karongo" String literal. This "Karongo" is then liable for garbage collection

// This implies that “String” objects are immutable (non-changing)

## **To Create mutable (changable) strings, we use either “StringBuffer” or “StringBuilder”**

* “StringBuffer” is thread-safe whereas “StringBuilder” is not. Otherwise they work the same

StringBuffer name = new StringBuffer("Karongo");

StringBuffer name1 = new StringBuffer();

System.out.println(name.capacity());        // returns 23 (16 + length of "Karongo")

System.out.println(name1.capacity());       // returns 16 - the space alotted in case of reassignment

name.append("Daniel");                  // How you concatenate strings in StringBuffer

name1.append("Kungu");

name1.insert(0, "Daniel");       // How you concatenate string at a specific index

System.out.println(name1);

name.deleteCharAt(2);

System.out.println(name);                   // Returns "KarongoDaniel"

System.out.println(name.capacity());

System.out.println(name.length());          // The capacity does not change but the length does

name.setLength(10);                               / Removes the extra "el"

System.out.println(name);                   // Returns "KaongoDaniel"

System.out.println(name.capacity());

System.out.println(name.length());

## **Static Keyword**

This makes the member (variable/ method) associated with it to be assigned to the class itself rather than to the objects/instances of the class. E.g

class Mobile {

    String brand;

    int price;

    static String phoneType;      // All the students will share this as their "stdType" and changing this value will change it for all the class instances as well.

    static {                    // Called only once, when the class is loaded.

        phoneType = "Smartphone";     // Initialisation of the static variable

    }

    public Mobile(){                // Object Constructor (called every time there is a new object being created for the class)

        brand = "Samsung";

        price = 20000;

        System.out.println("In constructor");

    }

public static void showDetails(Mobile mobile) {

        System.out.println("Phone Type: " + phoneType);

        // System.out.println(brand + price);       // You cannot use instance variables directly in a static method

        // System.out.println(mobile.brand + mobile.price);     // You have to pass an object to a static method so as to access the instances variables

    }

}

class Demo {

    public static void main(String args[]) throws ClassNotFoundException {

        Class.forName("Mobile");        // This is used to explicitly load classes, "Mobile" in this case, because, even though a class is loaded once, it will not be loaded until at least one object is created or a static method is called.

//Class.forName(“Mobile”).newInstance(); - Does the same thing as above as well as create an object of the same class.

        // As a result, "System.out.println("In static method");" in the "Mobile", class "static" block will execute

    }

}

## **Encapsulation**

This is where the properties of a class are set to “private” so that the only way to access them is by using getters and setters.

class Human {

    private int age;

    private String name;

    public int getAge() {

        return age;

    }

    public void setAge(int age) {

        this.age = age;

    }

    // public void setAge(int age) {

    //     age = age;       This would modify the local variable rather than the instance variable, i.e. it would update the parameter variable with itself rather than update the variable of the object whouse setter is being called.

    // Preference is always given to local variables over instance variables.

    // }

    public String getName() {

        return name;

    }

    public void setName(String name) {

        this.name = name;

    }

}

class Demo {

    public static void main(String args[]) throws ClassNotFoundException {

        Human hum1 = new Human();

        hum1.setAge(30);

        hum1.setName("David");

        System.out.println(hum1.getName() + " : " + hum1.getAge());

    }

}

## **Constructors**

* Constructors in java have the same name as the class.
* Every class has a default constructor.

public Human() { // default constructor

    }

    public Human(int age, String name) {        // Parameterised constructor/ Method overloading (same mothod name different parameters)

        this.age = age;

        this.name = name;

    }

## **Inheritance (this() and super())**

Every class’s default constructor has an unseen, unless explicitly written, “super()” method that is called every time an object is created. This method calls the default constructor of the parent class. At the same time, all classes in java extend a class called “Object”.

Also, every constructor, especially the non-default/parameterized constructors, can use the “this()” method. This “this()” calls the default constructor of the current class. For this reason, it becomes possible to call two constructors in the same class when creating a class instance of the said class.

class A {   // Extends "Object"

    public A() {

        System.out.println("In A");

    }

    public A(int n) {

        this();               // Calls the default constructor of A

        System.out.println("In A int");

    }

}

class B extends A {

    public B() {

        this(5);            // Calls the parameterised constructor of B

        System.out.println("In B");

    }

    public B(int n) {

        super(5);           // Calls the parameterised constructor of A

        System.out.println("In B int");

    }

}

public class Inheritance {

    public static void main(String[] args) {

        B bObj = new B();

    }

}

*PS D:\Projects\Java\Refresher> java Inheritance*

*In A*

*In A int*

*In B int*

*In B*

In java, multi-level inheritance is allowed, i.e., if class C extends class B, and B extends A, then C gets all the properties/methods of class A. (Transitive property allowed).

However multiple inheritance is not allowed, i.e., class C cannot extend both A and B, if the two are not “related” (none of them extends the other).

## **Anonymous Objects**

These are objects that have no reference variable in the stack memory, i.e. objects created without their addresses being in a variable.

There only problem is that you cannot reuse them. Because you cannot refer to them.

class Example {

    Example() {

        System.out.println("Object Created");

    }

    public void show() {

        System.out.println("Showing");

    }

}

class Anonymous {

    public static void main(String[] args) {

        new Example();

        new Example().show();

    }

}

*PS D:\Projects\Java\Refresher> java Anonymous*

*Object Created*

*Object Created*

*Showing*

## **Method Overriding**

This is where methods have the same name, parameter types, parameter numbers and return types and yet function independently. It happens during inheritance when the child class has its own method definition such that when that method is called, the child method definition is chosen over the parent’s definition

class A {

    public int add(int n1, int n2) {

        return n1 + n2;

    }

}

class B extends A{

    public int add(int n1, int n2) {

        return n1 + n2 + 1;

    }

}

public class MethodOverriding {

    public static void main(String[] args) {

        B b = new B();

        int r1 = b.add(3, 4);       // The add() method in the child class, B, is called

        System.out.println(r1);

    }

}

## **Varargs**

These allow for the passing of a variable number of arguments. They are useful if the method signature should accept multiple objects of the same type. A single object can be passed as a single element of the varargs. For these reason it can be an alternative to method overriding.

public class Example {

    // Method accepting single or multiple objects using varargs

    public void process(Object... objs) {

        System.out.println("Processing objects:");

        for (Object obj : objs) {

            System.out.println(obj);

        }

    }

    public static void main(String[] args) {

        Example example = new Example();

        // Single object

        example.process("Single Object");

        // Multiple objects

        example.process("Object1", "Object2", "Object3");

        // Passing an array (similar to passing a list)

        Object[] objectArray = {"Object1", "Object2"};

        example.process(objectArray);

    }

}

## **Packages**

These are the folders that separate files, class files, in java.

* A class defines its package on the first line of the file.
* You can have packages within packages.
* When using a class in another package, it is imported from its package, as *“import packageName.classNme”*
* Every class imports the package “java.lang.\*” by default, the package containing classes such as “System” in “System.out.println”. The asterisk, “\*”, in an import statement refers to all the FILES, not directories, within a package.
* When sharing packages as libraries worldwide, these need to have a unique name. One way to ensure this is by using the reverse of the domain name, say “com.google.Calculator”. A good place to see this publicly shared libraries/packages is [***https://mvnrepository.com/***](https://mvnrepository.com/)

## **Access Modifiers**

Variables, as well as methods, can have their areas of visibility be restricted. There are 4 access modifiers in java:

* Public – can be accessed from anywhere.
* Private – can only be accessed from within the class. All instance variables should be private.
* Default (No other access modifier is specified – can be accessed from different classes but within the same package.
* Protected – can be accessed from different classes and packages, but the class has to be a child class

Note:

When using the “protected” access modifier and child classes are outside the package:

* You will need to create an instance of the child class from within the child class itself and then access the protected property (variable)/method using that instance.

package Protected;

public class ProtectedTest {

    protected int marks = 70;

    protected void show() {

        System.out.println("Hello");

    }

}

The child class:

package other;

import Protected.ProtectedTest;

public class ModifierTester extends ProtectedTest {

    public static void main(String[] args) {

        ModifierTester mT = new ModifierTester();

        mT.show();

    }

}

* To compile the .java files from the terminal you will need to compile the two files together such as:

*PS D:\Projects\Java\Refresher>* ***javac Protected\ProtectedTest.java other\ModifierTester.java***

## **Polymorphism**

This refers to something having multiple implementations depending on how it is used. There are two kinds: compile-time (method overloading), run-time(method overriding).

## **Dynamic Method Dispatching**

class A {

    public void show() {

        System.out.println("In A show");

    }

}

class B extends A{

    // Method overriding

    public void show() {

        System.out.println("In B show");

    }

}

class C extends A{

    // Method overriding

    public void show() {

        System.out.println("In C show");

    }

}

public class DynamicMethodDispatching {

    public static void main(String[] args) {

        // Dynamic Method Dispatching. Run-time polymorhism. Note the type of the reference variable "obj" is "A", the parent class but the instance is being changed to the children classes.

        A obj = new A();

        obj.show();

        obj = new B();

        obj.show();

        obj = new C();

        obj.show();

    }

}

## **Final Keyword**

This keyword is used with variables, classes and methods. When used with:

* Variables – Its makes the variable a constant (it can not be reassigned a new value)
* Classes – It makes the class uninheritable, i.e., the class cannot be extended.
* Method – It prevents method overriding by the class’s subclasses.

## **Wrapper Classes.**

Java has primitive data types but some java-based frameworks may have restrictions that require the use of objects exclusively rather than primitives. For this reason, java has classes that correspond to the primitives. For example:

* int – Integer
* double – Double
* char – Character

These classes are what are called wrapper classes. The process of storing a primitive value in an object is called ***“boxing”*** whereas that for getting the primitive from the object is called ***“unboxing”***.

public class WrapperClasses {

    public static void main(String[] args) {

        int x = 10;

        // Integer y = new Integer(x);  // Boxing

        Integer y = x;                  // Auto-boxing

        // int z = y.intValue();        // Unboxing

        int z = y;                      // Auto-unboxing

String str = "12";

        int num = Integer.parseInt(str);

        System.out.println(num \* 2);

        System.out.println(z);

    }

}

## **Abstract Keyword**

This keyword has the following implications:

* When used with methods, it is used to only declare a method but not to define its implementation.
* A class with any abstract method must also be declared as abstract.
* You cannot create an object of an abstract class.
* \*Any class that extends an abstract class must implement all the method declarations of the parent class’s abstract methods.
* If a child class of an abstract parent class cannot implement all the abstract methods of the parent, it must also be declared as abstract.

abstract class Car {

    // Method declaration with no implemetation

    public abstract void drive();

    public abstract void fly();

    // An abstract Class can also have concrete (non-abstract) methods

    public void playMusic() {

        System.out.println("Play Music");

    }

}

abstract class Toyota extends Car {

    // The child class has not implemented all the abstract methods of Car and so must also be declared as abstract

    public void drive() {

        System.out.println("Driving");

    }

}

class Corolla extends Toyota {

    // The class implements the last remaining method declration of the parent (Car) class. It therefore doe not need to be declared as abstract.

    public void fly() {

        System.out.println("Flying");

    }

}

// The class can be declared abstract but not have any abstract methods

abstract class Robot {

    public void killPeople() {

        System.out.println("Killing people");

    }

}

public class AbstractClasses {

    public static void main(String[] args) {

        // Cannot create objects of abstract classes

        // Car car = new Car();

        // Toyotta toyotta = new Toyotta();

        // Robot robot = new Robot();

        Corolla corolla = new Corolla();

        corolla.drive();

        corolla.fly();

        corolla.playMusic();

    }

}

## **Inner Class**

A class can have a class nested inside it, in the same way that it can have variables and methods.

// This outer class cannot be declared as static

class A {

    public void show() {

        System.out.println("In A Show");

    }

    // To Access B we need an object of class A

    class B {

        public void configB() {

            System.out.println("In Config B");

        }

    }

    // To Access C we do not need an object of class A

    static class C {

        public void configC() {

            System.out.println("In Config C");

        }

    }

}

public class InnerClasses {

    public static void main(String[] args) {

        A obj = new A();

        obj.show();

        // The period (.) denotes that B is the inner class to A

        A.B obj1 = obj.new B();

        obj1.configB();

        // The object of A is not necessary when creating an object of C because C is static

        A.C obj2 = new A.C();

        obj2.configC();

    }

}

*PS D:\Projects\Java\Refresher>* ***javac InnerClasses.java***

*PS D:\Projects\Java\Refresher>* ***java InnerClasses***

***In A Show***

***In Config B***

***In Config C***

## **Anonymous Inner Classes**

Sometimes we may want to override a method within a class but only want to do that once or a similar small number of times. In this case extending the class and creating a new one is unnecessary. To replicate the method overriding we can use anonymous inner classes.

class A {

    public void show() {

        System.out.println("In A show");

    }

}

// Unnecessary

// class B extends A {

//     public void show() {

//         System.out.println("In new show");

//     }

// }

// You can also create an anonymous inner class of an abstract class.

abstract class B {

    public abstract void show();

    public abstract void config();

}

public class AnonymousInnerClasses {

    public static void main(String[] args) {

        A obj = new A() {

            public void show() {

                System.out.println("In New Show");

            }

        };

        obj.show();

        // B obj1 = new B();        You cannot instantiate an abstract class

        B obj1 = new B() {

            public void show(){

                System.out.println("In show of the abstract class's child");

            }

            public void config(){

                System.out.println("In config of the abstract class's child");

            }

        };

        obj1.show();

        obj1.config();

    }

}

*PS D:\Projects\Java\Refresher>* ***javac AnonymousInnerClasses.java***

*PS D:\Projects\Java\Refresher>* ***java AnonymousInnerClasses***

***In New Show***

***In show of the abstract class's child***

***In config of the abstract class's child***

Compilation of the above code results in the two class files: “AnonymousInnerClasses.class” and “AnonymousInnerClasses$1.class”, the latter being the class file for the anonymous inner class.

## **Interfaces**

An interface, like an abstract class, is used when you want to define an entity and specify its behavior (methods) but also not providing the implementation.

* All method declarations are “public” and “abstract” by default and these keywords can therefore be omitted.
* All variables within an interface must be initialized (since variables cannot be extended between classes, only methods).
* All variables within an interface are “final” and “static” by default.
* Classes implement interfaces.
* A class can implement more than one interface.
* Interfaces can also implement other interfaces.
* Like abstract classes, it is impossible to instantiate an interface.
* Like classes, it is possible to declare a variable of the interface’s type, but instantiate it with an object of a “child” class (a class implementing the interface).

// class -- class  -> 'extends'

// class -- interface  -> 'implements'

// interface -- interface  -> 'extends'

interface A {

    int age = 22;       //  "final" and "static" by default

    void show();

    void config();

}

interface B extends A {         // Interface B inherits both the "show()" and "config()" methods

    void render();

}

interface C {

    void display();

}

class D implements B, C {           // The class implementS both interfaces B and C making it necessary to implement all the methods, lest it be declared as "abstract"

    public void show() {

        System.out.println("Showing");

    }

    public void config() {

        System.out.println("Configuring");

    }

    public void render() {

        System.out.println("Rendering");

    }

    public void display() {

        System.out.println("Display");

    }

}

public class Interfaces {

    public static void main(String args[]) {

        A obj = new D();        // The reference is of type A, the interface, but the object is of the class D

        obj.config();

        obj.show();

        D obj1 = new D();       // Regular class instantiation

        obj1.config();

        obj1.show();

        obj1.render();

        obj1.display();

    }

}

**Types of Interfaces**

* Normal Interfaces

These have more than one method.

* Functional/ Single Abstract Method (SAM) Interfaces

These have only one method. They can be marked by an annotation “***@FunctionalInterface***” so that all who have access to the code know that it should have only once method, and return an error when more than one method is declared.

They also allow for

### ***lambda expressions***.

These are java 8+ shorthands that were introduced to make the code less verbose. There only work for functional interfaces. For example:

@FunctionalInterface

interface A {

    int add(int i, int j);

}

public class FunctionalInterfaces {

    public static void main(String[] args) {

        // A obj = new A() {

        //     public int add(int i, int j) {

        //         return i + j;

        //     }

        // };

        //  System.out.println(obj.add(3,4));

        // Equivalent to the code comment above. This kind of notation is called a "lambda expression"

        A obj = (i,j) -> i+j;

        System.out.println(obj.add(3,4));

    }

}

* Marker Interfaces

These have no method. Often used for serialization (where you want to save the objects to the hard disk) and deserialization (reading the contents of the saved file into the object). E.g. in video games to save the player progress.

## **Enums (Enumerations)**

These are classes used to list out things, often unchangeable, sort of like a constant array. However, their values are objects and the can be given attributes. E.g. An enum containing a list of the days of the week and each day having an attribute like the “level of traffic” say for a bank. This attribute would be linked to the objects via a parameterised constructor with the name of the enum as the name of the class and consequently the name of the constructor.

* Enums cannot be extended.
* Enums can also not be instantiated used the “new” keyword.

enum Status {

    Running, Pending, Failed, Success;

}

// class A extends Status {         Will not work

// }

enum Laptop {

    // The values/ Objects of the Class "Laptop"

    Lenovo(35000), Hp(30000), Acer(25000), Dell(33000), Compaq;

    private int price;

    //  The default constructor of the class. Used with "Compaq"

    private Laptop() {

        this.price = 28000;

        System.out.println("Default Constructor");

    }

    // Parameterised constructor

    private Laptop(int price) {

        this.price = price;

        System.out.println("Parameterised Constructor");

    }

    // Getter for the class "Laptop", because "price" is private

    public int getPrice() {

        return price;

    }

    // Setter for the class "Laptop", because "price" is private

    public void setPrice(int price) {

        this.price = price;

    }

}

public class Enums {

    public static void main(String[] args) {

        Status s = Status.Running;

        // System.out.println(s);       Same as "s.name()"

        System.out.println(s.name());                       // Returns "Running"

        // System.out.println(s.getClass().getName());

        System.out.println(s.ordinal());                    // Returns "0"

        System.out.println(s.equals(Status.Running));       // Returns "true"

        // if(s == Status.Success) {

        //     System.out.println("All done");

        // }

        switch(s) {

            case Running:

                System.out.println("In Progress");

                break;

            case Pending:

                System.out.println("Please wait");

                break;

            case Failed:

                System.out.println("Sorry. Unsuccessful");

                break;

            default:

                System.out.println("All done ");

                break;

        }

        Status[] ss = Status.values();

        for(Status iS: ss) {

            System.out.println(iS.name() + " : " + iS.ordinal());

        }

        Laptop[] laptops = Laptop.values();

        for(Laptop laptop: laptops) {

            System.out.println(laptop.name() + " : " + laptop.ordinal() + " : " + laptop.getPrice());

        }

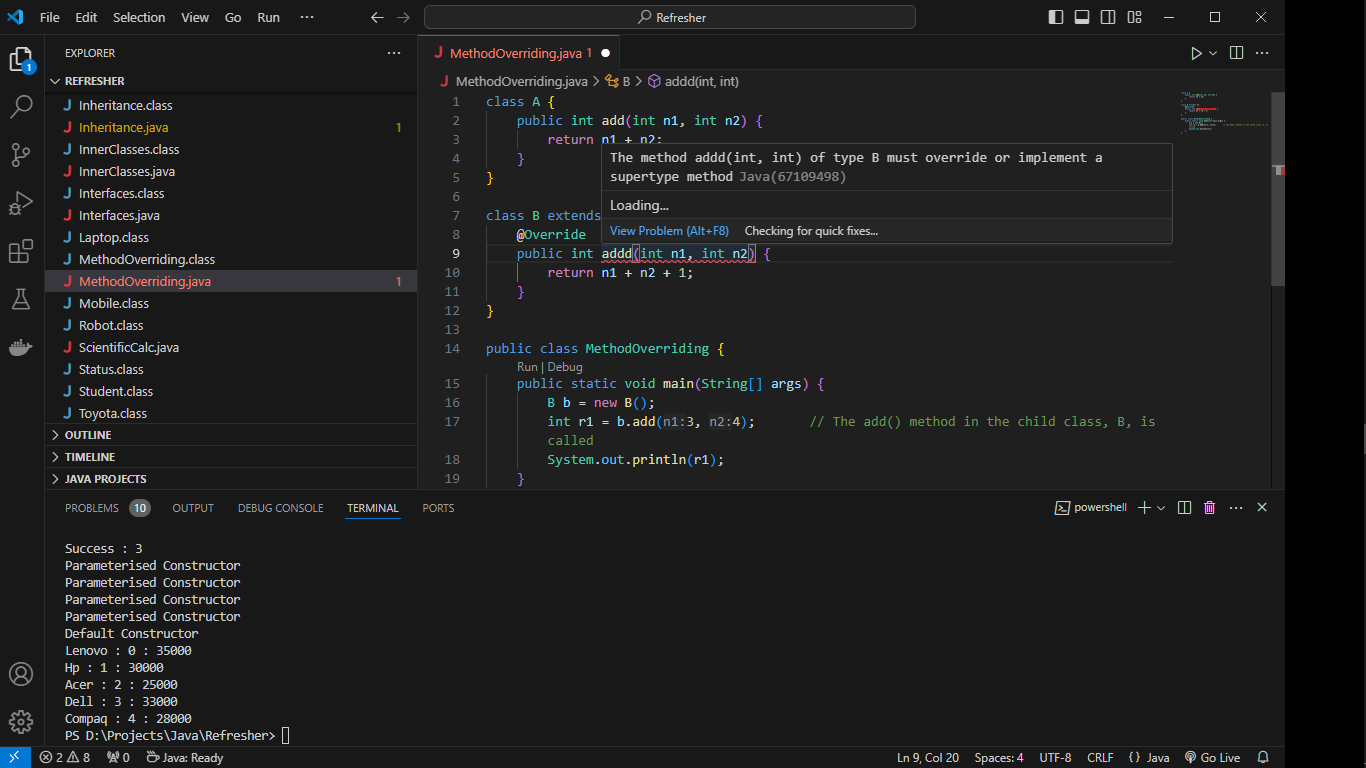
    }

}

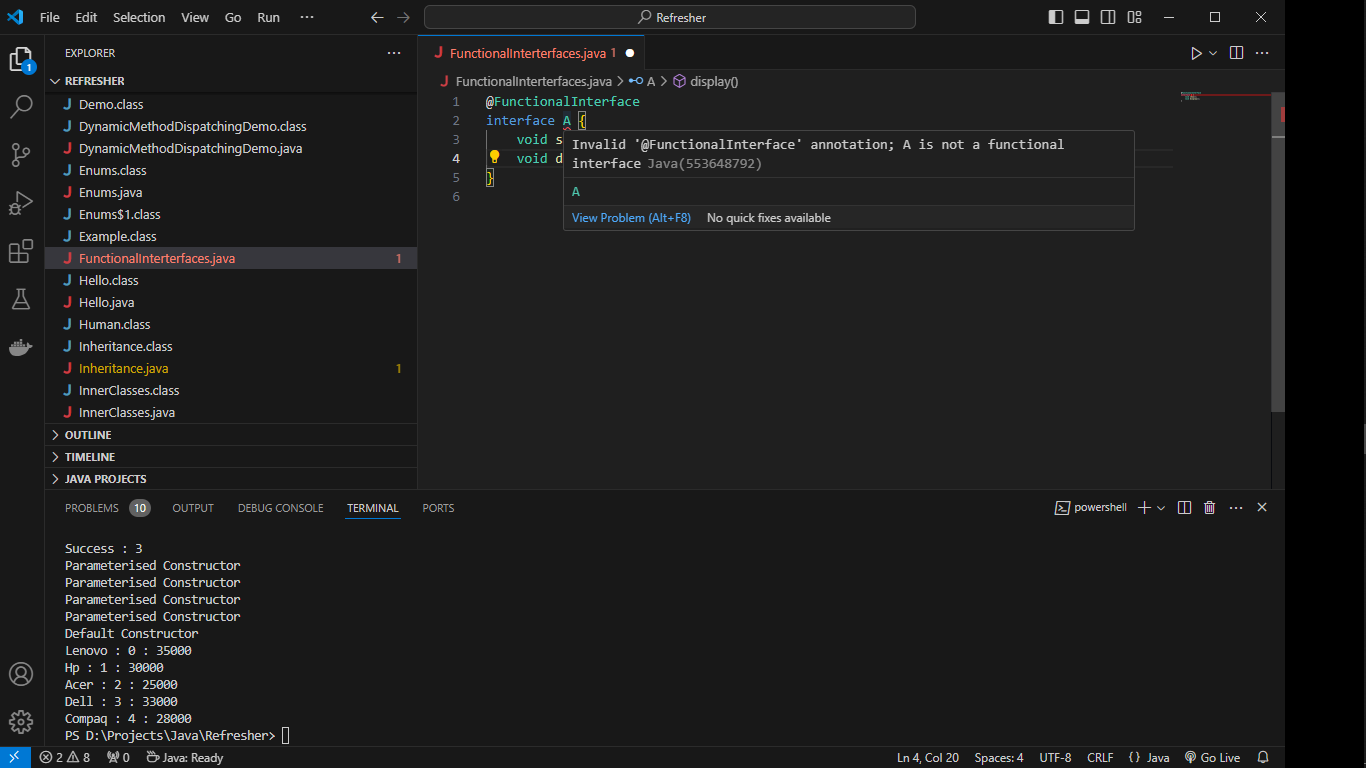
## **Annotations**

These are used to give the compiler some metadata.

* **@Override** – Denotes that the method under this line is an overriding of another in a parent class. E.g. When used and the method name does not match the parent’s method name, it returns an error on the child’s method name.



* ***@FunctionalInterface*** – Used with interface declarations to make sure that it is a functional interface so that all who have access to the code know that it should have only one method, and return an error when more than one method is declared.



## **Exceptions**

These are runtime errors. If left unhandled they terminate the program execution which is undesirable. To handle them, we wrap the *critical statements* within a “try” block and handle the error with the “catch” block.

This catch block is used to take the error, thrown by the compiler, and do something decided on by the developer. The errors can be of different types but all these types are objects of various classes.

For example, they may be of class:

* ArrayIndexOutOfBounds – thrown when try to access an element that is outside the length of the array you are specifying
* NullExceptionPointer – thrown when try to perform some operation that cannot take a “null” value as an operand.
* ArithmeticException – thrown when the numerical operation you are trying to perform cannot be done, e.g. diving a number by zero.
* .
* .
* .
* Exception
* Throwable

### **Hierarchy of Exceptions**

**Note:** Each type of exception should be handled in a different “catch” block. These exceptions have a hierarchy, with the higher classes recommended to be handled further down in the catch section of the code.

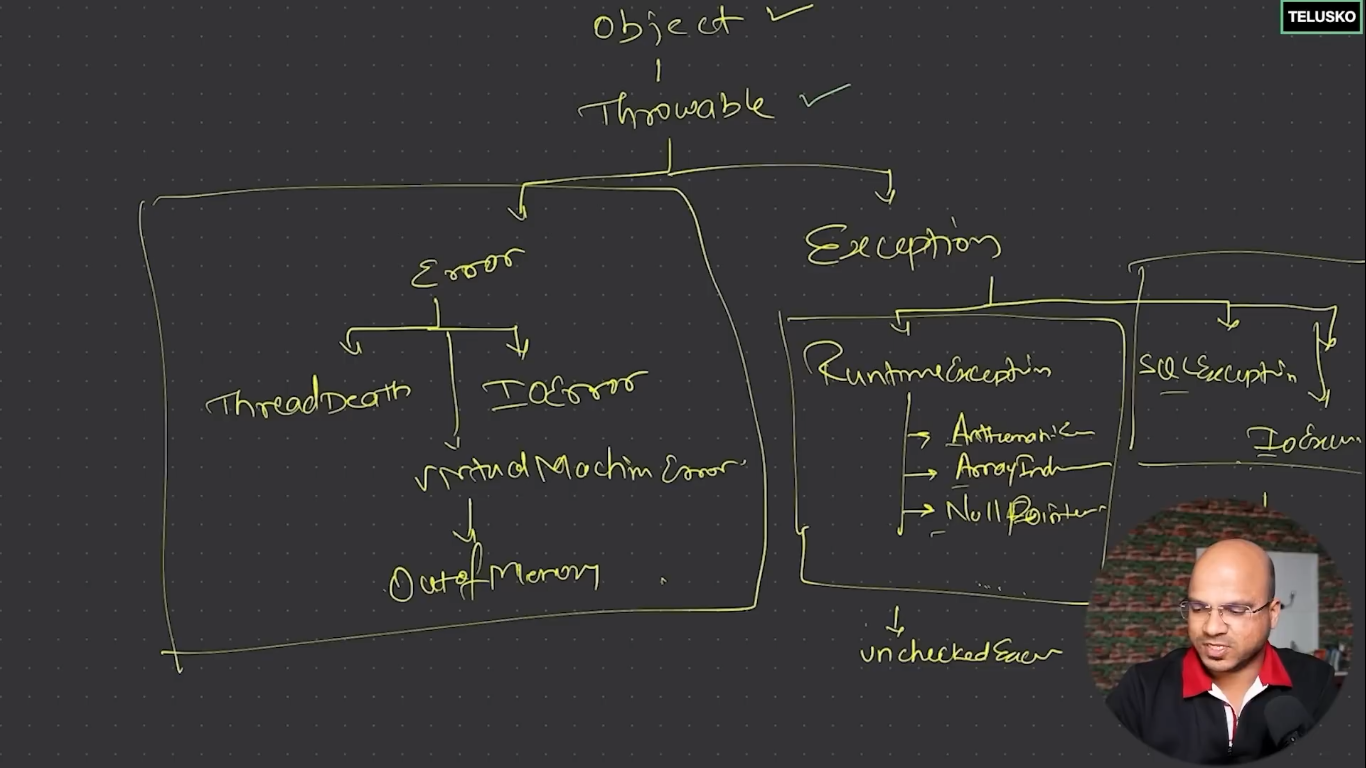


Figure 1: At 9:44:17 of tutorial

public class Exceptions {

    public static void main(String[] args) {

        int i = 2;

        int j = 0;

        int nums[] = {2,2,34,5};

        int num = 0;

        String str = null;

        try {

            j = 18/i;

            num = nums[3];

            num = str.length();

        } catch(ArithmeticException e) {

            System.out.println("Cannot divide by zero");

        } catch(ArrayIndexOutOfBoundsException e) {

            System.out.println("Array index specified is outside the length of the array");

        } catch(NullPointerException e) {

            System.out.println("You cannot perform that operation on a null value");

        } catch(Exception e) {

            System.out.println("Something else went wrong");

        } catch(Throwable e) {

            System.out.println("Something even more mysterious went wrong");

        }

        // Without the try - catch these statements would not execute

        System.out.println(j);

    }

}

### **“Throw” Keyword**

Sometimes we may to manually create an exception even if that particular kind of exceptions has not occurred at runtime. To do this we use the “throw” keyword.

public class Exceptions {

    public static void main(String[] args) {

        int i = 20;

        int j = 0;

        try {

            j = 18/i;

            if(i > 18) {

                throw new ArithmeticException("integer division does not allow for decimals. It returns 0 as the quotient if the divisor is greater than the dividend");

            }

        } catch(ArithmeticException e) {

            if(i > 18) {

                j = 18/1;

                System.out.println(e);

            } else {

                System.out.println("Cannot divide by zero");

            }

        }

        // Without the try - catch these statements would not execute

        System.out.println(j);

    }

}

### **Custom Exceptions**

Sometimes we may want to create our own exceptions. For example to handle the case above but with own custom exception class:

// Create the class and extend the "Exception" or "RuntimeException" class

class MyCustomException extends Exception {

    // Create a constructor to accept the error message

    MyCustomException(String errorMessage) {

        // Pass this error message to the parent class that then handles it.

        super(errorMessage);

    }

}

public class Exceptions {

    public static void main(String[] args) {

        int i = 20;

        int j = 0;

        try {

            j = 18/i;

            if(i > 18) {

                // Create a new object of the custom class and pass the message to the parameterised constructor

                throw new MyCustomException("integer division does not allow for decimals. It returns 0 as the quotient if the divisor is greater than the dividend");

            }

        } catch(ArithmeticException e) {

            System.out.println("Cannot divide by zero");

        }

        // Catch the error thrown

        catch(MyCustomException e) {

            System.out.println(e);

        }

        // Without the try - catch these statements would not execute

        System.out.println(j);

    }

}

### **“Throws” Keyword**

This keyword is used to pass the responsibility of handling the runtime exception created to the function higher in the stack, i.e. the function calling the one where the exception has occurred.

class Calc {

    // Throws the exception instead of surrounding "int res = i / j;" with a try catch block

    public static int divide(int i, int j) throws ArithmeticException {

        int res = i / j;

        return res;

    }

    // Throws the exception instead of surrounding "int num = nums[4];" with a try catch block

    public static int getArrayElement(int nums[]) throws ArrayIndexOutOfBoundsException {

        int num = nums[4];

        return num;

    }

}

public class ThrowsKeyword {

    // It is discouraged to use "throws" exceptions from the main method because this is then handled by the JVM which will stop execution

    public static void main(String[] args) {

        int i = 5;

        int j = 0;

        int nums[] = {1,2,3,4};

        try {

            int quotient = Calc.divide(i,j);

            int elem = Calc.getArrayElement(nums);

        }

        // Handling the exceptions thrown from the functions "divide()" and "getArrayElement"

        catch (ArithmeticException e) {

            System.out.println(e);

            e.printStackTrace();            // Displays the hierarchy of methods involved.

        } catch (ArrayIndexOutOfBoundsException e) {

            System.out.println(e);

        }

        System.out.println("After Error Handling");

    }

}

## **Accepting User Input**

There are three options of accepting user input from the terminal:

* Using “System.in.read()”
  + returns the ASCII code for the character you have entered.
  + One character at a time.
* Using “BufferReader” and “Integer.parseInt(bf.readLine())”
  + this is a resource which needs to be closed as a resource can only be used by one person at a time.
  + Accepts multiple character inputs.
  + “bf.readLine()” returns a string and hence the “Integer.parseInt()”
* Using “Scanner”
  + Introduced in java 1.5
  + Accepts multiple character inputs.
  + Accepts multiple input sources, terminal, files etc.

import java.io.BufferedReader;

import java.io.IOException;

import java.io.InputStreamReader;

import java.util.Scanner;

public class UserInput {

    public static void main(String[] args) {

        System.out.println("Enter a number: ");

        try {

            // Using System.in

            int num = System.in.read();          // Returns the ASCII code the input

            System.out.println(num - 48);

            // Using BufferedReader

            InputStreamReader in = new InputStreamReader(System.in);

            BufferedReader bf = new BufferedReader(in);

            // num = bf.read();             // Also returns the ASCII

            num = Integer.parseInt(bf.readLine());

            System.out.println(num);

            bf.close();

            // Using Scanner

            Scanner sc = new Scanner(System.in);

            num = sc.nextInt();

            System.out.println(num);

            sc.close();

        } catch(IOException e) {

            System.out.println(e);

            e.printStackTrace();

        }

    }

}

## **Try … Finally/ Try With Resources**

“finally” is a block that is used in conjunction with “try” when you want the statements within to be executed regardless of whether an exception from the “try” block occurs or not.

It is mainly used to close resources such as “BufferedReader”.

An alternative notation of the same is to declare the resources inside opening and closing parentheses on the same line as the “try” statement, e.g. try(…..declare resource here…..) {…}. Here, once all the statements in the try block are executed, the resource will be closed automatically.

import java.io.BufferedReader;

import java.io.IOException;

import java.io.InputStreamReader;

import java.util.Scanner;

public class UserInput {

    public static void main(String[] args) throws IOException {

        System.out.println("Enter a number: ");

        // Using "finally"

        BufferedReader bf = null;

        try {

            InputStreamReader in = new InputStreamReader(System.in);

            bf = new BufferedReader(in);

            // num = bf.read();             // Also returns the ASCII

            int num = Integer.parseInt(bf.readLine());

            System.out.println(num);

        } catch(IOException e) {

            System.out.println(e);

            e.printStackTrace();

        } finally {

            bf.close();

        }

        // Using "try()"/ "try with resources"

        try(BufferedReader bf = new BufferedReader(new InputStreamReader(System.in));) {

            int num = Integer.parseInt(bf.readLine());

            System.out.println(num);

        } catch(IOException e) {

            System.out.println(e);

            e.printStackTrace();

        }

    }

}

## **Threads**

These are the smallest units of software that the Operating System can work with. For example, in a code editor, one thread could be responsible for intellisense, another for error reporting, and another for displaying the code being typed out. Threads, by the same software, share resources and can be run in parallel (concurrently).

There are several methods of creating threads in java:

### **Extend “Thread” class**

// Turns the class intances into threads rather than normal objects

class A extends Thread{

    // Default first method called when a thread is started

    public void run() {

        for(int i=0; i<100; i++){

            System.out.println("Hi");

            try {

                // Tells/Suggests to the scheduler to wait before continuing with execution

                Thread.sleep(10);

            } catch (InterruptedException e) {

                // TODO Auto-generated catch block

                e.printStackTrace();

            }

        }

    }

}

// Turns the class intances into threads rather than normal objects

class B extends Thread{

    // Default first method called when a thread is started

    public void run() {

        for(int i=0; i<100; i++){

            System.out.println("Hello");

            try {

                // Tells/Suggests to the scheduler to wait before continuing with execution

                Thread.sleep(10);

            } catch (InterruptedException e) {

                // TODO Auto-generated catch block

                e.printStackTrace();

            }

        }

    }

}

public class Threads {

    public static void main(String[] args) {

        A obj1 = new A();

        B obj2 = new B();

        // Starts the threads

// obj1.setPriority(Thread.MAX\_PRIORITY);

        System.out.println(obj1.getPriority());

        obj1.start();

        // Suggests that the scheduler waits before continuing

        try {

            Thread.sleep(10);

        } catch (InterruptedException e) {

            // TODO Auto-generated catch block

            e.printStackTrace();

        }

// obj2.setPriority(Thread.MAX\_PRIORITY);

        System.out.println(obj2.getPriority());

        obj2.start();

    }

}

// Note: Different schedulers use different algorithms and so the "Thread.sleep()" is a suggestion whose implementation varies from OS to OS.

// All a programmer can do is try to optimize the running of these threads but not determine their running

// This optimisation, besides using "Thread.sleep()", can also be done by manually setting the priority of the threads where 10 is the maximum and 1 is the minimum

### **Implementing “Runnable” Interface**

This is better than extending “Thread” class because the former restricts the child class from extending another class. A class can implement an interface and extend a class at the same time.

// The parent class being inherited by "B"

class A {

    public static void show() {

        System.out.println("Hi");

    }

}

// The Thread class that is also extending the class "A" and implementing the "Runnable" interface

class B extends A implements Runnable {

    public void run() {

        for(int i = 0; i<5; i++) {

            show();

            try {

                Thread.sleep(10);

            } catch (InterruptedException e) {

                // TODO Auto-generated catch block

                e.printStackTrace();

            }

        }

    }

}

// The thread class that is implementing the "Runnable" class but not extending A

class C implements Runnable {

    public void run() {

        for(int i = 0; i<5; i++) {

            System.out.println("Hello");

            try {

                Thread.sleep(10);

            } catch (InterruptedException e) {

                // TODO Auto-generated catch block

                e.printStackTrace();

            }

        }

    }

}

public class Threads {

    public static void main(String[] args) {

        // Dynamic Method dispatching, i.e. Creating a "Runnable" interface reference but the objects are of different types.

        Runnable obj1 = new B();

        Runnable obj2 = new C();

        // Creating the threads but passing the objects into the constructor because the "Runnable" interface does not have a "run()" method implementation.

        Thread t1 = new Thread(obj1);

        Thread t2 = new Thread(obj2);

        // Starts the threads

        t1.start();

        // Suggests that the scheduler waits before continuing

        try {

            Thread.sleep(10);

        } catch (InterruptedException e) {

            // TODO Auto-generated catch block

            e.printStackTrace();

        }

        t2.start();

    }

}

### **Using lambda expressions (Anonymous Inner Classes)**

”Runnable” is a Functional Interface, i.e., a method with one method declaration

public class Threads {

    public static void main(String[] args) {

        // Using anonymous inner classes

        // Runnable obj1 = new Runnable() {

        //     public void run() {

        //         for(int i = 0; i<5; i++) {

        //             System.out.println("Hi");

        //             try {

        //                 Thread.sleep(10);

        //             } catch (InterruptedException e) {

        //                 // TODO Auto-generated catch block

        //                 e.printStackTrace();

        //             }

        //         }

        //     }

        // };

        // Runnable obj2 = new Runnable() {

        //     public void run() {

        //         for(int i = 0; i<5; i++) {

        //             System.out.println("Hello");

        //             try {

        //                 Thread.sleep(10);

        //             } catch (InterruptedException e) {

        //                 // TODO Auto-generated catch block

        //                 e.printStackTrace();

        //             }

        //         }

        //     }

        // };

        // Using lambda expressions to simply the above

        Runnable obj1 = () -> {

            for(int i = 0; i<5; i++) {

                System.out.println("Hi");

                try {

                    Thread.sleep(10);

                } catch (InterruptedException e) {

                    // TODO Auto-generated catch block

                    e.printStackTrace();

                }

            }

        };

        Runnable obj2 = () -> {

            for(int i = 0; i<5; i++) {

                System.out.println("Hello");

                try {

                    Thread.sleep(10);

                } catch (InterruptedException e) {

                    // TODO Auto-generated catch block

                    e.printStackTrace();

                }

            }

        };

        // Creating the threads but passing the objects into the constructor because the "Runnable" interface does not have a "run()" method implementation.

        Thread t1 = new Thread(obj1);

        Thread t2 = new Thread(obj2);

        // Starts the threads

        t1.start();

        // // Suggests that the scheduler waits before continuing

        // try {

        //     Thread.sleep(10);

        // } catch (InterruptedException e) {

        //     // TODO Auto-generated catch block

        //     e.printStackTrace();

        // }

        t2.start();

    }

}

## **Race Conditions**

A race condition refers to a situation where more than one thread access the same resource, say a variable, at the same time and modify the same leading to inconsistencies. For example, having a bank account have money withdrawn from it at the exact same time by different ATMS.

This can be solved by:

* Declaring the methods being called by the threads as “synchronized” so that only one thread can call them at a time.
* Calling the join() method on the individual threads from the parent method starting the threads.

class Counter {

    int counter;

    // This makes the method thread-safe

    public synchronized void increment() {

        counter++;

    }

}

public class RaceConditions {

    public static void main(String args[]) {

        // The shared resource

        Counter c = new Counter();

        // The different threads that are calling the shared resource

        Runnable obj1 = () -> {

            for(int i = 0; i<5000; i++) {

                c.increment();

            }

        };

        Runnable obj2 = () -> {

            for(int i = 0; i<5000; i++) {

                c.increment();

            }

        };

        Thread t1 = new Thread(obj1);

        Thread t2 = new Thread(obj2);

        t1.start();

        t2.start();

        try {

            // Instruct the thread-starting method (in this case, the "main" method), to wait for the completion of the tasks by the threads before continuing.

            t1.join();

            t2.join();

        } catch (InterruptedException e) {

            // TODO Auto-generated catch block

            e.printStackTrace();

        }

        System.out.println(c.counter);

    }

}

## **Thread States**

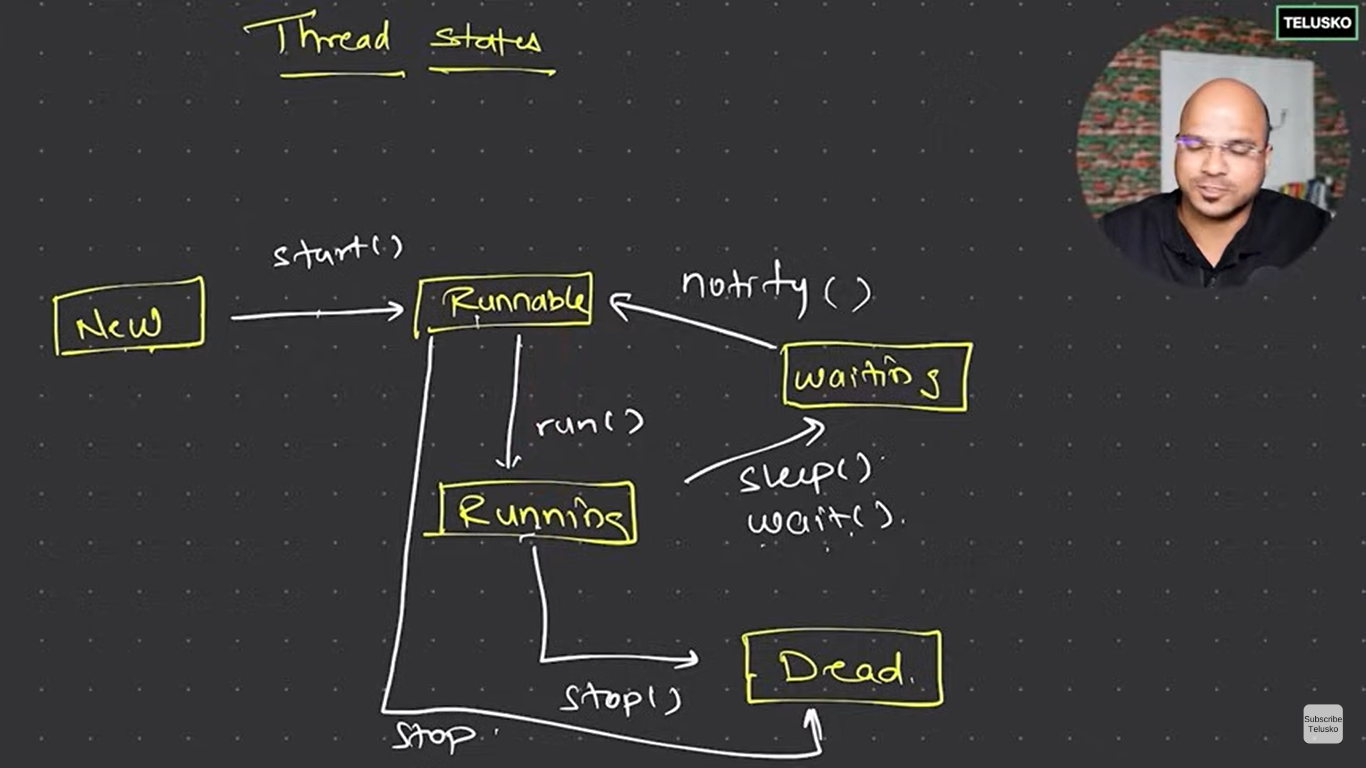


Figure 2: Thread States

## **collection API/ Collection/ Collections**

collection API/ collection framework – concept

Collection – Interface

Collections – Class

Arrays are a great tool in programming but they have some limitations:

* They are fixed in size
* They require a lot of work to turn into data structures such as stacks, queues etc.

As such, java provides some in built ways work with these more complex data structures, an API of sorts.

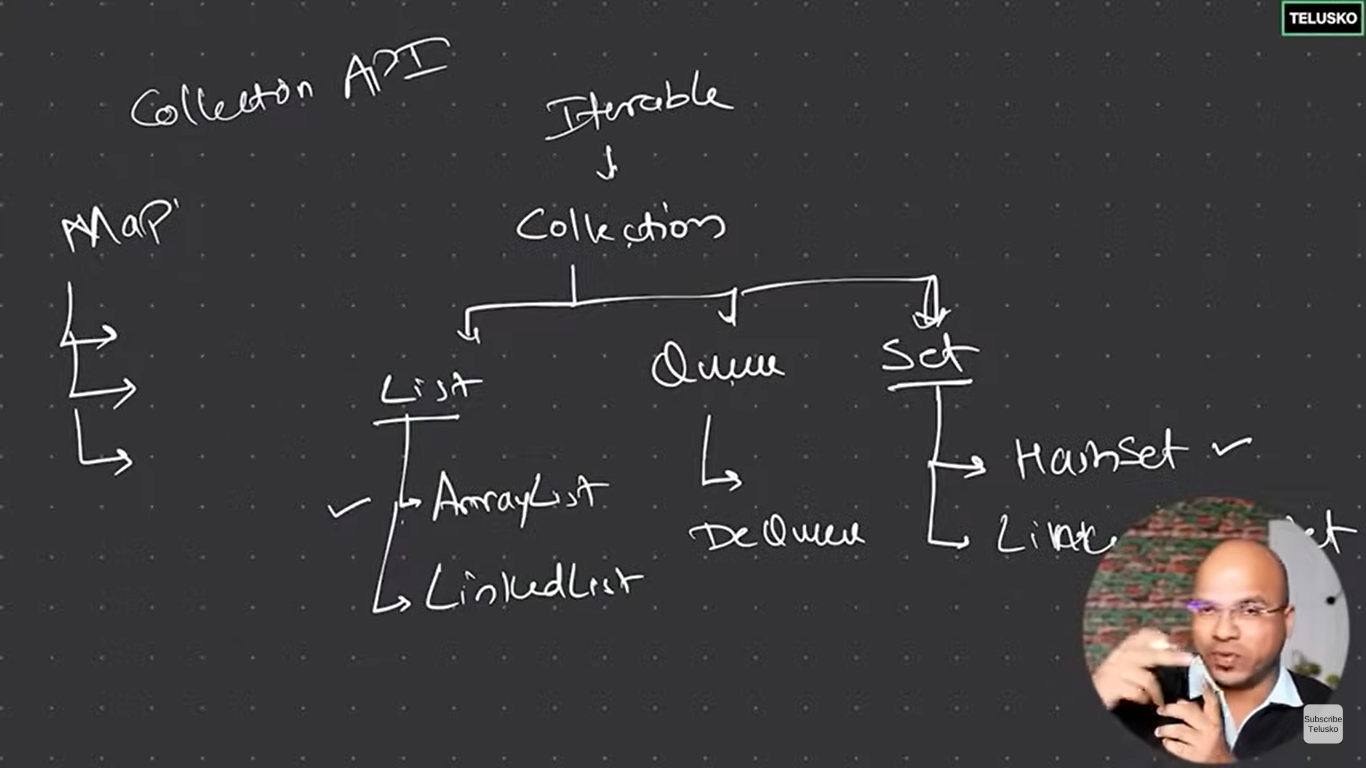


Figure 3: Collections Summary

**Collection Interface**

Belongs to the “java.util” package.

It has other children interfaces that extend the same, e.g. List, Queue and Set. Each of these has its own classes that implement the same, and these classes are what can be instantiated to create the complex data structures. These data structures work with objects and not primitives, so wrapper classes such as Integer are used.

Alongside this Collection Interface in the collection API concept, there is also a Map interface that has its own class implementations.

Collection’ class implementation’ instances can also be printed directly, without having to use a loop. However, because Collection interface is a child of another interface called “Iterable”, we can use this Iterable to loop through the collections.

These collection API interfaces provide a feature known as **generics** that is used to make the class instances type safe, i.e., allowing you to restrict the type of values a collection can take. Otherwise, collections can accept values of different types.

Collection interface does not support indexing but its child interface, List, does. When in need of this indexing functionality, we should therefore declare the type of the reference variables to the collection as “List”.

### **Collection examples:**

import java.util.ArrayList;

import java.util.Collection;

import java.util.HashSet;

import java.util.Iterator;

import java.util.List;

import java.util.Set;

import java.util.TreeSet;

public class Collections {

    public static void main(String[] args) {

// Recall: Collection is an interface, and NOT a functional interface.

        // Collection nums = new Collection<E>() {};       The use of anonymous inner class is unwise because the "Collection" interface has too many method declarations that would, otherwise, need to be implemented, failure to which it would require the class implementation be declared abstract, which in turn, cannot be instantiated.

        Collection<Integer> numsCollectionArrayList = new ArrayList<Integer>();    // The <Integer> are called generics and are used to make the collections type-safe.

        numsCollectionArrayList.add(6);

        numsCollectionArrayList.add(5);

        numsCollectionArrayList.add(4);

        System.out.println("Collection");

        System.out.println(numsCollectionArrayList);

        // List

            // supports indexing.

            // Allow for duplicate values.

        List<Integer> numsListArrayList = new ArrayList<Integer>();

        numsListArrayList.add(6);

        numsListArrayList.add(5);

        numsListArrayList.add(4);

        numsListArrayList.add(4);

        numsListArrayList.add(3);

        numsListArrayList.add(6);

        numsListArrayList.set(3, 1);

        System.out.println("ArrayList");

        System.out.println(numsListArrayList.get(0));

        System.out.println(numsListArrayList.indexOf(4));

        System.out.println(numsListArrayList);

        // Set

            // Does not support indexing.

            // Does not allow duplicate values.

            // Does not sort the elements in any particular order.

        Set<Integer> numsSetHashSet = new HashSet<Integer>();

        numsSetHashSet.add(86);

        numsSetHashSet.add(55);

        numsSetHashSet.add(32);

        numsSetHashSet.add(86);     // Omitted from the collection because it is a duplicate

        System.out.println("HashSet");

        System.out.println(numsSetHashSet);

        for(int n : numsSetHashSet) {

            System.out.println(n);

        }

        // TreeSet - similar to HashSet but this one sorted the elements in ascending order

        Set<Integer> numsSetTreeSet = new TreeSet<Integer>();

        numsSetTreeSet.add(86);

        numsSetTreeSet.add(55);

        numsSetTreeSet.add(32);

        numsSetTreeSet.add(44);

        System.out.println("TreeSet");

        System.out.println(numsSetTreeSet);

        for(int n : numsSetTreeSet) {

            System.out.println(n);

        }

        // Iterator - Type of Interface that is returned when the "iterator()" method is called by a child of the "Interable" interface.

        // "Interable" is the top most interface above Collection for iteration purposes.

        Set<Integer> numsIteratorTreeSet = new TreeSet<Integer>();

        numsIteratorTreeSet.add(86);

        numsIteratorTreeSet.add(55);

        numsIteratorTreeSet.add(32);

        numsIteratorTreeSet.add(44);

        System.out.println("Iterator");

        Iterator<Integer> values = numsIteratorTreeSet.iterator();

        while(values.hasNext()) {       // hasNext() returns a boolean if there is still another element in the collection thatis yet to be looped over.

            System.out.println(values.next());

        }

    }

}

### **Maps examples:**

import java.util.HashMap;

import java.util.Hashtable;

import java.util.Map;

public class Maps {

    public static void main(String[] args) {

        // Maps

            // Take key-value pairs, where the key is an actual label, rather than an index

            // The keys are unique

            // The put() method overwrites the value for the existing element with the key specified, otherwise it creates a new element.

            // The values do not need to be unique, they can be repeated

            // In summary, the keys are a set, and the values are a List

        // HashMap

            // Does not sort the elements

            // Not synchronized by default, as opposed to HashTables, when working with threads, so this has to be done externally, by declaring the methods making use of the hashMap as "synchronized"

        Map<String, Double> students = new HashMap<>();

        students.put("Daniel", 64.23);

        students.put("Blair", 71.23);

        students.put("Charles", 65.23);

        students.put("Agnes", 64.23);

        students.put("Daniel", 64.57);      // Overwriting the value for "Daniel" from "64.23" to "64.57"

        System.out.println("HashMap");

        System.out.println(students);

        System.out.println(students.get("Daniel"));     // Return the value at the key specified

        System.out.println(students.keySet());          // Returns the set of keys in the map

        System.out.println(students.values());          // Returns the list of values in the map

        // To loop through a map, we have to you the set of keys because there are no indices

        for(String key: students.keySet()) {

            System.out.println(key + ": " + students.get(key));

        }

        // HashTable

            //  Sorts the elements in ascending order based on the key

            //  Synchronized by default when working with threads. Otherwise it works the same way as the HashMap

        Map<String, Integer> players = new Hashtable<>();

        players.put("Lin Dan", 5);

        players.put("Lee Cong Wei", 0);

        players.put("Chen Long", 2);

        players.put("Victor Axelsen", 3);

        players.put("Kento Momota", 2);      // Overwriting the value for "Daniel" from "64.23" to "64.57"

        System.out.println("HashTable");

        System.out.println(players);

        System.out.println(players.get("Kento Momota"));     // Return the value at the key specified

        System.out.println(players.keySet());          // Returns the set of keys in the map

        System.out.println(players.values());          // Returns the list of values in the map

        // To loop through a map, we have to you the set of keys because there are no indices

        for(String key: players.keySet()) {

            System.out.println(key + ": " + players.get(key));

        }

    }

}

## **Sorting Collections Using Custom Logic**

import java.util.ArrayList;

import java.util.Collections;

import java.util.Comparator;

import java.util.List;

public class CustomSorting {

    public static void main(String[] args) {

        List<Integer> nums = new ArrayList<>();

        nums.add(23);

        nums.add(64);

        nums.add(55);

        nums.add(16);

        nums.add(37);

        //  Sorting functionality provided by the "Collections" class

        Collections.sort(nums);     // Sort the list in ascending order

        System.out.println(nums);

        // Creating a custom sorting algorthm using the "Comparator" interface and extending it to define this algorithm in the "compare" method

        Comparator<Integer> com = new Comparator<Integer>() {

            public int compare(Integer i, Integer j) {

                if(i%10 > j%10) {

                    return 1;           // Returning 1 means swap the elements

                } else {

                    return -1;          // Returning -1 means do not swap

                }

            }

        };

        // Passing the collection and the new sorting algorithm to the "sort()" method of the "Collections" class

        Collections.sort(nums, com);     // Sort the list in ascending order based on the last digit of the elements

        System.out.println(nums);

        List<String> strs = new ArrayList<>();

        strs.add("Joseph");

        strs.add("Aquillas");

        strs.add("Peter");

        strs.add("Bartholomew");

        strs.add("Mary");

        Collections.sort(strs);     // Sort the list in ascending order

        System.out.println(strs);

        // Creating a custom sorting algorthm using the "Comparator" interface and extending it to define this algorithm in the "compare" method

        Comparator<String> comStr = new Comparator<String>() {

            public int compare(String i, String j) {

                if(i.length() > j.length()) {

                    return 1;           // Returning 1 means swap the elements

                } else {

                    return -1;          // Returning -1 means do not swap

                }

            }

        };

        // Passing the collection and the new sorting algorithm to the "sort()" method of the "Collections" class

        Collections.sort(strs, comStr);     // Sort the list in ascending order based on the lengths of the strings in the collection

        System.out.println(strs);

    }

}

If you want to compare objects of a custom class held within a collection, you can use a comparator, as above, or:

* Make the class implement the “Comparable” interface that declares a method “compareTo()”
* Override this “compareTo()” method within your class so that when calling the “sort()” method on the collection holding the class objects, you do need to pass a comparator class implementation.
* Use lambda expressions to simplify the regular comparator because the “Comparable” interface is a functional interface (having one method declaration (compareTo()))

import java.util.ArrayList;

import java.util.Collections;

import java.util.Comparator;

import java.util.List;

class Student implements Comparable<Student>{

    int age;

    String name;

    public Student(int age, String name) {

        this.age = age;

        this.name = name;

    }

    public String toString() {

        return "Student [age=" + age + ", name=" + name + "]";

    }

    public int compareTo(Student that) {

        if(this.age > that.age) {

            return 1;           // Returning 1 means swap the elements

        } else {

            return -1;          // Returning -1 means do not swap

        }

    }

}

public class CustomSorting {

    public static void main(String[] args) {

        // Sorting Objects

        List<Student> students = new ArrayList<>();

        students.add(new Student(32, "Michael"));

        students.add(new Student(23, "Karongo"));

        students.add(new Student(28, "Maina"));

        students.add(new Student(37, "Njeri"));

        students.add(new Student(19, "Charles"));

        // 1. Sorting Using a regular comparator

        Comparator<Student> comStudents = new Comparator<Student>() {

            public int compare(Student i, Student j) {

                if(i.age > j.age) {

                    return 1;           // Returning 1 means swap the elements

                } else {

                    return -1;          // Returning -1 means do not swap

                }

            }

        };

        Collections.sort(students, comStudents);

        // 2. Sorting using lambda expressions

        Comparator<Student> comStudentsLambda = (i,j) -> i.age > j.age ? 1 : -1;

        Collections.sort(students, comStudentsLambda);

        // 3. Using the overridden "compareTo()" method from the "Comparable" interface

        Collections.sort(students);

        // Displaying the collection using the enhanced for loop

        for(Student s: students) {

            System.out.println(s);

        }

    }

}

## **ForEach and Consumer**

Besides the regular and enhanced for loops, java, since version 1.8, provided a new functionality called “forEach” that loops through a list giving you one element at a time.

import java.util.ArrayList;

import java.util.Arrays;

import java.util.List;

import java.util.function.Consumer;

public class ForEachAndConsumer {

    public static void main(String[] args) {

        List<Integer> nums = new ArrayList<>();

        nums.add(35);

        nums.add(13);

        nums.add(24);

        nums.add(35);

        nums.add(91);

        List<Integer> nums1 = Arrays.asList(35, 13, 24, 35, 91);    // Equivalent to the above

        System.out.println(nums);

        // System.out.println(nums1);

        // To loop through either of the lists the following functionalities exist:

        // 1. Regular for loop

        for(int i=0; i<nums.size(); i++) {

            System.out.println(nums.get(i));

        }

        // 2. Enhanced for loop

        for(Integer i: nums) {

            System.out.println(i);

        }

        // 3. forEach loop

            // Consumer

            Consumer<Integer> consumer = new Consumer<Integer>() {

                public void accept(Integer e) {

                    System.out.println(e);

                }

            };

            // forEach accepts a consumer class implementation as a parameter

            nums.forEach(consumer);

            // Consumer lambda expression - Consumer is a functional interface

            Consumer<Integer> consumerLambda = e -> System.out.println(e);

            nums.forEach(consumerLambda);

            nums.forEach(e -> System.out.println(e));       // Replacing the Consumer parameter with the body of the class implementation "e -> System.out.println(e)"

    }

}

## **Stream API**

Consider a list. This list can be turned into a Stream class implementation object (Stream is an interface) using the stream() method.

* Changes can then made to this stream without affecting the original list.
* Once used, a Stream cannot be reused.

import java.util.Arrays;

import java.util.List;

import java.util.stream.Stream;

public class Streams {

    public static void main(String[] args) {

        List<Integer> nums = Arrays.asList(8,4,5,7,1);

        // Stream<Integer> s1 = nums.stream();         // Creating a stream from the list

        // s1.forEach(e -> System.out.println(e));     // Allows for the same operations as "List" itself

        // s1.forEach(e -> System.out.println(e));     // This will not work as it will return an exception "stream has already been operated upon or closed"

        // methods executed on streams return a new stream destroying the old one.

        // Stream<Integer> s2 = s1.filter(n -> n%2 == 0);      // Returns the even numbers from the stream

        // Stream<Integer> s3 = s2.map(n -> n\*2);      // Doubles the numbers in the stream

        // int result = s3.reduce(0, (c,e) -> c+e);      // Add all the elements in the stream and returns a single value

        // System.out.println(result);

        // The above can be simplified into one statement as:

        int result = nums.stream()

                        .filter(e -> e%2 == 0)

                        .map(e -> e\*2)

                        .reduce(0, (c,e) -> c+e);

        System.out.println(result);

        Stream<Integer> sortedStream = nums.stream()

                                           .map(e -> e\*2)

                                           .sorted();

        sortedStream.forEach(n -> System.out.println(n));

    }

}

### **Filter Method**

This is used to separate data that meets a specified condition from a stream, returning a new stream.

import java.util.Arrays;

import java.util.List;

import java.util.function.Predicate;

import java.util.stream.Stream;

public class FilterMethod {

    public static void main(String[] args) {

        List<Integer> nums = Arrays.asList(1,2,3,4,5,6);

        Stream<Integer> s1 = nums.stream();

        // filter method requires a parameter of type "Predicate", which is a functional interface with one method declaration, "test()"

        Predicate<Integer> p = new Predicate<Integer>() {

            public boolean test(Integer n) {

                return n%2==0;

            }

        };

        // This can be simplified into a lambda expression

        Predicate<Integer> p1 = n -> n%2==0;

        // Stream<Integer> s2 = s1.filter(p);

        // Stream<Integer> s2 = s1.filter(p1);          // Equivalent of the above

        Stream<Integer> s2 = s1.filter(n -> n%2==0);    // Equivalent of the above

        s2.forEach(n -> System.out.println(n));

    }

}

### **Map Method**

This one performs an arbitrary function on the elements in a stream, returning a new stream of the modified values.

import java.util.Arrays;

import java.util.List;

import java.util.function.Function;

import java.util.function.Predicate;

import java.util.stream.Stream;

public class MapMethod {

    public static void main(String[] args) {

        List<Integer> nums = Arrays.asList(1,2,3,4,5,6);

        Stream<Integer> s1 = nums.stream();

        // map method requires a parameter of type "Function", which is a functional interface with one method declaration, "apply()"

        Function<Integer, Integer> f = new Function<Integer, Integer>() {

            public Integer apply(Integer n) {

                return n\*2;

            }

        };

        // This can be simplified into a lambda expression

        Function<Integer, Integer> f1 = n -> n\*2;

        // Stream<Integer> s2 = s1.map(f);

        // Stream<Integer> s2 = s1.map(f1);          // Equivalent of the above

        Stream<Integer> s2 = s1.map(n -> n\*2);    // Equivalent of the above

        s2.forEach(n -> System.out.println(n));

    }

}

### **Reduce Method**

This one performs an arbitrary function on the elements in a stream, returning an aggregate value of the function carried out on all the elements of the stream.

public class ReduceMethod {

    public static void main(String[] args) {

        List<Integer> nums = Arrays.asList(1,2,3,4,5,6);

        Stream<Integer> s = nums.stream();

        // reduce method takes two parameters, an initial value and a function

        int result = s.reduce(0, (c,e) -> c+e);

        System.out.println(result);

    }

}

## **Sealed Classes**

Recall that declaring a class as final makes the class uninheritable. We may want to restrict a class such that it is uninheritable but having some classes that can inherit it. For example, you may have a class Computer that can only be restricted by the classes Laptop, Desktop and Mobile but no other class. To do this, we use the “sealed” keyword.

// Note

    // Once a class is sealed, it has to specify the classes that it permits

    // Classes included in the "permits" section of a sealed must extend the sealed parent class

    // Classes included in the "permits" section of a sealed must be declared as either sealed, non-sealed or final

    // The grand-parent sealed class can extend other classes

sealed class A extends Thread permits B,C,D {          // Class E is not permitted

}

non-sealed class B extends A {          // class B can be extended by any class

}

final class C extends A {               // Class C cannot be extended by any other class

}

sealed class D extends A permits E {

}

non-sealed class E extends D {

}

public class SealedClasses extends E {

}

## **Sealed Interfaces**

Interfaces can also be declared as sealed. They also have to declare the classes and interfaces that can implement/extend the same.

sealed interface A permits B, C {

}

non-sealed interface B  extends A {

}

non-sealed class C implements A {

}

// class D implements A, B {        // Class D is not permitted to implement interface A

// }

class D implements B {        // Class D is can implement interface B because it non-sealed

}

public class SealedInterfaces {

}

## **Record Classes**

These were introduced, in java 14, to provide a shorter, less verbose method for creating Data Carrier classes, i.e., classes with no functional methods. Classes that only have properties. Used during data storage/transfer between clients and servers.

// The class below is a data carrier class

class Alien {

    // The properties are encapsulated and therefore require getters and setters(constructor)

    private final int age;

    private final String name;

    public Alien(int age, String name) {

        this.age = age;

        this.name = name;

    }

    public int getAge() {

        return age;

    }

    public String getName() {

        return name;

    }

    // This is meant to return a meaningful output when the object is rendered out by: "System.out.println(a1);"

    @Override

    public String toString() {

        return "Alien [age=" + age + ", name=" + name + "]";

    }

    @Override

    public int hashCode() {

        final int prime = 31;

        int result = 1;

        result = prime \* result + age;

        result = prime \* result + ((name == null) ? 0 : name.hashCode());

        return result;

    }

    // Meant to change the equality comparison of the class instances to only look at the values rather than the "hashcode" as well.

    @Override

    public boolean equals(Object obj) {

        if (this == obj)

            return true;

        if (obj == null)

            return false;

        if (getClass() != obj.getClass())

            return false;

        Alien other = (Alien) obj;

        if (age != other.age)

            return false;

        if (name == null) {

            if (other.name != null)

                return false;

        } else if (!name.equals(other.name))

            return false;

        return true;

    }

}

// The whole of the above can be simplified into the following, a RECORD CLASS

record AlienSimplied (int age, String name) implements Cloneable {}

// This creates everything as above including the constructor. This type of constructor is called a canonical constructor.

// Note: "record" cannot extend any other class because it already extends a class called "Record". It can however implement interfaces.

public class RecordClasses {

    public static void main(String[] args) {

        Alien a1 = new Alien(23, "Karongo");

        Alien a2 = new Alien(23, "Karongo");

        System.out.println(a1.equals(a2));

        System.out.println(a1.getAge());

        System.out.println(a1.getName());

        System.out.println(a1);

        AlienSimplied aS1 = new AlienSimplied(23, "Karongo");

        AlienSimplied aS2 = new AlienSimplied(23, "Karongo");

        System.out.println(aS1.equals(aS2));

        System.out.println(aS1.age());          // The record class's getters are as these, they do not contain "get". There are no setters, besides the constructor, because the variables declared are final.

        System.out.println(aS1.name());

        System.out.println(aS1);

    }

}

## **Lombok**

Lombok is a popular third-party java library that helps reduce boilerplate code by automating the generation of common methods like getters, setters, constructors, equals(), hashCode(), and toString(). By using Lombok annotations, developers can simplify code readability and maintenance, making it cleaner and less repetitive.

**Core Features of Lombok**

1. **@Getter and @Setter**: Automatically generates getter and setter methods for class fields.

@Getter @Setter

private String name;

1. **@ToString**: Generates the toString() method, providing a string representation of the object.

@ToString

public class Person { ... }

1. **@EqualsAndHashCode**: Creates implementations for equals() and hashCode() based on the class fields.

@EqualsAndHashCode

public class Person { ... }

1. **@NoArgsConstructor, @AllArgsConstructor**: Automatically generates constructors with no arguments or all fields as parameters.

@NoArgsConstructor @AllArgsConstructor

public class Person { ... }

1. **@Data**: A shorthand for combining multiple Lombok annotations, such as @Getter, @Setter, @ToString, @EqualsAndHashCode, and @RequiredArgsConstructor, in one annotation.

@Data

public class Person { ... }

The key differences between Lombok and “Record” classes are that records are natively supported by the Java language, enforcing immutability, while Lombok is a third-party library that allows more flexibility, including mutable fields. Lombok still remains useful for older Java versions or when features beyond immutability are needed.

package com.housesearchKE.SpringbootJPADemo.model;

import jakarta.persistence.\*;

import lombok.Data;

@Entity

@Table(name = "aliens")

@Data // Generates all the getters and setters, ToString, equalsAndHashode methods.

public class Alien {

    @Id

    @GeneratedValue(strategy = GenerationType.IDENTITY)

    private int id;

    @Column(name = "name")

    private String name;

    @Column(name = "technology")

    private String technology;

}

If using Maven, to be discussed, add the following dependency. Otherwise you have to add the jar file manually to the project.

<dependency>

    <groupId>org.projectlombok</groupId>

    <artifactId>lombok</artifactId>

    <version>1.18.34</version>

    <scope>provided</scope>

</dependency>

# **JUNIT**

This is a unit-testing framework for java. To demonstrate this:

* Create a maven project. Maven is a project building tool, alongside “Gradle”, that is used to configure the project making it easier to manage the same from start (design) to finish (building). Add the JUNIT dependency to pom.xml and save the file. This will add the dependencies to the project in a folder called “Maven Dependencies”.

<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 https://maven.apache.org/xsd/maven-4.0.0.xsd">

  <modelVersion>4.0.0</modelVersion>

  <groupId>com.karongo.learning</groupId>

  <artifactId>JUnitIntroduction-01</artifactId>

  <version>0.0.1-SNAPSHOT</version>

  <dependencies>

    <!-- https://mvnrepository.com/artifact/junit/junit -->

    <dependency>

        <groupId>junit</groupId>

        <artifactId>junit</artifactId>

        <version>4.13.2</version>

        <scope>test</scope> <!-- This dependency will not be included in the build when deploying the project -->

    </dependency>

  </dependencies>

</project>

* Within “src/main” directory, create a class with some function.

package com.introduction.JUnit;

public class StringFunctions {

    public static String reverseString(String inputString) {

        char[] inputCharArray = inputString.toCharArray();

        char[] reversedCharArray = new char[inputString.length()];

        for(int i=inputString.length()-1, j=0; i>=0; i--, j++) {

            reversedCharArray[j] = inputCharArray[i];

        }

        return new String(reversedCharArray);

    }

}

* Within “src/test” directory, create a class that describes a test case then run it.

package com.introduction.JUnit;

import static org.junit.jupiter.api.Assertions.\*;

import org.junit.jupiter.api.Test;

class StringFunctionsTest {

    @Test

// Necessary to make the respective be run as a test case.

// In JUnit 4, this annotation required that the method be declared "public".

// In JUnit 5, this method can be default, protected or public

    void testReverseString() {  // This method checks for failures, not success, such that it only fails if there is a failure and every thing else is considered a success

//      fail("Not yet implemented");        - Invoked to explictly fail the test

//      The third parameter is the error message in the case of a failed assertion

        assertEquals("leinaD", StringFunctions.reverseString("Daniel"));

        assertEquals("avaJ", StringFunctions.reverseString("Java"));

    }

@Test

void testReverseString\_Multiple() {

//      fail("Not yet implemented");

    assertEquals("eman ym si leinaD", StringFunctions.reverseString("Daniel is my name"));

}

}

## **JUNIT5**

This is also a testing framework that is more recent but that is not the same as JUNIT4 (and its predecessors) + a few features. JUNIT5 is a completely different thing.

It provides some APIs that can be used to interact with the testing engine/platforms. These APIS include:

* Jupiter – main API used by JUNIT 5. It contains all the methods, annotations etc. necessary for making the assertions.
* Vintage – JUNIT 5 does not support backward compatibility to the JUNIT 4 series. As such this API is used to run all the test cases that were written in the previous frameworks.
* Extension – Used as an alternative when we do not want to use Jupiter.

### **Junit5 Features**

1. Supplier Interface – For efficiently handling the error messages in the event of a failed assertion (Lazy Evaluation)

package com.introduction.JUnit;

import static org.junit.jupiter.api.Assertions.\*;

import org.junit.jupiter.api.Test;

class StringFunctionsTest {

    @Test

    // Using the Supplier interface to pass the error message. The lambda expression is what denotes the Supplier interface

    void testReverseString\_with\_Supplier\_Interface() {

//      fail("Not yet implemented");

//      The the parameter is the error message in the case of a failed assertion

        assertEquals("leinaD", StringFunctions.reverseString("Daniel"), ()->"Method implemented wrongly");

        assertEquals("avaJ", StringFunctions.reverseString("Java"), ()->"Method implemented wrongly");

    }

}

1. assertNotEquals() – This works in the opposite of how “assertEquals()” works. It fails the test case when the actual and expected values are the same.

@Test

void testReverseString\_AssertNotEquals() {

    assertNotEquals("avaJ", StringFunctions.reverseString("Java"), ()->"Method implemented correctly");

}

1. assertTrue() –Checks if the assertion returns “true”, in which case it passes.

@Test

void testAssertTrue() {

    String str = "Java";

    assertTrue("Java".equals(str), ()->"Failing because result is false");

}

1. assertFalse() – Passes the test if the assertion returns false.

@Test

void testAssertFalse() {

    assertFalse("JUnit5".length()<5), ()->"Failing because result is true"););

}

1. assertArrayEquals() – Passes the test if the arrays being compared:
   * are of the same type
   * have the same number of elements
   * have the same elements
   * have the same order of elements

@Test

void testArrays() {

    int[] actual = {2,3,4,5};

    int[] expected = {5,3,4,2};

    Arrays.sort(expected);

    assertArrayEquals(actual, expected);

//      assertEquals(actual, expected);     Checks the reference variables and is therefore false

}

1. assertThrows() - This passes the test when there is an exception generated within the test case.

@Test

void testArray() {

//      In this case, the lambda expression is compulsory

    assertThrows(NullPointerException.class, ()-> ArraySorting.sortArray(null));

}

1. assertTimeout – This passes when the operation passed is executed within the duration specified

@Test

//  @Test(timeout=100)          // Equivalent for JUNIT 4

void testSortArrayManyTimes() {

//      In this case, the lambda expression is also compulsory

    int unsorted[] = {4,7,2,9,1};

    assertTimeout(Duration.ofMillis(100), ()-> ArraySorting.sortArrayManyTimes(unsorted));

}

### **Junit5 Annotations/ Test Case Life Cycle**

Every test method in a Junit test case is annotated with “@Test”. We may however manipulate the order with which we execute the methods in a test case using annotations such as:

1. @BeforeEach

This makes the method it is associated with run before each method annotated with “Test” such that if there are five “@Test” methods, this “@BeforeEach” annotated method will run five times as well. Used when there are shared operations between the various “@Test” methods.

1. @AfterEach

This makes the method it is associated with run before each method annotated with “Test” such that if there are five “@Test” methods, this “@BeforeEach” annotated method will run five 5 times as well. Also used when there are shared operations between the various “@Test” methods.

1. @BeforeAll

This makes the method it is associated with run before every other method within the test class. This method runs only once and must be a “static” method. For example, a method that establishes the database connection.

1. @AfterAll

This makes the method it is associated with run after every other method within the test class. This method runs only once and must also be a “static” method. For example, a method that closes the database connection.

Also, it is important to note that, by default, new class instances (objects) are created for every “@test” method. This can be verified by the creation of a custom constructor as described below. To change this behavior so that the class instance is created only once, and all the methods be run by that one class, we have to use the “@TestInstance” annotation as described below. Doing this alleviates the necessity to declare the methods under “@BeforeAll” and “@AfterAll” as static because the object will only be one for the class.

@TestInstance(TestInstance.Lifecycle.PER\_CLASS)

//@TestInstance(TestInstance.Lifecycle.PER\_METHOD)      -- This is the default

class JavaTest {

    JavaTest() {

        System.out.println("Test Class Instance being created");

    }

    @BeforeAll

//  @BeforeClass - JUnit 4 equivalent

//  static void beforeAll() {       -- -- Alleviated by the "TestInstance"

    void beforeAll() {

        System.out.println("Before all tests");

    }

    @AfterAll

//  @AftereClass - JUnit 4 equivalent

//  static void afterAll() {        -- Alleviated by the "TestInstance"

    void afterAll() {

        System.out.println("After all tests");

    }

    Java java;

    @BeforeEach

    void init() {

        java = new Java();

        System.out.println("Before Each Test");

    }

    @Test

    void testPurchaseCourseNonStatic() {

        java.purchaseCourseNonStatic();

    }

    @Test

    void testPurchaseCourseNonStaticB() {

        java.purchaseCourseNonStatic();

    }

    @AfterEach

    void destroy() {

        java = new Java();

        System.out.println("After Each Test");

    }

}

Test Class Instance being created

Before all tests

Before Each Test

Java course purchased

After Each Test

Before Each Test

Java course purchased

After Each Test

After all tests

## **Test-Driven Development**

This is where you build the test case first, invoking a dummy entity that will later be developed. This can be done by the project lead as he/she outlines a list functions that need to be implemented and then requires his team to create the said functions. He/she creates tests that those methods listed will need to pass so that when all is done, he/she/they can test the success of the methods.

# **DATA STRUCTURES AND ALGORITHMS**

**Abstract Data Type (ADT)** - This is a concept that implies having a conventional way of storing certain types of data, alongside the sort of operations you can perform on this data; but whose implementation varies from language to language.

**Time Complexity** – This is the measure of how the running time of an algorithm increases as the size of the input data increases. This is denoted using a standard known as the Big O Notation which specifies the relationship between the input data and the number of steps required to find the solution.

The higher the notation in the figure below, the more efficient the algorithm and therefore the more scalable the application (able to handle multiple users concurrently).

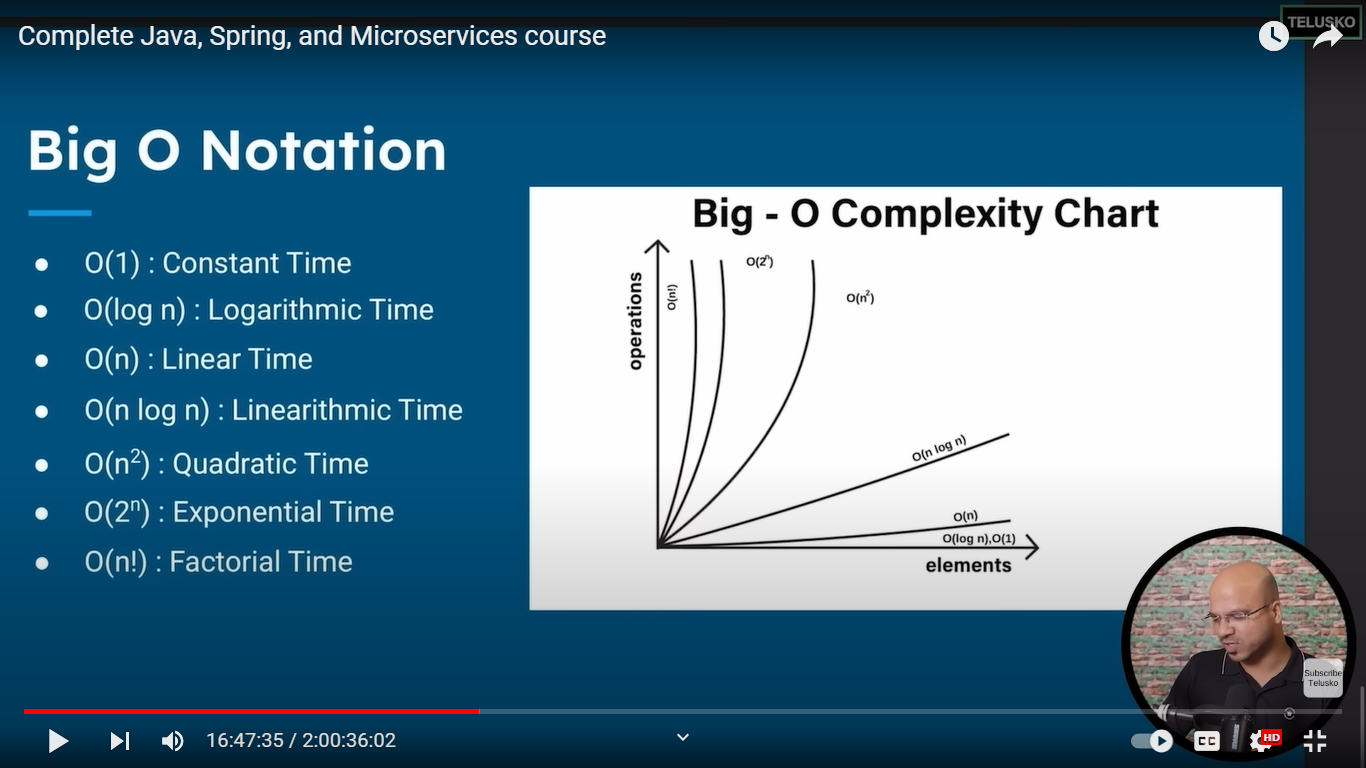


Figure 4: Chart of Big O notations. In increasing order of time complexity

## **Algorithms**

### **Searching Algorithms**

Any Abstract Data Type needs to allow for a read operation. This reading may involve searching for a particular element from within a larger collection of similar-typed values, an array of sorts. To do this searching, there are several search algorithms available:

#### **Linear Search Algorithm**

Elements within the array are looped one by one until the target value is found.

// Returns the index in the array passed of the value specified by looping through the array element by element. To determine the big O notation, we look at the worst case scenario (in this case, if the target value is the last value in the array/ does not exist). The more the numbers in the array, the more the number of steps/iterations necessary to find the index. E.g. If the array has 7 numbers, it will take 7 iterations to find the last value of the array. If it has 1000 numbers, it will take 1000 iterations to do the same.

    public static int linearSearch(int[] arr, int target) {

        int n = arr.length;

        for(int i = 0; i < n; i++) {

            if(arr[i] == target) {                  // O(n) where n is the size of the input array

                return i;

            }

        }

        return -1;

    }

#### **Binary Search Algorithm**

The SORTED array is split into two according to a midpoint that is updated during each iteration until the target value is found. This algorithm has a big O value of O(log n) such that the number of iterations required in the worst case scenario are still significantly less that those it would take to loop through the array one by one.

// Returns the index in the array of the value specified by looping through the array and splitting the array into two during each iteration according to a midpoint, then working with the side that the value being searched for is in, disregarding the rest.

    // To determine the big O notation, we look at the worst case scenario (in this case, if the target value is the last value in the array/ does not exist). The more the numbers in the array, the more the number of steps/iterations necessary to find the index. E.g. If the array has 7 numbers, it will take 3 iterations to find the last value of the array. If it has 1000 numbers, it will take log 1000 (base 2)iterations to do the same.

    public static int binarySearch(int[] arr, int target) {

        int right = arr.length - 1;

        int left = 0;

        int mid;

        while(left <= right) {

            mid = ((left+right)/2)+1;

            if(arr[mid] == target){

                return mid;

            } else if (arr[mid] > target) {                 // O(log n) where n is the size of the input array

                right = mid;

            } else {

                left = mid;

            }

        }

        return -1;

    }

### **Sorting Algorithms**

Some sorting algorithms are very efficient but very difficult to understand. Others are very easy to understand but very inefficient.

The sorting algorithms include bubble sort, selection sort, quick sort, merge sort, heap sort, etc.

#### **Bubble Sort Algorithm**

This is the easiest one to understand but it is not very efficient. It involves looping through an array, one element at a time and swapping the elements, two at a time, if the one before is larger than the one after. Once the looping is done from left to right and the largest value is at the right, the process is repeated but this time up to the second-last value. The procedure is repeated until all the values are in their correct order.

This algorithm has a big O notation value of O(n2) because it involves the use of a nested loop.

private static void bubbleSort(int[] nums) {

    int size = nums.length;

    int temp = 0;

    for(int i=0; i<size; i++) {

        for(int j=0; j<(size-i)-1; j++) {

//  The -1 is because of the last element, i.e, “if(nums[j]>nums[j+1]” will return an “ArrayIndexoutOfBounds” exception if already on the last element.

// The “size-i” is because for iteration of i, i number of elements are in their correct position at the end of the array.

            if(nums[j] > nums[j+1]) {

                temp = nums[j+1];

                nums[j+1] = nums[j];

                nums[j] = temp;

            }

        }

//            To display the array after each iteration

//            System.out.println();

//            for(int num : nums){

//                System.out.print(num + " ");

//            }

    }

}

#### **Selection Sort Algorithm**

This works in a similar manner as bubble sort except for the swapping. Here, swapping only occurs once per iteration, rather than for every pair of elements that are in the wrong order, as happens in the bubble sort algorithm. To do this a tracker variable is used to keep track of the index of the largest element as the array of elements is looped over. At the end of the loop, the value at the end is swapped with the value whose index was held in the tracker variable.

Note the same can be done but swapping according to the smallest element rather than the largest.

Also, selection sort has a time complexity of O(n2), similar to bubble sort because of the use of a nested loop, but it is more efficient because of the significantly fewer number of swaps per iteration.

public class Selection\_Sort {

    public static void main(String[] args) {

        int nums[] = {8, 47, 5, 22, 9, 3, 50, 6};

        System.out.println("Before Sorting");

        for (int num : nums) {

            System.out.print(num + " ");

        }

        System.out.println();

//        selectionSort(nums);

        selectionSortModified(nums);

        System.out.println();

        System.out.println("After Sorting");

        for (int num : nums) {

            System.out.print(num + " ");

        }

    }

    private static void selectionSort(int[] nums) {

        int countOfSorted = 0;

        int maxElement = nums[0];

        int indexOfMaxElement = 0;

        int temp = 0;

        while(countOfSorted != nums.length) {

            for(int i=0; i<((nums.length) - countOfSorted); i++) {

                if(nums[i] > maxElement) {

                    maxElement = nums[i];

                    indexOfMaxElement = i;

                }

                if(i == (((nums.length) - countOfSorted)-1)) {

                    temp = nums[i];

                    nums[i] = nums[indexOfMaxElement];

                    nums[indexOfMaxElement] = temp;

                    countOfSorted++;

                    maxElement=nums[0];

                    indexOfMaxElement=0;

                    i=0;

                    System.out.println();

                    for (int num : nums) {

                        System.out.print(num + " ");

                    }

                }

            }

        }

    }

    private static void selectionSortModified(int[] nums) {

        int maxIndex = 0;

        int temp = 0;

        System.out.println();

        for(int i=0; i<nums.length; i++) {

            for(int j=0; j<(nums.length-i); j++) {

                if(nums[j] > nums[maxIndex]) {

                    maxIndex = j;

                }

            }

//            System.out.print("Elements swapped: " + nums[(nums.length-i)-1] + ", " + nums[maxIndex] + "    [ ");

            temp = nums[(nums.length-i)-1];

            nums[(nums.length-i)-1] = nums[maxIndex];

            nums[maxIndex] = temp;

            for (int num : nums) {

                System.out.print(num + " ");

            }

//            System.out.print("]      Last Element index sorted: " + ((nums.length-i)-1));

            System.out.println();

            maxIndex = 0;

        }

        System.out.println();

    }

}

#### **Insertion Sort**

This algorithm is different from the two previous ones in that it does not involve swapping. Instead it involves shifting elements.

First the array of elements is “divided” into two such that the one part is, initially, considered sorted and the other not sorted. The sorted part is the first element of the array. Each element in the unsorted portion of the array is looped over and compared with each element in the sorted portion of the array. If the adjacent element, in the sorted portion, is larger than the one being looped over in the unsorted portion, then the element is shifted right. Before the element being looped over is placed in the space left, all the other elements in the sorted portion are compared against it and, again, if there is any other element larger than the same, the element is shifted right. Only when there is no larger element to the left of the element being looped over will this element be placed in its correct position.

This algorithm also has a time complexity of O(n2).

 private static void insertionSort(int[] nums) {

    for(int i=1; i<nums.length; i++) {

        int j = 0;

        int currentElement = nums[i];

        j = i-1;

        // Decrementing j means at some point j=-1 which is not a valid index for an array. Also, only shift when the element is larger than the current element

        while(j>=0 && nums[j]>currentElement) {

            nums[j+1] = nums[j];        // Shift the element one place to the right. currentElement holds the element whose place is being taken

            j--;                        // To look at the other elements before the one that has been shifted.

        }

        nums[j+1] = currentElement;

        // For Rendering the array for each iteration.

        for (int num : nums) {

            System.out.print(num + " ");

        }

        System.out.println();

    }

}

#### **Quick Sort**

This algorithm is more efficient than the above ones, having a best case time complexity of O(nlogn). In the worst case, however, it also has a time complexity of O(n2).

It works by dividing the arrays in chunks, sorting these chunks individually, and then combining them at the end. It is very complex. It uses the following concepts: recursion, divide and conquer (the splitting), pivot and tree.

The choosing of the pivot needs to be done on an element that is in its correct final position. Finding this pivot is when most of the work lies.

public class Quick\_Sort {

    public static void main(String[] args) {

        int nums[] = {8, 47, 5, 22, 9, 3, 50, 6, 100, -3, 45, 13};

        System.out.println("Before Sorting");

        for (int num : nums) {

            System.out.print(num + " ");

        }

        System.out.println();

        int low = 0;

        int high = nums.length-1;

        quickSort(nums, low, high);

        System.out.println();

        System.out.println("After Sorting");

        for (int num : nums) {

            System.out.print(num + " ");

        }

    }

    // Takes the array itself, the starting point, and the end point of the section that needs to be sorted. In the beginning, the section will be the whole array but eventually, it will be a smaller and smaller section of the array.

    private static void quickSort(int[] nums, int low, int high) {

        if(low < high) {

            int pivot = partition(nums, low, high);

            // Called twice because the array is split into two, based on the pivot.

            quickSort(nums, low, pivot-1);

            quickSort(nums, pivot+1, high);

        }

    }

    private static int partition(int[] nums, int low, int high) {

        int pivot = nums[high];         // For the first time, the pivot is a always the last element in the array.

        int i = low - 1;

        int temp = 0;

        for(int j=low; j<high; j++) {

            // To determine the correct position of the pivot element

            if(nums[j] < pivot) {

                i++;

                temp = nums[i];

                nums[i] = nums[j];

                nums[j] = temp;

            }

        }

        // To swap the pivot into where, in the array, it should be.

        temp = nums[i+1];

        nums[i+1] = nums[high];

        nums[high] = temp;

        return i+1;

    }

}

#### **Merge Sort**

This algorithm, similar to the quick sort algorithm, is a divide and conquer algorithm. However, it does not involve using a pivot. Instead it involves splitting the array into two parts based on a midpoint (calculated on the indices of the array rather than the elements thems), and dividing these sub-array again and again until they are one-element arrays at the bottom of the tree.

Once they have been split, they are then merged starting from the arrays on the left of the tree, and as they are merged, elements are compared between two arrays at a time, and one element at a time, until the original array is fully merged again.

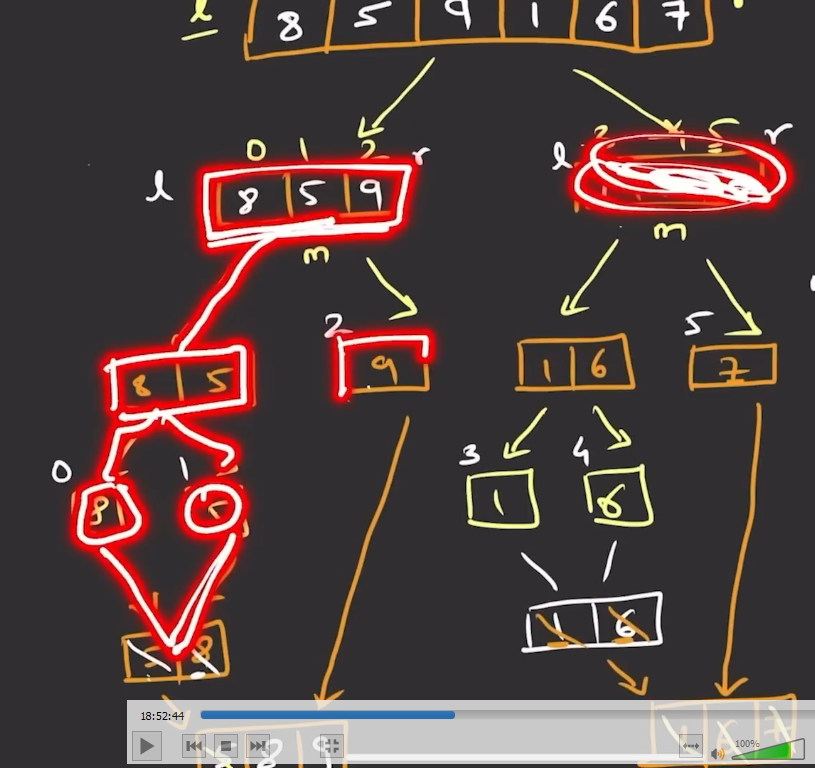


Figure 5: Merge Sort Demonstration

public class Merge\_Sort {

    private static void mergeSort(int[] nums, int left, int right) {

        if(left < right) {

            int mid = (left+right)/2;

            mergeSort(nums, left, mid);

            mergeSort(nums, mid+1, right);

            merge(nums, left, mid, right);

        }

    }

    private static void merge(int[] nums, int left, int mid, int right) {

        int leftArraySize = (mid-left)+1;

        int rightArraySize = right-mid;

        // Create two arrays to hold the elements on either side of the mid-point.

        int[] leftArray = new int[leftArraySize];

        int[] rightArray = new int[rightArraySize];

        // Copy the values from the original array to these newly-created arrays.

        for(int i=0; i<leftArraySize; i++) {

            leftArray[i] = nums[left + i];

        }

        for(int i=0; i<rightArraySize; i++) {

            rightArray[i] = nums[i+mid+1];

        }

        // Start merging the two arrays.

        int i = 0;      // To track the left array

        int j = 0;      // To track the right array

        int k = left;   // To track the original array as it is being modified.

        while(i<leftArraySize && j<rightArraySize) {    // Loop through both the left and right arrays

            if(leftArray[i] <= rightArray[j]) {         // If the left array has the smaller of values being compared, place this smaller number in the original number at the index tracked by k.

                nums[k] = leftArray[i];

                i++;

            } else {            // If the right array has the smaller value, do the same.

                nums[k] = rightArray[j];

                j++;

            }

            k++;    // Move the original array's tracker one place to the right after one element is added from either the left or right array.

        }

        // To handle the elements that remain in either the left or right array. These may been left because one of the sub-arrays was fully looped over having contained more of the smaller elements, forcing the termination of the while loop above.

        while(i<leftArraySize) {

            nums[k] = leftArray[i];

            k++;

            i++;

        }

        while(j<rightArraySize) {

            nums[k] = rightArray[j];

            k++;

            j++;

        }

    }

    public static void main(String[] args) {

        int nums[] = {8, 47, 5, 22, 9, 3, 50, 6, 100, -3, 45, 13};

//        int nums[] = {6,5,4,3,2,1};

        System.out.println("Before Sorting");

        for (int num : nums) {

            System.out.print(num + " ");

        }

        System.out.println();

        mergeSort(nums, 0, nums.length-1);

        System.out.println();

        System.out.println("After Sorting");

        for (int num : nums) {

            System.out.print(num + " ");

        }

    }

}

### **Tips for Determining if your algorithm is good**

* **If the algorithm is not iterating over all/most of the values.** E.g. To print all the even numbers between 1 and 10, the algorithm with a loop that starts at 2 and increments by 2, is more efficient that one that starts at 1, increments by 1, and checks if the number being iterated over is divisible by 2.

## **Data Structures**

### **Linked List**

This is a data structure similar to an array but with some differences. An array:

* Is stored in a continuous block of memory.
* Cannot be extended/ shrunk in size.
* Allows for indexing of its elements and therefore data retrieval from the same is very fast.

A linked list:

* Is a collection of objects known as nodes.
* Allows for the nodes to be stored in different locations on the memory. Each node has two attributes:
  + The data itself that it is supposed to hold.
  + The address of the next node in the list.
* Is extendable/ shrinkable because of the property described above.
* Is slower in terms of data retrieval because it does not support indexing. Rather, to get to a particular node, a loop is necessary to move from the first node in the list, known as the head, to the specific node being searched for.

In java, there is already an implementation of the linked list. This linked list implementation allows for several operations/methods such as:

* insert(value) – To add to the end of the list
* insertAt(index, value) – To a value at a specific “index” of the list.
* insertAtStart(value) – To add at the start/ head of the list.
* delete(value)

However, below is a custom-made linked list. Three classes are necessary to implement the same:

* A “Node” class – To represent the elements (nodes) of the linked list.
* A “LinkedList” class – To represent the linked list itself.
* A “Runner” class – To hold the main method from where the linked list can be created and operated on.

#### **Custom-made Linked List**

package Data\_Structures\_And\_Algorithms.Data\_Structures.Linked\_List;

public class LinkedListRunner {

    public static void main(String[] args) {

        LinkedList list = new LinkedList();

        list.insert(12);

        list.insert(22);

        list.insert(32);

        list.insertAtStart(25);

        list.insertAt(2,67);

        list.insertAt(0,457);

        list.deleteAt(1);

        list.show();

    }

}

package Data\_Structures\_And\_Algorithms.Data\_Structures.Linked\_List;

public class Node {         // To hold the elements of the linked list.

    int data;       // The data itself

    Node next;      // The pointer to the next node in the list.

}

package Data\_Structures\_And\_Algorithms.Data\_Structures.Linked\_List;

public class LinkedList {

    Node head;          // The Linked list must have a head, pointing to the first node. This head is null if there are nodes in the list.

    public void insert(int data) {      // To add a node at the end of the linked list

        Node node = new Node();     // To create a node object

        node.data = data;           // To assign the data being passed to the "data" attribute of the node object.

        if(head == null) {      // True for a list with no nodes yet.

            head = node;        // Assign the newly-created node to the head attribute of the Linked List.

            System.out.println("First Node Being Populated");

        } else {                // When there is at list one other node in the linked list

            Node n = head;      // Take the node in the head attribute of the list.

            while(n.next != null) {     // Loop through all the nodes in the list by moving from one node to the next using the "next" attribute of the nodes. Stop looping when the last node is reached (this last node does not have a "next" attibute. It is null).

                n = n.next;

            }

            n.next = node;      // Assign the newly-created node to the "next" attribute of the current, last node in the list.

            System.out.println("Consequent node being populated");

        }

    }

    public void insertAtStart(int data) {

        Node node = new Node();     // To create a node object

        node.data = data;

        node.next = head;

        head = node;

    }

    public void insertAt(int index, int data) {

        Node node = new Node();     // To create a node object

        node.data = data;

        if(index == 0) {            // If the index is zero, using the loop below will insert the node at index 1.

            insertAtStart(data);

        } else {

            Node n = head;

            for(int i=0; i<index-1; i++) {      // "index-1" because we need to modify the node before the one specified by "index".

                n = n.next;

            }

            node.next = n.next;         // Assign the node that was at the index specified to the newly-created node.

            n.next = node;              // Place the newly-created node at the index specified.

        }

    }

    public void deleteAt(int index) {

        if(index == 0) {

            Node n1 = head;

            head = n1.next;

            n1 = null; // Make the deleted object null so that it is available for garbage collection

        } else {

            Node n = head;

            for(int i=0; i<index-1; i++) {      // "index-1" because we need to modify the node before the one specified by "index".

                n = n.next;

            }

            Node n1 = n.next;

            n.next = n1.next;

            System.out.println(n1.data + " deleted");

            n1 = null; // Make the deleted object null so that it is available for garbage collection

        }

    }

    public void show() {        // To display the values (data) in the list.

        Node node = head;       // Start at the head

        while(node.next != null) {                  // Loop through all the nodes that point to some other node in their "next" attribute.

            System.out.print(node.data + " ");      // Print the "data" attribute of each node.

            node = node.next;                       // Go to the next node.

        }

        System.out.println(node.data);              // Print the "data" of the last node. The one whose "next" attribute is null.

    }

}

### **Stack**

A stack is another abstract data structure, whose implementation varies from language to language, and that works as Last In First Out (LIFO). Operations/methods that can be done/ called on a stack include:

* pop() – returns the lastly entered value and removes it from the top of the stack.
* push(value) – adds a value to the top of the stack.
* peak() - returns the lastly entered value but does not remove it from the top of the stack.
* isEmpty() – returns a boolean that is based on whether the stack has elements or not. True for an empty stack.
* size() – returns the number of elements remaining in the stack, that have not been popped off, that had been pushed into the stack.
* capacity() – returns the number of elements that can be held in a stack. I.e. the size/length of the array.

Note: Pushing data to an already full stack results in an overflow exception. Popping from an empty stack results in an underflow exception.

Again, java has its own implementation of stacks. However, we can created our own custom-stack. To do this we require to modify an array and create a class that will represent the stack entity, so that objects can be created as individual stacks.

Given the nature of arrays, as fixed-sized, we can create two types of stacks: fixed-sized and expandable/shrinkable stacks.

#### **Custom-made Stacks**

##### **Fixed-Sized Stack**

package Data\_Structures\_And\_Algorithms.Data\_Structures.Stack;

public class Stack {

    int stack[] = new int[5];

    int top = 0;

    public int size() {

        return top;

    }

    public int capacity() {

        return stack.length;

    }

    public void push(int data) {

        if(top >= stack.length) {

            System.out.println("Stack already full");

        } else {

            stack[top] = data;

            top++;

        }

    }

    public int pop() {

        int topElement = 0;

        if(top <= 0) {

            System.out.println("No elements remaining to pop");

        } else {

            topElement = stack[top-1];

            stack[top-1] = 0;

            top--;

        }

        return topElement;

    }

    public int peak() {

        int topElement = 0;

        if(top > 0) {

            topElement = stack[top-1];

        }

        return topElement;

    }

    public void show() {

        for(int n : stack) {

            System.out.print(n + " ");

        }

    }

}

##### **Dynamically-Sized Stack**

This involves the creation of two method that expand or shrink the stack based on whether the limit has been reached when pushing or popping respectively.

At the lowest level, it involves creating a new array of a carefully-calculated size based on the size of the existing stack. Once created, elements are copied from the original array to the newly created one and the reference variable of the stack changed to that of the newly-created array.

package Data\_Structures\_And\_Algorithms.Data\_Structures.Stack;

public class StackRunner {

    public static void main(String[] args) {

        Dynamic\_Stack dynamicStack = new Dynamic\_Stack();

        dynamicStack.push(3);

        dynamicStack.push(5);

        dynamicStack.show();

        dynamicStack.push(6);

        dynamicStack.show();

        dynamicStack.push(7);

        dynamicStack.show();

        dynamicStack.push(8);

        dynamicStack.show();

        dynamicStack.push(9);

        dynamicStack.show();

        dynamicStack.push(10);

        dynamicStack.show();

        dynamicStack.push(11);

        dynamicStack.show();

        dynamicStack.push(12);

        dynamicStack.show();

        dynamicStack.pop();

        dynamicStack.show();

        dynamicStack.pop();

        dynamicStack.show();

    }

}

package Data\_Structures\_And\_Algorithms.Data\_Structures.Stack;

public class Dynamic\_Stack {

    int capacity = 2;

    int stack[] = new int[capacity];

    int top = 0;

    public int size() {

        return top;

    }

    public int capacity() {

        return stack.length;

    }

    public void expand() {

        int[] newStack = new int[capacity \* 2];

        System.arraycopy(stack, 0, newStack, 0, stack.length);

        stack = newStack;

        capacity = stack.length;

    }

    public void shrink() {

        int[] newStack = new int[capacity / 2];

        System.arraycopy(stack, 0, newStack, 0, top);

        stack = newStack;

        capacity = stack.length;

    }

    public void push(int data) {

        if(top >= stack.length) {

            expand();

        }

        stack[top] = data;

        top++;

    }

    public int pop() {

        int topElement = 0;

        if(top <= 0) {

            System.out.println("No elements remaining to pop");

        } else {

            if(top <= (capacity / 2)) {

                shrink();

            }

            topElement = stack[top-1];

            stack[top-1] = 0;

            top--;

        }

        return topElement;

    }

    public int peak() {

        int topElement = 0;

        if(top > 0) {

            topElement = stack[top-1];

        }

        return topElement;

    }

    public void show() {

        for(int n : stack) {

            System.out.print(n + " ");

        }

        System.out.println();

    }

}

3 5

3 5 6 0

3 5 6 7

3 5 6 7 8 0 0 0

3 5 6 7 8 9 0 0

3 5 6 7 8 9 10 0

3 5 6 7 8 9 10 11

3 5 6 7 8 9 10 11 12 0 0 0 0 0 0 0

3 5 6 7 8 9 10 11 0 0 0 0 0 0 0 0

3 5 6 7 8 9 10 0

### **Queue**

This is similar to the stack except it uses the “First In First Out” (FIFO) approach rather than the stack’s LIFO. For this reason, it’s implementation involves the use of two variables, one marking the front, and another marking the rear of the queue. Also, the array implementation is known as a circular array. Here, even though the array is linear at the physical level, the “front” and “rear” variables create the illusion of having a circular array. This is done be using the modulus (%) operator when wanting to access the array indices. This is advantageous because the is no necessary swapping/ shifting of values in the queue when an element is dequeued.

The methods involved in queues include:

* enqueue(data) – adds an element to the rear of the queue.
* dequeue() – returns the element at the front of the queue.

#### **Custom-made Queue**

To create a fixed-sized queue:

package Data\_Structures\_And\_Algorithms.Data\_Structures.Queue;

public class Queue {

    int capacity = 5;

    int queue[] = new int[capacity];

    int size;

    int front;

    int rear;

    public void enqueue(int data) {

        if(!isFull()) {

            queue[rear%capacity] = data;

            rear++;

            size++;

        } else {

            throw new ArrayIndexOutOfBoundsException("The queue is full");

        }

    }

    public int dequeue() {

        if(!isEmpty()) {

            int data = queue[front%capacity];

            queue[front%capacity] = 0;

            front++;

            size--;

            return data;

        } else {

            throw new ArrayIndexOutOfBoundsException("The queue is empty");

        }

    }

    public int getSize() {

        return size;

    }

    public boolean isEmpty() {

        return getSize() == 0;

    }

    public boolean isFull() {

        return getSize() == capacity;

    }

    public void show() {

        System.out.print("Queue Elements: ");

        for(int i=0; i<getSize(); i++) {

            System.out.print(queue[(front + i)%capacity] + " ");

        }

        System.out.println();

        System.out.print("Queue Structure: ");

        for(int i=0; i<capacity; i++) {

            System.out.print(queue[i] + " ");

        }

        System.out.println();

    }

}

package Data\_Structures\_And\_Algorithms.Data\_Structures.Queue;

public class Queue\_Runner {

    public static void main(String[] args) {

        Queue queue = new Queue();

        try {

            queue.enqueue(5);

            queue.enqueue(4);

            queue.enqueue(3);

            queue.enqueue(2);

            queue.enqueue(1);

//            queue.enqueue(0);

            queue.dequeue();

            queue.dequeue();

            queue.dequeue();

            queue.enqueue(0);

            queue.enqueue(-1);

        } catch(Exception e) {

            e.printStackTrace();

        }

        queue.show();

    }

}

Queue Elements: 2 1 0 -1

Queue Structure: 0 -1 0 2 1

### **Binary Search Tree**

This ADT is similar to the linked list. However, there are a few differences:

* The elements (nodes) are sorted on insertion.
* The nodes themselves have three attributes rather than the linked list’s two: the data itself, the left node and the right node.

The binary search tree is a subset of the **tree** data structure. Trees have the nodes and edges. Edges are the linked between the nodes, drawn as straight lines. The nodes in turn have children nodes. Consequently, trees can have levels of nodes and children with the level furthest away from the root node having what are known as the leaf nodes.

Nodes also have two attributes: height and depth. Height refers to the number of levels that are directly after the same, similar to the number of descendants but for levels rather than the individual nodes. Depth refers to the number of the levels above the node, from the root node to the one just above the node. For this reason, for example, the root node has a depth of 0 and its height is the same as the height of the tree.

There are several kind of binary trees, beside the binary search tree:

* Strict Tree – where each node has either two or no children.
* Full Binary tree – where all the leaf nodes are on the same level
* Complete tree – where all the leaf nodes are either on the same level or on the level just above the lowest leaf nodes as in:

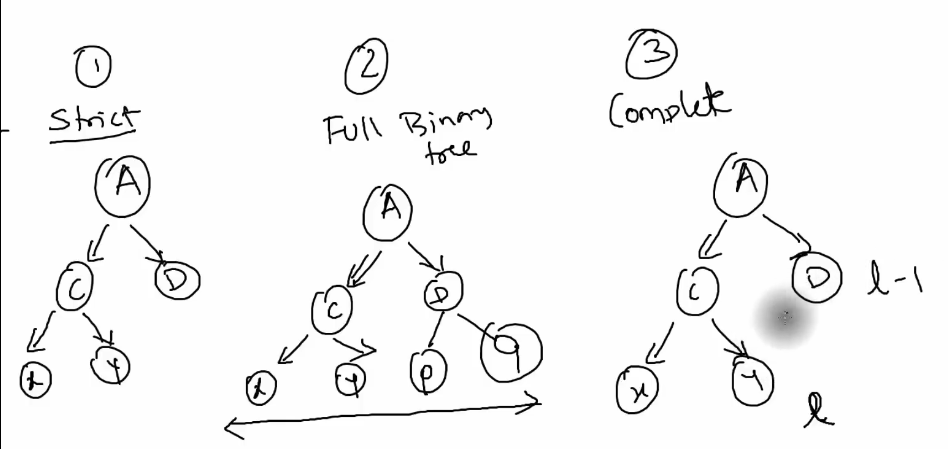


Figure 6: Binary Trees

With the binary search tree, every node has the smaller elements on the left and the bigger elements on the right. There are also several traversal modes across the tree, say during displaying the same:

* In-order – you start with the left, then root, then right nodes, e.g. X, C, Y in the strict binary tree diagram above .
* Pre-order – you start with the root, then the left, then the right nodes, as in C, X, Y.
* Post-order – you start with the left, then the right, then the root nodes, as in X, Y, C.

#### **Custom-made binary search tree:**

To implement a binary search tree:

package Data\_Structures\_And\_Algorithms.Data\_Structures.Binary\_Search\_Tree;

public class Node {

    int data;

    Node left;

    Node right;

    public Node(int data) {

        this.data = data;

    }

}

package Data\_Structures\_And\_Algorithms.Data\_Structures.Binary\_Search\_Tree;

public class BinarySearchTree {

    Node root;

    public void insert(int data) {

        root = insertRec(root, data);

    }

    public Node insertRec(Node root, int data) {

        if(root == null) {

            root = new Node(data);

        } else if (data < root.data) {

            root.left = insertRec(root.left, data);

        } else if (data > root.data) {

            root.right = insertRec(root.right, data);

        }

        return root;

    }

    public void inOrder() {

        System.out.print("In Order: ");

        inOrderRec(root);

        System.out.println();

    }

    public void preOrder() {

        System.out.print("Pre-Order: ");

        preOrderRec(root);

        System.out.println();

    }

//

    public void postOrder() {

        System.out.print("Post-Order: ");

        postOrderRec(root);

        System.out.println();

    }

    public void inOrderRec(Node root) {

        if(root != null) {

            inOrderRec(root.left);

            System.out.print(root.data + " ");

            inOrderRec(root.right);

        }

    }

    public void preOrderRec(Node root) {

        if(root != null) {

            System.out.print(root.data + " ");

            preOrderRec(root.left);

            preOrderRec(root.right);

        }

    }

    public void postOrderRec(Node root) {

        if(root != null) {

            postOrderRec(root.left);

            postOrderRec(root.right);

            System.out.print(root.data + " ");

        }

    }

}

package Data\_Structures\_And\_Algorithms.Data\_Structures.Binary\_Search\_Tree;

public class BinarySearchTreeRunner {

    public static void main(String[] args) {

        BinarySearchTree tree = new BinarySearchTree();

        tree.insert(8);

        tree.insert(7);

        tree.insert(12);

        tree.insert(15);

        tree.insert(2);

        tree.insert(5);

        tree.inOrder();

        tree.preOrder();

        tree.postOrder();

    }

}

In Order: 2 5 7 8 12 15

Pre-Order: 8 7 2 5 12 15

Post-Order: 5 2 7 15 12 8

# **JDBC (JAVA DATABASE CONNECTIVITY)**

This is how you can connect your java application to a database via a database management software (DBMS). There are many kinds of DBMSs available. Some manage relational databases (RDBMS) e.g. MySQL, MariaDB, etc. some NoSQL databases e.g. MongoDB etc. There are 8 steps involved in connecting a java application to a database:

## **Procedure For Connection A Java Application To A Database**

1. Import the SQL package - from “java.sql.\*”.
2. Load the specific DBMS’s driver - e.g. if the DBMS is MySQL, the driver is from “com.mysql.jdbc.Driver”. Download the driver and place it in the libraries, “libs”, folder of your application. Clean the project and build it again if need be.
3. Register the loaded driver - using the “forName” method from the class “Class”, say, “Class.forName(com.mysql.jdbc.Driver)“.
4. Establish the connection between the application and the database – by instantiating the “Connection” interface.
5. Create the SQL statements. There are three kinds of SQL statements:
   1. Statement – normal queries. For DQL (Data Query language) SQL.
   2. PreparedStatement – queries whose values are not provided at compile time. Queries with parameters. For DML (Data Manipulation Language) SQL. E.g. Inserting and updating. Returns the numbers of rows affected. Protect against sql injections such as *“SELECT \* FROM aliens WHERE name = 'admin' AND points = 'anything' OR '1'='1';”* which returns all the records in the table alien.
   3. CallableStatement – queries that emulate the stored procedures in SQL.
6. Execute the queries.
7. Process the results, e.g. if the query was a select queries, the result is a table of records. If the query was an insert query, the response is the number of records affected.
8. Close the database connection

Example code of the above flow of actions:

import java.sql.\*;

public class JDBC {

    public static void main(String[] args) {

        String url = "jdbc:mysql://localhost:3306/students";

        String username = "root";

        String password = "";

        try {

//            Class.forName("com.mysql.jdbc.Driver");           -- Deprecated

            Class.forName("com.mysql.cj.jdbc.Driver");

            Connection conn = DriverManager.getConnection(url, username, password);

            selectQuery(conn);

            insertQuery(conn);

            selectQuery(conn);

            updateQuery(conn);

            selectQuery(conn);

            conn.close();

        } catch (ClassNotFoundException e) {

            throw new RuntimeException(e);

        } catch (SQLException e) {

            throw new RuntimeException(e);

        }

    }

    public static void selectQuery(Connection conn) {

        String selectQuery = "select \* from students";

        try {

            Statement st = conn.createStatement();

            ResultSet rs = st.executeQuery(selectQuery);

            while(rs.next()) {          // rs.next() checks whether there is another record and also, if they is a next record, moves the pointer to the next record.

//                Also, it is important to note that this "rs" pointer is, at first, always before the first record. Therefore, you to "rs.next()" before doing anything if you want to retrieve the record(s) passed.

                System.out.println("Sn: " + rs.getInt("sn") + " Full Name: " + rs.getString("full\_name"));

            }

            System.out.println();

            st.close();

        } catch (SQLException e) {

            throw new RuntimeException(e);

        }

    }

    public static void insertQuery(Connection conn) {

        int sn = 6;

        String fullName = "Ivy Njeri";

        String insertQuery = "insert into students values (?,?)";

        try {

            PreparedStatement st = conn.prepareStatement(insertQuery);

            st.setInt(1, sn);

            st.setString(2, fullName);

            int count = st.executeUpdate();

            System.out.println(count + " rows affected");

            st.close();

        } catch (SQLException e) {

            throw new RuntimeException(e);

        }

    }

    public static void updateQuery(Connection conn) {

        int sn = 5;

        String fullName = "Stella Wambui Kihara";

        String insertQuery = "update students set full\_name = ? where sn = ?";

        try {

            PreparedStatement st = conn.prepareStatement(insertQuery);

            st.setInt(2, sn);

            st.setString(1, fullName);

            int count = st.executeUpdate();

            System.out.println(count + " rows affected");

            st.close();

        } catch (SQLException e) {

            throw new RuntimeException(e);

        }

    }

}

## **Data Access Model With JDBC**

For the sake of simplicity, it is important to hand the database connection outside of the business logic so that this connection logic can be handled in one module of the application rather than having to replicate the same everywhere whenever some database functionality is needed.

To do this, we use what is known as a Data Access Model which, essentially, is a class that has the database connection logic that is then called from other classes and given the parameters needed for the various queries this DAO class supports. It is conventional to store this DAO class in a separate package.

package DataAccessModel;

public class Student {

    String fullName;

    int sn;

    public Student(String name) {

        this.fullName = name;

        this.sn = StudentDAO.getLastSn() + 1;

    }

    public static void addStudent(Student s) {

        StudentDAO.addStudent(s);

    }

    public static void deleteStudent(String studentName) {

        StudentDAO.deleteStudent(studentName);

    }

}

package DataAccessModel;

import java.io.IOException;

import java.util.Scanner;

public class DAORunner {

    public static void main(String[] args) {

        System.out.print("Enter the student's name: ");

        String name = "";

        Scanner sc = new Scanner(System.in);

        name = sc.nextLine();

        Student s = new Student(name);

        Student.addStudent(s);

        System.out.print("Enter the name of the student you want to delete: ");

        name = "";

        name = sc.nextLine();

        sc.close();             // Closed once every input has been entered.

        Student.deleteStudent(name);

    }

}

package DataAccessModel;

import java.sql.\*;

public class StudentDAO {

    static String url = "jdbc:mysql://localhost:3306/students";

    static String username = "root";

    static String password = "";

    public static Connection connect() {

        try {

            Class.forName("com.mysql.cj.jdbc.Driver");

            return DriverManager.getConnection(url, username, password);

        } catch (ClassNotFoundException e) {

            throw new RuntimeException("Driver not found", e);

        } catch (SQLException e) {

            throw new RuntimeException("Connection failed", e);

        }

    }

    public static int getLastSn() {

        String selectQuery = "SELECT MAX(sn) FROM students";

        try (Connection conn = connect();

             Statement st = conn.createStatement();

             ResultSet rs = st.executeQuery(selectQuery)) {

            if (rs.next()) {

                return rs.getInt(1);

            } else {

                return 0;

            }

        } catch (SQLException e) {

            throw new RuntimeException("Error fetching last SN", e);

        }

    }

    public static void addStudent(Student s) {

        String insertQuery = "INSERT INTO students (sn, full\_name) VALUES (?, ?)";

        try (Connection conn = connect();

             PreparedStatement st = conn.prepareStatement(insertQuery)) {

            st.setInt(1, s.sn);

            st.setString(2, s.fullName);

            st.executeUpdate();

            System.out.println(s.fullName + " added as a student");

        } catch (SQLException e) {

            throw new RuntimeException("Error adding student", e);

        }

    }

    public static void deleteStudent(String studentName) {

        String deleteQuery = "DELETE FROM students WHERE full\_name = ?";

        try (Connection conn = connect();

             PreparedStatement st = conn.prepareStatement(deleteQuery)) {

            st.setString(1, studentName);

            int count = st.executeUpdate();

            if (count == 0) {

                System.out.println("No such student in the records");

            } else {

                System.out.println(studentName + " deleted from the record of students");

            }

        } catch (SQLException e) {

            throw new RuntimeException("Error deleting student", e);

        }

    }

}

# **SERVLETS AND JAVA SERVER PAGES (JSP)**

## **Servlets**

Consider a client and server setup. The server machine has a unit known as a web container that handles the dynamic requests from the client, e.g. returning a html file that is non-existent at the moment but whose creation-logic is present in the web container. Within this container are java files known as servlets, which, essentially, are class files that extend a class known as “HttpServlet”. Within this web container, is a unit known as the deployment descriptor which maps the client requests to the necessary servlet, and converts the response from the servlet into a format acceptable for return to the client, e.g. XML, HTML or JSON.

### **Procedure for creating your first Java Servlets project**

1. Ensure you have eclipse installed, *“Eclipse IDE for Enterprise Java and Web Developers - 2024-06”*.
2. Ensure you have tomcat installed. You can download it directly from google or install it as part of XAMPP.
3. Configure the tomcat server on your IDE. Here you will need to pass the directory within which tomcat was installed, e.g., *“C:\xampp\tomcat”*.
4. Create a new project of type “Dynamic Web Project”. Ensure you check the “Generate web.xml deployment descriptor”.
5. Set the newly-configured tomcat as the target runtime for your project. Here, you can right-click on your project > properties > targeted runtimes.
6. Create some html files in your project. Here, right-click on the project and select “new > HTML File”. These will be created within the “src/main/webapp” folder.
7. Create the Servlet classes within the project. Again, right-click on the project and select “new > Servlet”.
8. Link the HTML files with their respective servlet classes from within the “web.xml” deployment descriptor file located within the “src/main/webapp/WEB-INF” folder.

To demonstrate the above:

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body>

    <form action="add">

        Enter the first number: <input type="number" name="num1"><br>

        Enter the second number: <input type="number" name="num2"><br>

        <input type="submit">

    </form>

</body>

</html>

*The HTML that accept two numbers and sends them to the server to be added.*

package com.demo;

import java.io.IOException;

import javax.servlet.http.HttpServlet;

import javax.servlet.http.HttpServletRequest;

import javax.servlet.http.HttpServletResponse;

// This is the class/servlet responsible for the adding.

// Extending the "HttpServlet" makes the class a servlet.

public class AddServlet extends HttpServlet {

    // Servlets implement the services provided by the server hence the method name "service()".

    // The servlet takes the request from the client and returns an response.

    // The "res.getWriter()" may return an IOException and hence the "throws".

    public void service(HttpServletRequest req, HttpServletResponse res) throws IOException {

        int a = Integer.parseInt(req.getParameter("num1"));             // the "getParameter()" returns a string and hence the Integer.parseInt().

        int b = Integer.parseInt(req.getParameter("num2"));

        int sum = a+b;

        res.getWriter().println("The Result is: " + sum);

    }

    //  It is possible to restrict the servlet so that it can only accept either get or post requests. We do this by using the doGet() or doPost() methods instead of service(). E.g. However, the service method in this case and should omitted.

    public void doPost(HttpServletRequest req, HttpServletResponse res) throws IOException {

        int a = Integer.parseInt(req.getParameter("num1"));             // the "getParameter()" returns a string and hence the Integer.parseInt().

        int b = Integer.parseInt(req.getParameter("num2"));

        int sum = a+b;

        res.getWriter().println("The Result is: " + sum);

    }

    public void doGet(HttpServletRequest req, HttpServletResponse res) throws IOException {

        int a = Integer.parseInt(req.getParameter("num1"));             // the "getParameter()" returns a string and hence the Integer.parseInt().

        int b = Integer.parseInt(req.getParameter("num2"));

        int sum = a+b;

        res.getWriter().println("The Result is: " + sum);

    }

}

*The servlet that accepts the numbers sent from the browser, add them and prints out the result.*

<?xml version="1.0" encoding="UTF-8"?>

<web-app xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="http://xmlns.jcp.org/xml/ns/javaee" xsi:schemaLocation="http://xmlns.jcp.org/xml/ns/javaee http://xmlns.jcp.org/xml/ns/javaee/web-app\_3\_1.xsd" id="WebApp\_ID" version="3.1">

  <!-- Each Servlet class requires two XML tags: <servlet> and <servlet-mapping>-->

  <servlet>

    <servlet-name>addingServlet</servlet-name>          <!-- Here the name is arbitrary -->

    <servlet-class>com.demo.AddServlet</servlet-class>          <!-- Here you must provide the fully-qualified class name. I.e the package + class name -->

  </servlet>

  <servlet-mapping>

    <servlet-name>addingServlet</servlet-name>          <!-- Here the name is arbitrary -->

    <url-pattern>/add</url-pattern>         <!-- This is the same url as that called by the "action" attribute of the form -->

  </servlet-mapping>

</web-app>

*The deployment descriptor file that maps the servlet class to the request’s named service.*

### **Calling a servlet from another servlet**

Sometimes it is necessary to call one servlet from another servlet, e.g. to call a servlet that handles the squaring of numbers from one that handles the summing of numbers such that the former returns the square of the sum of the parameters passed.

There are two ways to call servlets from other servlets:

* RequestDispatcher
* sendRedirect

#### **RequestDispatcher**

This is an interface. It can, however, be instantiated using the “request.getRequestDispatcher()” method that is provided in the HttpReceptor package.

Using RequestDispatcher is okay when the servlets belong to the same website (are in the same server) because requestDispatcher does not notify the client/browser that there has been a redirect. In fact the url, on the browser does not change from the one specified on the html form in the “action” attribute.

package com.demo;

import java.io.IOException;

import javax.servlet.RequestDispatcher;

import javax.servlet.ServletException;

import javax.servlet.http.HttpServlet;

import javax.servlet.http.HttpServletRequest;

import javax.servlet.http.HttpServletResponse;

public class AddServlet extends HttpServlet {

    public void service(HttpServletRequest req, HttpServletResponse res) throws IOException, ServletException {

        int a = Integer.parseInt(req.getParameter("num1"));

        int b = Integer.parseInt(req.getParameter("num2"));

        int sum = a+b;

        req.setAttribute("sum", sum);       // There is no available "req.setParameter()" method;

        RequestDispatcher rd = req.getRequestDispatcher("square");          // This takes the servlet url in "<url-pattern>/square</url-pattern>" of the deployment descriptor

        rd.forward(req, res); // Works in the same way as require(file name in php, i.e. even though this servlet calls another file the url on the browser only shows this parent url, and none of the other servlet urls .

    }

}

The caller servlet

  <servlet>

    <servlet-name>squaringServlet</servlet-name>

    <servlet-class>com.demo.SquareServlet</servlet-class>           <!-- Here you must provide the fully-qualified class name. I.e the package + class name -->

  </servlet>

  <servlet-mapping>

    <servlet-name>squaringServlet</servlet-name>

    <url-pattern>/square</url-pattern>          <!-- This is the same url as that called by the "action" attribute of the form -->

  </servlet-mapping>

</web-app>

The xml configuration of the newly-added servlet

package com.demo;

import java.io.IOException;

import java.io.PrintWriter;

import javax.servlet.ServletException;

import javax.servlet.annotation.WebServlet;

import javax.servlet.http.HttpServlet;

import javax.servlet.http.HttpServletRequest;

import javax.servlet.http.HttpServletResponse;

public class SquareServlet extends HttpServlet {

    // The type of method (service, doGet, doPost), even if called from another servlet still restrict the type of method accepted from the browser.

    protected void doPost(HttpServletRequest request, HttpServletResponse response) throws IOException {

        int sum = (int)request.getAttribute("sum");

        int square = sum \* sum;

        PrintWriter out = response.getWriter();

        out.println("The sum is " + sum + " and the square is " + square);

    }

}

The servlet being called

#### **sendRedirect**

Sometimes we may want to notify the client that there is a redirect happening. For example, on Amazon when you click on the checkout button, you will be redirected to a payment gateway, say, paypal.

This works as follows:

* The submit of the form calls a servlet, say s1.
* The servlet triggers the redirect.
* This redirect is a response to the browser, say, r1, telling the same to send another request to the other servlet say s2. This second servlet handles the new request and returns a response, say, r2.

*Note: Using sendRedirect() always creates GET requests rather than POST methods.*

During this triggering of the redirect by the first servlet, there may be a need to pass some data. This can be done in three ways, all of which fall under a concept known as session management:

* URL Rewriting
* Cookies
* Session

##### **sendRedirect with URL Rewriting**

public class AddServlet extends HttpServlet {

    public void doPost(HttpServletRequest req, HttpServletResponse res) throws IOException, ServletException {

        int a = Integer.parseInt(req.getParameter("num1"));

        int b = Integer.parseInt(req.getParameter("num2"));

        int sum = a+b;

        res.sendRedirect("square?sum=" + sum);          // URL Rewriting - This always creates a GET request.

    }

}

public class SquareServlet extends HttpServlet {

    protected void doGet(HttpServletRequest request, HttpServletResponse response) throws IOException {

        int sum = Integer.parseInt(request.getParameter("sum"));

        response.getWriter().println("The sum of the values is " + sum + " and the square of this sum is " + sum \* sum);

    }

}

##### **sendRedirect using Session**

Sometimes we may want to pass multiple parameters without wanting to cluter the URL, or we may have sensitive information we want to pass etc. Passing the same over the URL is risky because the client machine can easily be penetrated illegally. For this reason, it is wiser to store the data within the server where it is more secure. Sessions provide a means using which we can do that.

In the same way that the tomcat server provides the instances of the HttpServletRequest and HttpServletResponse, tomcat also provides the instances of the sessions. As such:

public class AddServlet extends HttpServlet {

    public void doPost(HttpServletRequest req, HttpServletResponse res) throws IOException, ServletException {

        int a = Integer.parseInt(req.getParameter("num1"));

        int b = Integer.parseInt(req.getParameter("num2"));

        int sum = a+b;

        HttpSession session = req.getSession();

        session.setAttribute("sum", sum);

        res.sendRedirect("square");

    }

}

public class SquareServlet extends HttpServlet {

    protected void doGet(HttpServletRequest request, HttpServletResponse response) throws IOException {

        HttpSession session = request.getSession();     // Refers to the same session as the one referenced by the add servlet.

        int sum = (int)session.getAttribute("sum");

        response.getWriter().println("The sum of the values is " + sum + " and the square of this sum is " + sum \* sum);

        session.removeAttribute("sum");         // Remove the attribute from session storage.

    }

}

##### **sendRedirect using Cookies**

This is slightly similar to session except, cookies are sent back to the client as part of the HttpServletResponse. When retrieving the same from the server, from the next servlet, the HttpServletRequest contains all the cookies from the client and the server therefore has to find the one it created from amongst the list of cookies passed by the request, using the key of the cookie.

public class AddServlet extends HttpServlet {

    public void doPost(HttpServletRequest req, HttpServletResponse res) throws IOException, ServletException {

        int a = Integer.parseInt(req.getParameter("num1"));

        int b = Integer.parseInt(req.getParameter("num2"));

        int sum = a+b;

        Cookie cookie = new Cookie("sum", sum + "");        // Adding the empty string converts the integer to a string.

        res.addCookie(cookie);

        res.sendRedirect("square");

    }

}

public class SquareServlet extends HttpServlet {

    protected void doGet(HttpServletRequest request, HttpServletResponse response) throws IOException {

        Cookie cookies[] = request.getCookies();

        int sum = 0;

        for(Cookie c : cookies) {

            if(c.getName().equals("sum")) {

                sum = Integer.parseInt(c.getValue());

            }

        }

        response.getWriter().println("The sum of the values is " + sum + " and the square of this sum is " + sum \* sum);

    }

}

### **ServletContext and ServletConfig**

Sometimes, you may want to specify some parameters outside the individual servlets so that the same can be shared across the servlets, or still do the same but the restrict the parameter’s visibility to a particular servlet. For example, you may want to specify the username, or file location etc. that are used within at least one of the servlets. To do this, we use ServletContext and ServletConfig.

ServletContext provides these parameters to all the servlets. ServletConfig provides the parameters to a particular servlet.

  <servlet>

    <servlet-name>myServlet</servlet-name>

    <servlet-class>com.demo.MyServlet</servlet-class>

    <init-param>                                          <!-- ServletConfig - Restricted to this servlet-->

      <param-name>bodyCount</param-name>

      <param-value>0</param-value>

    </init-param>

  </servlet>

  <servlet-mapping>

    <servlet-name>myServlet</servlet-name>

    <url-pattern>/myServlet</url-pattern>

  </servlet-mapping>

  <context-param>                                        <!-- ServletContext - Available for all the servlets-->

    <param-name>name</param-name>

    <param-value>Daniel</param-value>

  </context-param>

  <context-param>

    <param-name>age</param-name>

    <param-value>23</param-value>

  </context-param>

</web-app>

@WebServlet(name = "MyServlet", urlPatterns = { "/MyServlet" })

public class MyServlet extends HttpServlet {

    private static final long serialVersionUID = 1L;

    protected void service(HttpServletRequest request, HttpServletResponse response) throws ServletException, IOException {

        // ServletContext:

//          - All the servlets can access its parameters

//          - Defined using the <context-param> tag

        ServletContext ctx = getServletContext();

        String name = ctx.getInitParameter("name");

        int age = Integer.parseInt(ctx.getInitParameter("age"));

        response.getWriter().println("Hi " + name + ". You are " + age + " years old");

//      ServletConfig:

//          - Restricted to one servlet, the one within which the parameters are defined.

//          - Defined using the <init-param> tag, with the servlet's <servlet> tag

        ServletConfig cfg = getServletConfig();

        int bodyCount = Integer.parseInt(cfg.getInitParameter("bodyCount"));

        response.getWriter().println("You have slept with " + bodyCount + " people");

    }

}

### **Servlet Annotation Configuration**

We do not need to configure everything on the web.xml deployment descriptor. Instead, we can use annotations on the servlets themselves, passing the URLs of the servlets.

@WebServlet("/add")

public class AddServlet extends HttpServlet {

}

@WebServlet("/square")

public class SquareServlet extends HttpServlet {

}

Following this notation, the forms targeting this servlet files should have their “action” attributes being as:

<form action="add" method="post"> <!-- Note the missing "/"-->

  Enter the first number: <input type="number" name="num1"><br>

  Enter the second number: <input type="number" name="num2"><br>

<input type="submit">

</form>

## **Java Server Pages (JSP)**

Servlets are good but they are also very verbose. For instance, to render a HTML page via servelets, the html tags have to be written within “response.getWriter().println()”. This, if the page is big will lead to the you writing a lot of code.

Java server pages are how that problem was handled. These JSPs are essentially HTML files, that allow for java for to be coded within the same. This java code is separated using “<% java code %>”, known as a scriplet.

To link the HTML files from the client machine to the JSP files in the server, we link the same in the “action” attribute of the forms, where we include the “.jsp” extention.

Also, JSP provide implicit objects such as request and response so that you do not have to explicitly, manually write them down.

However, tomcat can only run servlets. It cannot run JSP files. For this reason, all JSP files are translated in servlets with the class names of the servlets being the JSP file name together with the JSP extension combined into a single name. E.g. “demo.JSP” becomes “DemoJSP”.

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body>

    <form action="add.jsp" method="post">

        Enter the first number: <input type="number" name="num1"><br>

        Enter the second number: <input type="number" name="num2"><br>

        <input type="submit">

    </form>

</body>

</html>

<%@ page language="java" contentType="text/html; charset=UTF-8"

    pageEncoding="UTF-8"%>

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body bgcolor="cyan">

    <%

        int a = Integer.parseInt(request.getParameter("num1"));     // Implicit "request" object

        int b = Integer.parseInt(request.getParameter("num2"));

        int sum = a+b;

        out.println("The sum is " + sum);                           // Implicit "PrintWriter" object

    %>

</body>

</html>

### **Types of tags in JSP**

There are four kinds of tags in JSP:

#### **Directive**

Where you want to specify the imports. Denoted by *“<%@ page import=”someImport, anotherImport” %>”*. Directive tags have three sub-directives:

##### **page**

Used to define page-dependent attributes like scripting language, error pages, buffer size, etc. It has the following attributes:

* language: Specifies the scripting language used in the page, typically set to "java".
* contentType: Defines the MIME (Multipurpose Internet Mail Extensions) type of the response. Default is "text/html".
* import: Used to import Java classes, similar to the import statement in Java.
* session: Indicates whether the page participates in an HTTP session. Default is true.
* buffer: Specifies the buffer size for the output stream.
* autoFlush: Indicates whether the buffer should automatically flush when it is full. Default is true.
* isThreadSafe: Declares whether the JSP page is thread-safe. Default is true.
* errorPage: Defines a JSP page to be used as an error page.
* isErrorPage: Specifies whether the page is an error page. Default is false.
* extends: Specifies a superclass for the JSP-generated servlet.
* info: Provides information about the JSP page.

An example:

<%@ page

    language="java" contentType="text/html; charset=UTF-8" pageEncoding="UTF-8" import="java.util.\*, java.text.\*" session="true" buffer="8kb" autoFlush="true" isThreadSafe="true" errorPage="error.jsp" isErrorPage="false" extends="com.example.CustomServlet" info="This is a JSP page example"

%>

##### **include**

Used to include the content of another file at the time the JSP is translated into a servlet. It’s a static inclusion, meaning that the included content is integrated into the JSP page before the page is processed.

It has one attribute, “file”, that specifies the actual file to be included. For example, To incorporate a header that is common to many pages, simply include the separated-out file that has the header’s design and/or logic:

<%@ include file="header.jsp" %>

##### **taglibs**

Used to declare a tag library containing custom tags that can be used in the JSP page. This directive has two attributes:

* uri: Identifies the URI that references the tag library descriptor (TLD) file.
* prefix: Defines a prefix that will be used in the JSP page to refer to the custom tags.

For example:

<%@ taglib uri="http://java.sun.com/jsp/jstl/core" prefix="c" %>

#### **Declaration**

Where you want to specify the properties of the JSP file’s destination class that are outside the “service()” method, say the global variables. Denoted by *“<%! someClassAttributes %>”*

#### **Scriplet**

Where you specify what you want to go into the service method. Denoted by *“<%%>”*

#### **Expression**

Where you specify what you want to go into the out.println(). Denoted by *“<%= someOutput %>”*. Accepts a single expression only. This expression is not even terminated by a semi-colon.

<%@ page language="java" contentType="text/html; charset=UTF-8"

    pageEncoding="UTF-8"%>

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body bgcolor="cyan">

    <%@ page

        import="javax.servlet.ServletException"

    %>

    <%!

        int sum = 0;

    %>

    <%

        int a = Integer.parseInt(request.getParameter("num1"));

        int b = Integer.parseInt(request.getParameter("num2"));

        sum = a+b;

    %>

    <%=

        "The sum is " + sum

    %>

</body>

</html>

### **Implicit Objects in JSP**

JSP provides several objects that are already initialized by the server and only need to be referenced within the JSP files. These objects can be used within the scriplet and expression directives of the JSPs.

1. request
2. response
3. out
4. session
5. application – this is the “ServletContext”
6. config – this is the “ServletConfig”
7. pageContext – This one is similar to the “ServletContext” and “ServletConfig” except it is, by default, restricted to the page you are on. However, it takes a third parameter that allows you to change the scope to which it is restricted, say to the session. For example:

pageContext.setAttribute("name", "Daniel", PageContext.SESSION\_SCOPE);

1. exception – this gets the exception triggered in the event of an runtime-error. However, it only works in files that are error pages, i.e. with a *“<%@ page isErrorPage=”true” %>”.* It is important to note that JSP allow for the try … catch syntax but this is discouraged. Instead, it is an industry convention to have a dedicated page that shows the errors, hence the “isErrorPage” page attribute.

<%@ page language="java" contentType="text/html; charset=UTF-8"

    pageEncoding="UTF-8" errorPage="errorpage.jsp"%>

    <!-- Note the errorPage="errorpage.jsp" above. This is what links this page to the error page -->

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body bgcolor="cyan">

    <%

        <!-- Discouraged -->

        <!-- try {

            sum = sum / 0;      // Manually triggering an error

        } catch (Exception e) {

            e.getMessage();

        } -->

        sum = sum / 0;      // Manually triggering an error

    %>

</body>

</html>

<%@ page language="java" contentType="text/html; charset=UTF-8"

    pageEncoding="UTF-8" isErrorPage="true"%>

    <!-- Note the "isErrorPage="true"" -->

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body bgcolor = "red">

    <%= "Error: " + exception.getMessage() %>           <!-- The implicit object "exception"-->

</body>

</html>

### **Connecting a database to a JSP file using JDBC**

The procedure for doing this is the same as that used when linking a normal .java file/project to a database. However, it is important to note that when loading the jdbc jar file, you should place it within the “src/main/webapp/WEB-INF/lib” directory.

### **MVC Architecture**

This is an industry standard that works as follows:

* The entities involved are the client machine, The JSP files that are used to only render the user interface/view (V), and the data that is being rendered on the view, known as the model (M). This model data being fed into the view is coming from a controller (C) , that essentially is a servlet.
* The controller servlet should, at the same time, only accept requests from the client and return responses to the same. No business logic should be written within it. For this reason, the controller should have its business logic implemented by another class.

### **Expression Language in JSP (JSP EL)**

According to the MVC model described above, there should be little, to no, java code written within the JSP files, the view. This is probably because the designers of this page are not even java developers. For this reason, the expression languages was developed that simplified the code so that it would be less verbose and allow for the use of short variable-like statements that would hold the model data that was being passed from the controller servlets.

For example, instead of having the JSP file create a variable and initialize this variable with the data gotten from the Session attribute, after first creating a reference to this session, the whole of this logic can be simplified into a single variable, say, ${sessionAttributeName}.

The end result is that EL helps to keep the JSP pages clean by replacing Java scriptlets (<% %>).

@WebServlet("/ProfileController")

public class ProfileController extends HttpServlet {

        protected void service(HttpServletRequest request, HttpServletResponse response) throws ServletException, IOException{

        request.setAttribute("name", "Karongo");       // There is no available "req.setParameter()" method;

        RequestDispatcher rd = request.getRequestDispatcher("/profile.jsp");

//        This will work because the path provided to "getRequestDispatcher()" is relative to the web application's context root even though this file is in a different package altogether.

        rd.forward(request, response);

        }

}

<%@ page language="java" contentType="text/html; charset=UTF-8"

    pageEncoding="UTF-8"%>

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body>

    <!-- <%

        String name = (String)request.getAttribute("name");

    %>

    <%= name %> -->

    <!-- The above can be simplified as: -->

    ${name}

</body>

</html>

### **JSTL (JavaServer Pages Standard Tag Library)**

The JavaServer Pages Standard Tag Library (JSTL) is a powerful collection of tags designed to simplify the development of dynamic web pages in Java-based web applications. JSTL encapsulates common tasks like iteration, conditional processing, and internationalization into a set of easy-to-use tags, making it easier for developers to manage complex logic within JSP pages without embedding Java code directly in the HTML.

JSTL has a close and complementary relationship with JSP Expression Language (EL). For example, JSTL tags can evaluate expressions written in EL. I.e. JSTL core tags, such as <c:out>, <c:if>, and <c:forEach>, often utilize EL to evaluate expressions within the tags. For example, <c:out value="${user.name}" /> uses EL to output the name property of the user object.

#### **Procedure for getting started with JSTL**

* Download the necessary JAR files from the internet. Depending on the source, there are a combination of files, or one file is enough. Also the jstl dependency is also dependent on the tomcat version.
  + jstl-1.2.jar
  + standard.jar (if needed)
* Copy the files and paste them into the “WEB-INF/lib” folder. This will automatically add them into the classpath.
* Define the “taglib” in the JSP file where you want to use them. To do this:
  + Use the <%@ taglib%> directive
  + Set the prefix as any arbitrary string. The convention, however, is ”c”.
  + Set the URI. This is similar to the web.xml deployment descriptor in servlets, i.e, it is a URL that helps to uniquely identify and locate the tag library within the JSP engine. On eclipse, pressing “ctrl+space” when inside the quotes in uri”” will return the list of available URIs and you can then choose “=<http://java.sun.com/jsp/jstl/core>.
* Use the JSTL tags within the file.

#### **Maven configuration for JSTL when using Tomcat 10.1**

<dependency>

    <groupId>jakarta.servlet.jsp.jstl</groupId>

    <artifactId>jakarta.servlet.jsp.jstl-api</artifactId>

    <version>3.0.0</version>

</dependency>

<dependency>

    <groupId>org.glassfish.web</groupId>

    <artifactId>jakarta.servlet.jsp.jstl</artifactId>

    <version>3.0.1</version>

</dependency>

<%@ taglib prefix="c" uri="jakarta.tags.core" %>

#### **JSTL Nuances**

When working with objects, JSTL tags can only work with beans, i.e, objects with defined getters and setters.

public class Student {

    int regNo;

    String Name;

    public Student(int regNo, String name) {

        super();

        this.regNo = regNo;

        Name = name;

    }

    // Not using the getters and setters will result in a nullExceptionPointer

    public int getRegNo() {

        return regNo;

    }

    public void setRegNo(int regNo) {

        this.regNo = regNo;

    }

    public String getName() {

        return Name;

    }

    public void setName(String name) {

        Name = name;

    }

@Override

public String toString() {

    return "Student [regNo=" + regNo + ", Name=" + Name + "]";

}

}

public class ProfileController extends HttpServlet {

    protected void service(HttpServletRequest request, HttpServletResponse response) throws ServletException, IOException{

        Student s = new Student(1, "Karongo");

        request.setAttribute("student", s);

        RequestDispatcher rd = request.getRequestDispatcher("/profile.jsp");

        rd.forward(request, response);

    }

}

<%@ page language="java" contentType="text/html; charset=UTF-8"

    pageEncoding="UTF-8"%>

<%@ taglib prefix="c" uri="http://java.sun.com/jsp/jstl/core" %>

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body>

    <c:out value="${student.name}" />

</body>

</html>

JSTL has many tags as described in the official documentation:

|  |  |
| --- | --- |
| [**catch**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/catch.html) | Catches any Throwable that occurs in its body and optionally exposes it. |
| [**choose**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/choose.html) | Simple conditional tag that establishes a context for mutually exclusive conditional operations, marked by <when> and <otherwise> |
| [**if**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/if.html) | Simple conditional tag, which evalutes its body if the supplied condition is true and optionally exposes a Boolean scripting variable representing the evaluation of this condition |
| [**import**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/import.html) | Retrieves an absolute or relative URL and exposes its contents to either the page, a String in 'var', or a Reader in 'varReader'. |
| [**forEach**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/forEach.html) | The basic iteration tag, accepting many different collection types and supporting subsetting and other functionality |
| [**forTokens**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/forTokens.html) | Iterates over tokens, separated by the supplied delimeters |
| [**out**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/out.html) | Like <%= ... >, but for expressions. |
| [**otherwise**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/otherwise.html) | Subtag of <choose> that follows <when> tags and runs only if all of the prior conditions evaluated to 'false' |
| [**param**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/param.html) | Adds a parameter to a containing 'import' tag's URL. |
| [**redirect**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/redirect.html) | Redirects to a new URL. |
| [**remove**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/remove.html) | Removes a scoped variable (from a particular scope, if specified). |
| [**set**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/set.html) | Sets the result of an expression evaluation in a 'scope' |
| [**url**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/url.html) | Creates a URL with optional query parameters. |
| [**when**](https://docs.oracle.com/javaee/5/jstl/1.1/docs/tlddocs/c/when.html) | Subtag of <choose> that includes its body if its condition evalutes to 'true' |

public class ProfileController extends HttpServlet {

    protected void service(HttpServletRequest request, HttpServletResponse response) throws ServletException, IOException{

        List<Student> students = Arrays.asList(new Student(1, "Karongo"), new Student(2, "Violet"), new Student(3, "Isaac"));

        request.setAttribute("students", students);

        RequestDispatcher rd = request.getRequestDispatcher("/profile.jsp");

        rd.forward(request, response);

    }

}

<body>

    <c:forEach items="${students}" var="s">

        ${s} <br/>

    </c:forEach>

</body>A

#### **JSTL SQL Tags**

JSTL also allows for database connectivity similar to JDBC. However, this functionality should be handled by the Controller implementer in the MVC model.

For example:

<%@ page language="java" contentType="text/html; charset=UTF-8"

    pageEncoding="UTF-8"%>

<%@ taglib prefix="sql" uri="http://java.sun.com/jsp/jstl/sql" %>           <!-- URI for the SQL functions -->

<%@ taglib prefix="c" uri="http://java.sun.com/jsp/jstl/core" %>            <!-- URI for the core JSTL tags -->

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body>

    <sql:setDataSource var="db" driver="com.mysql.cj.jdbc.Driver" url="jdbc:mysql://localhost:3306/students" user="root" password=""/>      <!-- To establish the connectioN. You need:

     the arbitrary name of the variable holding the database (var)

     the jdbc driver (similar procedure as the jdbc except you place the jar file within "WEB-INF/lib") - (driver)

     the url of the db - (url)

     the user name of the database server - (user)

     the password of the database - (password)

-->

<sql:query var="rs" dataSource="${db}">select \* from students</sql:query>

<!-- To specify the sql query itself, you need:

     the arbitrary name of the variable holding the resultset (var)

     the variable holding the database within which the query will be executed. - (dataSource)

     the query itself

-->

    <c:forEach items="${rs.rows}" var="student">

        <c:out value="${student.regNo} : ${student.name}"></c:out>

        </br>

    </c:forEach>

</body>

</html>

#### **JSTL Function tags**

JSTL also provides many functions that can be applied on the content. For example, finding the length of a string:

<%@ page language="java" contentType="text/html; charset=UTF-8"

    pageEncoding="UTF-8"%>

<%@ taglib prefix="sql" uri="http://java.sun.com/jsp/jstl/sql" %>

<%@ taglib prefix="fn" uri="http://java.sun.com/jsp/jstl/functions" %>

<%@ taglib prefix="c" uri="http://java.sun.com/jsp/jstl/core" %>

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body>

    <c:set var="str" value="Karongo is Full Stack Developer. He is proficient in Angular(TS) and Springboot(Java)"/>

    ${str} </br>

    Length: ${fn:length(str)}   </br>

    <c:forEach items="${fn:split(str, ' ')}" var="word">

        ${word} </br>

    </c:forEach>

    Index of "is": ${fn:indexOf(str, "is")} </br>

    <c:if test="${fn:contains(str, 'Java')}">

        Karongo is a Java developer </br>

    </c:if>

    <c:choose>

        <c:when test="${fn:contains(str, 'C#')}">

            Karongo is a C# developer</br>

        </c:when>

        <c:when test="${fn:contains(str, 'Python')}">

            Karongo is a Python developer</br>

        </c:when>

        <c:otherwise>

            Karongo is not mentioned as a C# or Python developer</br>

        </c:otherwise>

    </c:choose>

    <c:if test="${fn:endsWith(str, '(Java)')}">

        Karongo is a proficient Java developer  </br>

    </c:if>

    ${fn:toUpperCase(str)}      </br>

</body>

</html>

## **Filters**

These are classes that lie in between the client and the servlets. Their job is to intercept the Http request and do some validation, stopping the request and returning a response to the client in the event of a failure in the validation of the request. Multiple filters can be configured in what is called a filter chain such that the request is passed onto the next filter if it passes the validation of the current filter. The filters are unaware of each other. The servlets are also unaware of the filter. Also, individual filters can be linked to multiple servlets.

Similar to the servletconfig, filters also have a filterconfig, which is also done on the web.xml deployment descriptor file. These filter classes implement an interface known as “Filter”.

To create a filter simply, on eclipse, right-click on the project > new > filter and then configure the necessary parameters.

<body>

    <a href="addTeacher.html">Add Teacher</a>

    <form action="AddStudent" method="post">

        Enter the id of the student: <input type="number" name="id"><br>

        Enter the name of the student: <input type="text" name="name"><br>

        <input type="submit">

    </form>

</body>

<body>

    <a href="index.html">Add Student</a>

    <form action="AddTeacher" method="post">

        Enter the id of the teacher: <input type="number" name="id"><br>

        Enter the name of the teacher: <input type="text" name="name"><br>

        <input type="submit">

    </form>

</body>

Two views pointing to two different servlets

@WebServlet("/AddStudent")

public class AddStudent extends HttpServlet {

    protected void service(HttpServletRequest request, HttpServletResponse response) throws IOException {

        System.out.println("In Student Servlet");

        int id = Integer.parseInt(request.getParameter("id"));

        String name = request.getParameter("name");

        response.setContentType("text/html");

        response.getWriter().println(id + " : " + name);

    }

}

@WebServlet("/AddTeacher")

public class AddTeacher extends HttpServlet {

    protected void service(HttpServletRequest request, HttpServletResponse response) throws ServletException, IOException {

        System.out.println("In Teacher Servlet");

        int id = Integer.parseInt(request.getParameter("id"));

        String name = request.getParameter("name");

        response.setContentType("text/html");

        response.getWriter().println(id + " : " + name);

    }

}

Two servlets for the two different views.

@WebFilter(urlPatterns={"/AddStudent", "/AddTeacher"})      // Linked to multiple servlets

public class IDFilter implements Filter {

    public void destroy() {

    }

    public void doFilter(ServletRequest request, ServletResponse response, FilterChain chain) throws IOException, ServletException {

        System.out.println("In ID Filter");

        HttpServletRequest req = (HttpServletRequest) request;      // Type-cast the request to be of type "HttpServletRequest"

        int id = Integer.parseInt(req.getParameter("id"));

        if(id >= 1) {

            chain.doFilter(request, response);

        } else {

            response.setContentType("text/html");

            response.getWriter().println("Invalid ID");

        }

    }

    public void init(FilterConfig fConfig) throws ServletException {

    }

}

@WebFilter(urlPatterns={"/AddStudent", "/AddTeacher"})  // Linked to multiple servlets

public class NameFilter implements Filter {

    public void destroy() {

    }

    public void doFilter(ServletRequest request, ServletResponse response, FilterChain chain) throws IOException, ServletException {

        System.out.println("In Name Filter");

        HttpServletRequest req = (HttpServletRequest) request;      // Type-cast the request to be of type "HttpServletRequest"

        String name = req.getParameter("name");

        if(name.length() >= 3) {

            chain.doFilter(request, response);

        } else {

            response.setContentType("text/html");

            response.getWriter().println("Invalid Name");

        }

    }

    public void init(FilterConfig fConfig) throws ServletException {

    }

}

Two different filters each linked to multiple servlets such that the filter intercepts all requests that are headed to any of the linked servlets.

## **Logging In/Out Management using Sessions**

Many times in enterprise-level applications, there is usually a need for logging in so as to access the enterprise’s system. Consequently, there are some views within that enterprise’s website that will be locked such that only a user who is logged can access the said pages.

Also, once the user is done he/she may want to log out. This should be implemented in such a way that if someone presses the back button on the browser after logging out, the restricted pages should still remain locked.

To implement the above, two things are needed:

* To invalidate/clear the session on the server. This session is browser specific such that a user on one browser will still need to log in if he/she wants to access the same pages in a different browser.
* To configure the restricted pages such that they are not cached in the browser and/or proxy servers.

To demonstrate this:

<%@ page language="java" contentType="text/html; charset=UTF-8"

    pageEncoding="UTF-8"%>

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body>

    <form action="login" method="post">

        Enter the user name: <input type="text" name="uname"><br>

        Enter the password: <input type="password" name="pass"><br>

        <input type="submit" value="Submit">

    </form>

</body>

</html>

The first login page

@WebServlet("/login")

public class Login extends HttpServlet {

    protected void doPost(HttpServletRequest request, HttpServletResponse response) throws IOException  {

        String uname = (String) request.getParameter("uname");

        String pass = (String) request.getParameter("pass");

        if(DAO.login(uname, pass)) {

            HttpSession session = request.getSession();

            session.setAttribute("uname", uname);

            response.sendRedirect("welcome.jsp");

        } else {

            response.sendRedirect("login.jsp");

        }

    }

}

The controller called from the login page.

package com.demo.DAO;

import java.sql.Connection;

import java.sql.DriverManager;

import java.sql.PreparedStatement;

import java.sql.ResultSet;

public class DAO {

    static String url = "jdbc:mysql://localhost:3306/students";

    static String username = "root";

    static String password = "";

    public static boolean login(String uname, String pass) {

        try {

            Class.forName("com.mysql.cj.jdbc.Driver");

            // Try-with-resources block for Connection

            try (Connection conn = DriverManager.getConnection(url, username, password)) {

                String query = "select \* from users where username=? and password=?";

                // Try-with-resources block for PreparedStatement

                try (PreparedStatement st = conn.prepareStatement(query)) {

                    st.setString(1, uname);

                    st.setString(2, pass);

                    try (ResultSet rs = st.executeQuery()) {

                        if (rs.next()) {

                            return true;

                        }

                    }

                }

            }

        } catch (Exception e) {

            e.printStackTrace();

            e.getMessage();

            throw new RuntimeException(e);

        }

        return false;

    }

}

The DAO for this login controller

<%@ page language="java" contentType="text/html; charset=UTF-8"

    pageEncoding="UTF-8"%>

<!DOCTYPE html>

<html>

<head>

    <meta charset="UTF-8">

    <title>Insert title here</title>

</head>

<body>

    <%

        // Prevents caching

        response.setHeader("Cache-Control", "no-cache, no-store, must-revalidate");  // HTTP 1.1

        response.setHeader("Pragma", "no-cache");  // HTTP 1.0

        response.setHeader("Expires", "0");  // Proxies

        // Check if the user is logged in

        if (session.getAttribute("uname") == null) {

            response.sendRedirect("login.jsp");

            return;  // Ensure no further code is executed after redirection

        }

    %>

    <!-- Display welcome message and username -->

    Welcome, ${sessionScope.uname}<br>

    <a href="videos.jsp">Videos</a><br>

    <!-- Logout form -->

    <form action="logout" method="post">

        <input type="submit" value="Logout">

    </form>

</body>

</html>

<%@ page language="java" contentType="text/html; charset=UTF-8"

    pageEncoding="UTF-8"%>

<!DOCTYPE html>

<html>

<head>

<meta charset="UTF-8">

<title>Insert title here</title>

</head>

<body>

    <%

        // Prevents caching

        response.setHeader("Cache-Control", "no-cache, no-store, must-revalidate");  // HTTP 1.1

        response.setHeader("Pragma", "no-cache");  // HTTP 1.0

        response.setHeader("Expires", "0");  // Proxies

        // Check if the user is logged in

        if (session.getAttribute("uname") == null) {

            response.sendRedirect("login.jsp");

            return;  // Ensure no further code is executed after redirection

        }

    %>

    <iframe width="560" height="315" src="https://www.youtube.com/embed/4XTsAAHW\_Tc?si=4Axsiu0g0-3Zolyr" title="YouTube video player" frameborder="0" allow="accelerometer; autoplay; clipboard-write; encrypted-media; gyroscope; picture-in-picture; web-share" referrerpolicy="strict-origin-when-cross-origin" allowfullscreen></iframe>

    <!-- This tag is obtained from youtube's share > embed panel-->

</body>

</html>

The pages blocked for all non-logged-in users

@WebServlet("/logout")

public class Logout extends HttpServlet {

    protected void doPost(HttpServletRequest request, HttpServletResponse response) throws IOException{

        HttpSession session = request.getSession();

        session.removeAttribute("uname");

        session.invalidate();               // To clear the session

        response.sendRedirect("login.jsp");     // To redirect to the login page

    }

}

The controller holding the logout logic

# **MAVEN**

Consider the steps we followed to add the jdbc and jstl libraries to the projects. Imagine having a project with very many, such, dependencies. This procedure would be very cumbersome to repeat for all the dependencies. As such, there is need for an automated equivalent to the above.

Maven is a build tool that provide the automation described above. When using maven, all you have to do is specify the dependency you want to include in your project in a file called ”pom.xml”. On saving this file, maven automatically downloads these dependencies and adds them to your project.

To create a maven project in eclipse IDE:

* Go “File > New > Maven Project”.
* Choose the location of the project.
* Select an archetype for your project. This is like the type/template of the project, say a web application, etc.
  + Select the catalog as “Internal”
  + Write a filter, say “web” then select the apache archetype that is left, say, “maven-archetype-webapp”
* Configure the other project details
  + Group ID, e.g. “com.housesearch”
  + Articact ID, e.g.”FileUpload”
  + The package in the above case will be “com.housesearch.FileUpload”
* Wait for the maven initialization downloads to finish.
* Configure the pom.xml to include your desired project dependencies.

## **Maven Example Project – File Uploads**

Create a view from which you can select the files you want to upload.

<html>

<body>

    <h2>Hello World!</h2>

    <form action="upload" method="post" enctype="multipart/form-data">

        <input type="file" name="file" multiple/>

        <br>

        <input type="submit">

    </form>

</body>

</html>

Create a servlet to control the actual file upload:

import java.io.File;

import java.io.IOException;

import java.util.List;

import javax.servlet.http.HttpServlet;

import javax.servlet.http.HttpServletRequest;

import javax.servlet.http.HttpServletResponse;

import javax.servlet.http.HttpSession;

import org.apache.commons.fileupload.FileItem;

import org.apache.commons.fileupload.disk.DiskFileItemFactory;

import org.apache.commons.fileupload.servlet.ServletFileUpload;

public class FileUpload extends HttpServlet {

    protected void doPost(HttpServletRequest request, HttpServletResponse response) throws IOException {

        // Configure the DiskFileItemFactory to use a temporary directory

        DiskFileItemFactory factory = new DiskFileItemFactory();

        File tempDir = (File) request.getServletContext().getAttribute("javax.servlet.context.tempdir");

        factory.setRepository(tempDir);

        HttpSession session = request.getSession();

        // Create a new instance of ServletFileUpload to handle file uploads

        ServletFileUpload sf = new ServletFileUpload(factory);

        try {

            // Get the real path of the "File Uploads" directory relative to the project context

            String uploadDirectory = request.getServletContext().getRealPath("File Uploads");

            // Create the "File Uploads" directory if it doesn't exist

            File uploadDir = new File(uploadDirectory);

            if (!uploadDir.exists()) {

                uploadDir.mkdirs();

            }

            // Parse the request to get all the uploaded files

            List<FileItem> files = sf.parseRequest(request);

            // Iterate over each uploaded file

            for (FileItem file : files) {

                // Print the name of the uploaded file to the console (for debugging purposes)

                System.out.println(file.getName());

                // Handle duplicate file names by checking if the file already exists

                File uploadedFile = new File(uploadDir, file.getName());

                if (uploadedFile.exists()) {

                    // Generate a unique file name if a file with the same name exists

                    String baseName = file.getName().substring(0, file.getName().lastIndexOf('.'));

                    String extension = file.getName().substring(file.getName().lastIndexOf('.'));

                    int count = 1;

                    // Increment the count until a unique name is found

                    while (uploadedFile.exists()) {

                        String newFileName = baseName + "\_" + count + extension;

                        uploadedFile = new File(uploadDir, newFileName);

                        count++;

                    }

                }

                // Write the file to the "File Uploads" directory

                file.write(uploadedFile);

                // Delete the temporary file used during the upload process

                if (!file.isInMemory()) {

                    file.delete();

                }

            }

            session.setAttribute("fileUploadSuccess", "true");

            System.out.println("About to redirect after a success");

            // Redirect to a success page (PRG pattern)

            response.sendRedirect("afterUpload.jsp");

        } catch (Exception e) {

            // Handle any exceptions that occur during file upload

            System.out.println(e.getMessage());

            session.setAttribute("fileUploadSuccess", "false");

            response.sendRedirect("afterUpload.jsp"); // Redirect on error

        }

    }

}

Create a view to redirected to after the upload are done. This is important so that in the event that the user reloads the page after the download is done, the server does not re-upload the same file(s) again.

<%@ taglib prefix="c" uri="http://java.sun.com/jstl/core" %>

<!DOCTYPE html>

<html>

<head>

    <title>Upload Success</title>

</head>

<body>

    <c:if test="${sessionScope.fileUploadSuccess == 'true'}">

        <h1>Files Uploaded Successfully</h1><br>

           <a href="index.jsp">Upload another file</a>

    </c:if>

    <c:if test="${sessionScope.fileUploadSuccess == 'false'}">

        <h1>File Upload Failed.</h1><br>

            <a href="index.jsp">Please try again</a>

    </c:if>

    Hello

</body>

</html>

# **HIBERNATE**

Hibernate is an ORM (Object Relational Mapping) tool that bridges the gap between DBMSs and the java applications. Originally, this connection was done via JDBC but with Hibernate, we don’t even need to write SQL queries. For example to save an object to a record in a table in a database we can simply say “save(object)”.

This mapping works as follows:

The tables in the database are essentially classes in the java applications. The columns of the tables are the class attributes. Objects are the records in the tables.

## **Sample Hibernate Project**

1. Create a simple maven project.
2. Add hibernate and DBMS connector dependencies to the pom.xml file.

<dependencies>

    <dependency>

      <groupId>junit</groupId>

      <artifactId>junit</artifactId>

      <version>3.8.1</version>

      <scope>test</scope>

    </dependency>

    <!-- https://mvnrepository.com/artifact/org.hibernate.orm/hibernate-core -->

  <dependency>

      <groupId>org.hibernate.orm</groupId>

      <artifactId>hibernate-core</artifactId>

      <version>6.6.0.Final</version>

  </dependency>

  <dependency>

      <groupId>com.mysql</groupId>

      <artifactId>mysql-connector-j</artifactId>

      <version>9.0.0</version>

  </dependency>

  </dependencies>

1. Install a Hibernate configuration plugin to the IDE, say, the JBoss plugin.
2. Create a Hibernate configuration file (hibernate.cfg.xml) and configure the database connection settings. This file should be under “src/main/resources” and this folder configured as the “resources” folder of the project. Also, you add a property that updates the database automatically, creating where none exists and updating where something exists, e.g. tables.

<?xml version="1.0" encoding="UTF-8"?>

<!DOCTYPE hibernate-configuration PUBLIC

    "-//Hibernate/Hibernate Configuration DTD 3.0//EN"

    "http://www.hibernate.org/dtd/hibernate-configuration-3.0.dtd">

<hibernate-configuration>

    <session-factory>

        <property name="hibernate.connection.driver\_class">com.mysql.cj.jdbc.Driver</property>

        <property name="hibernate.connection.url">jdbc:mysql://localhost:3306/javarefresher?createDatabaseIfNotExist=true</property>

        <property name="hibernate.connection.username">root</property>

        <property name="hibernate.dialect">org.hibernate.dialect.MySQLDialect</property>

        <property name="hbm2ddl.auto">update</property>

    </session-factory>

<property name="show\_sql">true</property>

<property name="hibernate.format\_sql">true</property>

</hibernate-configuration>

1. Create an entity class and specify its attributes.

package com.housesearchKE.DemoHibernate;

import jakarta.persistence.Column;

import jakarta.persistence.Entity;

import jakarta.persistence.GeneratedValue;

import jakarta.persistence.GenerationType;

import jakarta.persistence.Id;

import jakarta.persistence.Table;

@Entity

@Table(name = "developers") // Optional: If you want to specify a custom table name

public class Developer {

  @Id

  @GeneratedValue(strategy = GenerationType.IDENTITY) // AUTO\_INCREMENT equivalent

  @Column(name = "sn") // Optional: If your column name is different in the database

  private int sn;

  @Column(name = "full\_name") // Optional: Maps this field to the full\_name column

  private String full\_name;

  @Column(name = "technology") // Optional: Maps this field to the technology column

  private String technology;

  // Default constructor required by Hibernate

  public Developer() {}

  public Developer(String full\_name, String technology) {

    this.full\_name = full\_name;

    this.technology = technology;

  }

  // Getters and Setters

  public int getSn() {

    return sn;

  }

  public void setSn(int sn) {

    this.sn = sn;

  }

  public String getFull\_name() {

    return full\_name;

  }

  public void setFull\_name(String full\_name) {

    this.full\_name = full\_name;

  }

  public String getTechnology() {

    return technology;

  }

  public void setTechnology(String technology) {

    this.technology = technology;

  }

  @Override

  public String toString() {

    return "Developer [sn=" + sn + ", full\_name=" + full\_name + ", technology=" + technology + "]";

  }

}

1. Create another class to instantiate and save the entity objects.
2. Create an object of the “Configuration” class, link it to the Hibernate configuration file and add the entity class to this object.
3. Create an object of the “ServiceRegistry” class that gathers all necessary configurations.
4. Create an object of the “SessionFactory“ class that manages all database interactions.
5. Open a session that opens a specific communication channel to actually perform database operations.
6. Begin a transaction because Hibernate requires the ACID properties of databases to be kept.
7. Save/ persist the Developer object
8. Commit the transaction
9. Close the session
10. Close the SessionFactory.

package com.housesearchKE.DemoHibernate;

import org.hibernate.Session;

import org.hibernate.SessionFactory;

import org.hibernate.Transaction;

import org.hibernate.cfg.Configuration;

import org.hibernate.boot.registry.StandardServiceRegistryBuilder;

import org.hibernate.service.ServiceRegistry;

public class App {

    public static void main(String[] args) {

        Developer dev = new Developer("Daniel Karongo", "Java");

        // Create configuration and add annotated class

        Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class);

        // Create ServiceRegistry

        ServiceRegistry reg = new StandardServiceRegistryBuilder()

                                  .applySettings(con.getProperties())

                                  .build();

        // Build SessionFactory

        SessionFactory sf = con.buildSessionFactory(reg);

        // Open a session

        Session session = sf.openSession();

        // Begin transaction

        Transaction tx = session.beginTransaction();

        // Persist the Developer object

        //        session.save(dev);      - Deprecated

        session.persist(dev);

        // Commit the transaction

        tx.commit();

        // Close the session

        session.close();

        // Close the SessionFactory

        sf.close();

    }

}

## **Annotations in Hibernate**

Hibernate provides a wide range of annotations to map Java classes to database tables, and to configure how the properties of those classes relate to columns in the database. These annotations come from the JPA (Java Persistence API) specification as well as from Hibernate-specific extensions.

Core JPA Annotations (Used in Hibernate)

1. @Entity - Marks a class as a persistent entity, meaning it will map to a table in the database.
2. @Table - Specifies the name of the database table that the entity maps to.Example: @Table(name = "developers")
3. @Id - Specifies the primary key of the entity.
4. @GeneratedValue - Specifies how the primary key should be generated (e.g., auto-increment). Example: @GeneratedValue(strategy = GenerationType.IDENTITY)
   1. GenerationType.AUTO - It's the default strategy that lets Hibernate choose the generation strategy based on the underlying database.
   2. GenerationType.IDENTITY - Uses the identity column feature in databases that support it (like MySQL). The database automatically generates a unique identifier for the primary key.
   3. GenerationType.SEQUENCE - Uses a database sequence to generate unique identifiers. It’s often used with databases like PostgreSQL and Oracle. You can specify a custom sequence using the @SequenceGenerator annotation.
   4. GenerationType.TABLE - This strategy uses a special table in the database to generate unique identifiers. It’s a fallback for databases that don’t support sequences or identity columns.
5. @Column - Specifies the name of the database column that a field maps to and its properties like nullable, length, etc. Example: @Column(name = "full\_name", nullable = false, length = 100)
6. @OneToOne - Defines a one-to-one relationship between two entities. Example: @OneToOne(mappedBy = "developer")
7. @OneToMany - Defines a one-to-many relationship, where one entity is related to multiple entities. Example: @OneToMany(mappedBy = "developer")
8. @ManyToOne - Defines a many-to-one relationship, where many entities are related to one entity. Example: @ManyToOne
9. @ManyToMany - Defines a many-to-many relationship between entities. Example: @ManyToMany(mappedBy = "developers")
10. @JoinColumn - Specifies the column that joins two entities in a relationship. Example: @JoinColumn(name = "developer\_id")
11. @JoinTable - Specifies the table used for a many-to-many relationship. Example: @JoinTable(name = "developer\_project", joinColumns = @JoinColumn(name = "developer\_id"), inverseJoinColumns = @JoinColumn(name = "project\_id"))
12. @Embedded - Used to embed a value object or another entity inside an entity.
13. @Embeddable - Marks a class whose instances are stored as an intrinsic part of the owning entity.
14. @Transient - Indicates that a field should not be persisted in the database.
15. @Lob - Marks a field for storing large objects (like BLOB or CLOB).
16. @Temporal - Specifies the date/time precision for a field (e.g., DATE, TIME, TIMESTAMP). Example: @Temporal(TemporalType.DATE)
17. @Enumerated - Specifies that a field should be persisted as an enumerated type. Example: @Enumerated(EnumType.STRING)
18. @Version - Used for optimistic locking by maintaining a version field in the entity.
19. @MappedSuperclass - Indicates that the class is a superclass whose fields are inherited by subclasses but is not an entity itself.
20. @Inheritance - Specifies the inheritance strategy for an entity hierarchy. Example: @Inheritance(strategy = InheritanceType.SINGLE\_TABLE)
21. @DiscriminatorColumn - Used in single-table inheritance to differentiate between entity types. Example: @DiscriminatorColumn(name = "entity\_type")
22. @DiscriminatorValue - Specifies the value to use for a particular entity type in the discriminator column. Example: @DiscriminatorValue("Developer")

Hibernate-Specific Annotations

1. @NaturalId - Marks a field as a natural ID, which is an alternate key that uniquely identifies a record.
2. @Formula - Allows mapping a field to a SQL expression instead of a column.
3. @Generated - Marks a property as generated by the database and not to be inserted during insert/update.
4. @Fetch - Specifies the fetching strategy (FetchType.EAGER, FetchType.LAZY).
5. @Cascade - Defines cascading of operations (e.g., save, delete) to related entities.
6. @Type - Used to specify a custom type for a field. Example: @Type(type = "org.hibernate.type.StringType")
7. @DynamicUpdate - Instructs Hibernate to generate dynamic SQL for updates, only including the changed fields.
8. @DynamicInsert - Instructs Hibernate to generate dynamic SQL for inserts, only including non-null fields.
9. @Any and @AnyMetaDef - Used to define a polymorphic association to any entity that can be stored in a specific table.
10. @Filter - Used to apply a filter condition to an entity or collection.
11. @BatchSize - Specifies the size of batches to be loaded at once for collections.
12. @Where - Adds a SQL fragment to the generated SQL for the annotated entity or collection.

## **Fetching Data using Hibernate**

The procedure for this is similar to the one for saving except for the method called on the session, I.e., “get” or “load”.

public class App {

    public static void main(String[] args) {

        Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class);

        ServiceRegistry reg = new StandardServiceRegistryBuilder()

                                  .applySettings(con.getProperties())

                                  .build();

        SessionFactory sf = con.buildSessionFactory(reg);

        Session session = sf.openSession();

        Transaction tx = session.beginTransaction();

        Developer dev = session.get(Developer.class, 2);    // Takes the class and the primary key value as parameters

        tx.commit();

        session.close();

        sf.close();

        System.out.println(dev);

    }

}

There are differences between the “get” and “load” methods:

1. “Get” fires a query on the database whenever the method is called. “Load” only fires the query when the object, into which the retrieved record will be initialized, is used.
2. “Get” does not return an exception when there is no data in the that matches the specific criteria. "It returns null. “Load”, on the other hand, throws an “ObjectNotFoundException” if the requested object is accessed but does not exist."

## **Embeddables in Hibernate**

These are classes whose objects are saved as part of the object of another class that has been configured as an entity. For example, we may have a class called “FullName” that has “surname”, “first\_name” and “last\_name” as class attributes. Another class that is also an entity, say “Student”, may have an attribute “student\_name” whose type is the class “FullName”. This “FullName” is what is called an “Embeddable”.

package com.housesearchKE.DemoHibernate;

import jakarta.persistence.Embeddable;

@Embeddable

public class FullName {

  private String surname;

  private String first\_name;

  private String last\_name;

  public String getSurname() {

    return surname;

  }

  public void setSurname(String surname) {

    this.surname = surname;

  }

  public String getFirst\_name() {

    return first\_name;

  }

  public void setFirst\_name(String first\_name) {

    this.first\_name = first\_name;

  }

  public String getLast\_name() {

    return last\_name;

  }

  public void setLast\_name(String last\_name) {

    this.last\_name = last\_name;

  }

  // No-argument constructor (required by Hibernate)

    public FullName() {}

  public FullName(String surname, String first\_name, String last\_name) {

    super();

    this.surname = surname;

    this.first\_name = first\_name;

    this.last\_name = last\_name;

  }

  @Override

  public String toString() {

    return "FullName [surname=" + surname + ", first\_name=" + first\_name + ", last\_name=" + last\_name + "]";

  }

}

package com.housesearchKE.DemoHibernate;

import jakarta.persistence.Column;

import jakarta.persistence.Entity;

import jakarta.persistence.GeneratedValue;

import jakarta.persistence.GenerationType;

import jakarta.persistence.Id;

import jakarta.persistence.Table;

@Entity

@Table(name = "developers")

public class Developer {

  @Id

  @GeneratedValue(strategy = GenerationType.IDENTITY)

  @Column(name = "sn")

  private int sn;

  @Column(name = "full\_name")

  private FullName full\_name;

  @Column(name = "technology")

  private String technology;

  // Default constructor required by Hibernate

  public Developer() {}

  public Developer(FullName full\_name, String technology) {

    this.full\_name = full\_name;

    this.technology = technology;

  }

  public int getSn() {

    return sn;

  }

  public void setSn(int sn) {

    this.sn = sn;

  }

  public FullName getFull\_name() {

    return full\_name;

  }

  public void setFull\_name(FullName full\_name) {

    this.full\_name = full\_name;

  }

  public String getTechnology() {

    return technology;

  }

  public void setTechnology(String technology) {

    this.technology = technology;

  }

  @Override

  public String toString() {

    return "Developer [sn=" + sn + ", full\_name=" + full\_name + ", technology=" + technology + "]";

  }

}

public class App {

    public static void main(String[] args) {

      Developer dev = new Developer(new FullName("Njuguna", "Jecinta", "Wangui"), "Typescript");

      Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class);

      ServiceRegistry reg = new StandardServiceRegistryBuilder()

                                .applySettings(con.getProperties())

                                .build();

      SessionFactory sf = con.buildSessionFactory(reg);

      Session session = sf.openSession();

      Transaction tx = session.beginTransaction();

      session.persist(dev);

      tx.commit();

      session.close();

      sf.close();

      System.out.println(dev);

    }

}

## **Mapping Relations In Hibernate**

Consider two entities: Laptop and Student.

Consider the following scenarios:

### **One-To-One Relationships**

One student can only have one laptop

This is a one-to-one relationship. Drawing an entity relationship diagram (ERD) would entail having a foreign key on either of the tables, probably on the Student table. In hibernate. This mapping can be done using the “@OneToOne” annotation.

package com.housesearchKE.DemoHibernate;

import jakarta.persistence.\*;

@Entity

@Table(name="laptops")

public class Laptop {

    @Id

    @GeneratedValue(strategy = GenerationType.IDENTITY)

    private int sn;

    private String manufacturer;

    private String model;

    public int getSn() { return sn; }

    public void setSn(int sn) { this.sn = sn; }

    public String getManufacturer() { return manufacturer; }

    public void setManufacturer(String manufacturer) { this.manufacturer = manufacturer; }

    public String getModel() { return model; }

    public void setModel(String model) { this.model = model; }

    public Laptop(String manufacturer, String model) {

      this.manufacturer = manufacturer;

      this.model = model;

    }

    public Laptop() {}

    @Override

    public String toString() {

        return "Laptop{" + "sn=" + sn + ", manufacturer='" + manufacturer + '\'' + ", model='" + model + '\'' + '}';

    }

}

Laptop class/entity

package com.housesearchKE.DemoHibernate;

import jakarta.persistence.\*;

@Entity

@Table(name = "students")

public class Student {

    @Id

    @GeneratedValue(strategy = GenerationType.IDENTITY)

    private int sn;

    private FullName name;

    @Column(name = "year\_of\_study")

    private int yearOfStudy;

    private double gpa;

    @OneToOne

    private Laptop laptop;

    public Student() {

    }

    public Student(FullName name, int yearOfStudy, double gpa, Laptop laptop) {

        this.name = name;

        this.yearOfStudy = yearOfStudy;

        this.gpa = gpa;

        this.laptop = laptop;

    }

    public int getSn() { return sn; }

    public void setSn(int sn) { this.sn = sn; }

    public FullName getName() { return name; }

    public void setName(FullName name) { this.name = name; }

    public int getYearOfStudy() { return yearOfStudy; }

    public void setYearOfStudy(int yearOfStudy) { this.yearOfStudy = yearOfStudy; }

    public double getGpa() { return gpa; }

    public void setGpa(double gpa) { this.gpa = gpa; }

    public Laptop getLaptop() { return laptop; }

    public void setLaptop(Laptop laptop) { this.laptop = laptop; }

    @Override

    public String toString() {

        return "Student{" + "sn=" + sn + ", name=" + name + ", yearOfStudy=" + yearOfStudy + ", gpa=" + gpa + ", laptop=" + laptop + '}';

    }

Student class/entity

package com.housesearchKE.DemoHibernate;

import org.hibernate.Session;

import org.hibernate.SessionFactory;

import org.hibernate.Transaction;

import org.hibernate.boot.registry.StandardServiceRegistryBuilder;

import org.hibernate.cfg.Configuration;

import org.hibernate.service.ServiceRegistry;

public class App {

    public static void main(String[] args) {

      Laptop laptop1 = new Laptop("HP", "840 G3");

      Laptop laptop2 = new Laptop("HP", "Pavilion");

      Student student1  = new Student(new FullName("Kungu", "Daniel", "Karongo"), 4, 64.82, laptop1);

      Student student2  = new Student(new FullName("Kungu", "Victor", "Maina"), 4, 64.82, laptop2);

      Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class).addAnnotatedClass(Laptop.class).addAnnotatedClass(Student.class);

      ServiceRegistry reg = new StandardServiceRegistryBuilder()

                                .applySettings(con.getProperties())

                                .build();

      SessionFactory sf = con.buildSessionFactory(reg);

      Session session = sf.openSession();

      Transaction tx = session.beginTransaction();

      session.persist(laptop1);

      session.persist(laptop2);

      session.persist(student1);

      session.persist(student2);

      tx.commit();

      session.close();

      sf.close();

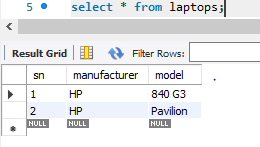
      System.out.println(student1);

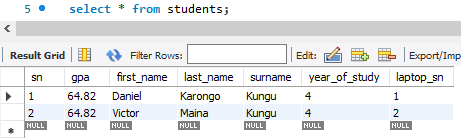
      System.out.println(student2);

    }

}

Main class





### **One-To-Many Relationships**

1. One student can have many laptops

This is a one-to-many relationship. Drawing an ERD would entail having a foreign key on the laptops table so that each laptop record can have a reference to a student record. In hibernate. This mapping can be done using the “@OneToMany” annotation on the parent table (students) alongside a “mappedBy” attribute pointed to the same annotation having the a value of the field of the child entity (Laptop).

@Entity

@Table(name="laptops")

public class Laptop {

    @ManyToOne          // Many laptops can be owned by one student. Consequently, each laptop record will have a foreign key pointing to the student who owns it.

    private Student student;

    public Laptop(String manufacturer, String model) {

        this.manufacturer = manufacturer;

        this.model = model;

    }

}

The Laptop entity

@Entity

@Table(name = "students")

public class Student {

  @OneToMany(mappedBy="student")      // So that "students" table can let the foreign key be assigned to the "laptops" table, rather than have a new composite table created.

  private List<Laptop> laptops;

  public Student(FullName name, int yearOfStudy, double gpa, List<Laptop> laptops) {

      this.name = name;

      this.yearOfStudy = yearOfStudy;

      this.gpa = gpa;

      this.laptops = laptops;

  }

  .

  .

  .

}

The student entity

public class App {

    public static void main(String[] args) {

      Laptop laptop1 = new Laptop("HP", "840 G3");

      Laptop laptop2 = new Laptop("HP", "Pavilion");

      Laptop laptop3 = new Laptop("Dell", "Inspiron 15");

      Laptop laptop4 = new Laptop("Dell", "XPS 14");

//    Passing the list of laptops when creating the Student objects, logically links the Laptop objects to the Student objects.

      Student student1  = new Student(new FullName("Kungu", "Daniel", "Karongo"), 4, 64.82, Arrays.asList(laptop1,laptop2));

      Student student2  = new Student(new FullName("Kungu", "Victor", "Maina"), 4, 64.82, Arrays.asList(laptop3,laptop4));

//    For the database to reflect this relationship properly, you must also set the Student reference in each Laptop object

      laptop1.setStudent(student1);

      laptop2.setStudent(student1);

      laptop3.setStudent(student2);

      laptop4.setStudent(student2);

      Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class).addAnnotatedClass(Laptop.class).addAnnotatedClass(Student.class);

      ServiceRegistry reg = new StandardServiceRegistryBuilder()

                                .applySettings(con.getProperties())

                                .build();

      SessionFactory sf = con.buildSessionFactory(reg);

      Session session = sf.openSession();

      Transaction tx = session.beginTransaction();

      session.persist(laptop1);

      session.persist(laptop2);

      session.persist(laptop3);

      session.persist(laptop4);

      session.persist(student1);

      session.persist(student2);

      tx.commit();

      session.close();

      sf.close();

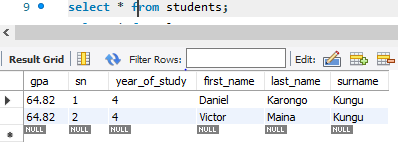
      System.out.println(student1);

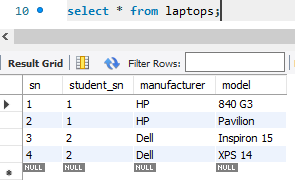
      System.out.println(student2);

    }

}

Main class





1. One laptop can be used by many students

This is the opposite of the above but still using the “@OneToMany” annotation. The “@OneToMany” annotation will be on the parent table (laptops) alongside a “mappedBy” attribute pointed to the same annotation having the a value of the field of the child entity (Student).

@Entity

@Table(name = "students")

public class Student {

    @ManyToOne      // Many students can use one laptop. So that "laptops" table can let the foreign key be assigned to the "students" table, rather than have a new composite table created.

    private Laptop laptop;

    public void setLaptop(Laptop laptop) {

        this.laptop = laptop;

    }

    public Laptop getLaptop() {

        return laptop;

    }

    public Student(FullName name, int yearOfStudy, double gpa, Laptop laptop) {

        this.name = name;

        this.yearOfStudy = yearOfStudy;

        this.gpa = gpa;

        this.laptop = laptop;

    }

}

The child (Student) entity

@Entity

@Table(name="laptops")

public class Laptop {

    @OneToMany          // One laptop can be used by many students. Consequently, each student record will have a foreign key pointing to the laptop he/she uses.

    private List<Student> students;

    public List<Student> getStudents() {

        return students;

    }

    public void setStudents(List<Student> students) {

        this.students = students;

    }

    public Laptop(String manufacturer, String model) {

        this.manufacturer = manufacturer;

        this.model = model;

    }

}

The parent (Laptop) entity

public class App {

    public static void main(String[] args) {

      Laptop laptop1 = new Laptop("HP", "840 G3");

      Laptop laptop2 = new Laptop("HP", "Pavilion");

//    Passing the list of laptops when creating the Student objects, logically links the Laptop objects to the Student objects.

      Student student1  = new Student(new FullName("Kungu", "Daniel", "Karongo"), 4, 64.82, laptop1);

      Student student2  = new Student(new FullName("Kungu", "Victor", "Maina"), 4, 64.82, laptop1);

      Student student3  = new Student(new FullName("Kamau", "Ivy", "Njeri"), 4, 64.82, laptop2);

      Student student4  = new Student(new FullName("Kamau", "Evelyne", "Waithera"), 4, 64.82, laptop2);

//    For the database to reflect this relationship properly, you must also set the Laptop reference in each Student object

      laptop1.setStudents(Arrays.asList(student1,student2));

      laptop2.setStudents(Arrays.asList(student3,student4));

      Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class).addAnnotatedClass(Laptop.class).addAnnotatedClass(Student.class);

      ServiceRegistry reg = new StandardServiceRegistryBuilder()

                                .applySettings(con.getProperties())

                                .build();

      SessionFactory sf = con.buildSessionFactory(reg);

      Session session = sf.openSession();

      Transaction tx = session.beginTransaction();

      session.persist(laptop1);

      session.persist(laptop2);

      session.persist(student1);

      session.persist(student2);

      session.persist(student3);

      session.persist(student4);

      tx.commit();

      session.close();

      sf.close();

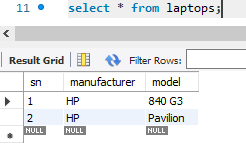
      System.out.println(student1);

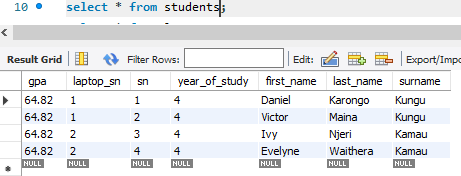
      System.out.println(student2);

    }

}

The Main class





### **Many-To-Many Relationships**

Any laptop can be used by any student/ Any student can use any laptop

This is a many to many relationship and will involve having a new table with a composite key holding all the various combinations of this relationship. However, this new table should be mapped by only one of the tables. This is done using the “@ManyToMany” annotation together with a “mappedBy” attribute. Failure to use this attribute will result in two new composite table, one mapped by each of the entities. With this kind of relationship, you should be careful about circular references leading to Stack Overflow errors, as a result of the toString() method invoked when printing out the objects involved.

@Entity

@Table(name = "students")

public class Student {

    @ManyToMany    // Any student can use any laptop. This will require a composite table to hold the various combinations.

    private List<Laptop> laptops;

    public void setLaptops(List<Laptop> laptops) {

      this.laptops = laptops;

    }

    public List<Laptop> getLaptops() {

      return laptops;

    }

    public Student(FullName name, int yearOfStudy, double gpa, List<Laptop> laptops) {

      this.name = name;

      this.yearOfStudy = yearOfStudy;

      this.gpa = gpa;

      this.laptops = laptops;

    }

    @Override

    public String toString() {

      return "Student{" +

              "sn=" + sn +

              ", name=" + name +

              ", yearOfStudy=" + yearOfStudy +

              ", gpa=" + gpa +

              ", laptop=" + (laptops != null ? laptops.size() + " laptops" : "no laptops") +

              '}';

  }

}

The Student entity

@Entity

@Table(name="laptops")

public class Laptop {

    @ManyToMany(mappedBy = "laptops")            // Any laptop can be used by any student.

    private List<Student> students;

    public List<Student> getStudents() {

      return students;

    }

    public void setStudents(List<Student> students) {

      this.students = students;

    }

    @Override

    public String toString() {

      return "Laptop{" +

              "sn=" + sn +

              ", manufacturer='" + manufacturer + '\'' +

              ", model='" + model + '\'' +

              ", students=" + (students != null ? students.size() + " users" : "no user") +

              '}';

    }

}

The Laptop entity

public class App {

  public static void main(String[] args) {

    Laptop laptop1 = new Laptop("HP", "840 G3");

    Laptop laptop2 = new Laptop("HP", "Pavilion");

    Student student1  = new Student(new FullName("Kungu", "Daniel", "Karongo"), 4, 64.82, Arrays.asList(laptop1, laptop2));

    Student student2  = new Student(new FullName("Kungu", "Victor", "Maina"), 4, 64.82, Arrays.asList(laptop1, laptop2));

    laptop1.setStudents(Arrays.asList(student1,student2));

    laptop2.setStudents(Arrays.asList(student1,student2));

    Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class).addAnnotatedClass(Laptop.class).addAnnotatedClass(Student.class);

    ServiceRegistry reg = new StandardServiceRegistryBuilder()

            .applySettings(con.getProperties())

            .build();

    SessionFactory sf = con.buildSessionFactory(reg);

    Session session = sf.openSession();

    Transaction tx = null;

    try {

      tx = session.beginTransaction();

      session.persist(laptop1);

      session.persist(laptop2);

      session.persist(student1);

      session.persist(student2);

      System.out.println();

      System.out.println(student1);

      System.out.println(student2);

      System.out.println(laptop1);

      System.out.println(laptop2);

      tx.commit();

    } catch (Exception e) {

      if (tx != null) {

        tx.rollback();

      }

      e.printStackTrace();

    } finally {

      session.close();

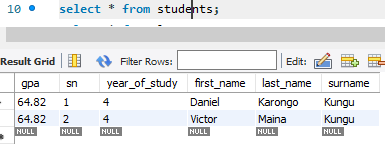
      sf.close();

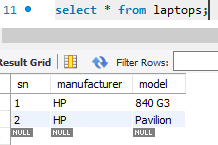
    }

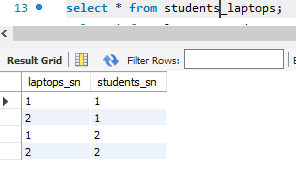
  }

}

The Main class







## **Fetch Types in Hibernate (Lazy and Eager loading)**

Consider the relationship between the Student and Laptop entities described above. In Hibernate, data is typically fetched from the database using the “session.get(className.class”, id) method. When the fetched data has a relationship with another entity, the fetching is, by default, done lazily. This means that when fetching a Student, for instance, in a one-to-many relationship, the associated Laptops are not immediately fetched. Instead, the Student's laptops property is initialized with a proxy object.

Because of this, any operation performed on the Student object after the Hibernate session has been closed will result in a LazyInitializationException if it tries to access the Laptops. This happens because the proxy object, which stands in for the uninitialized Laptops, cannot load the data after the session is closed.

To avoid this exception, there are several approaches you can take:

1. Perform the operation on the fetched object(s) before closing the Hibernate session.

public class App {

    public static void main(String[] args) {

      Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class).addAnnotatedClass(Laptop.class).addAnnotatedClass(Student.class);

      ServiceRegistry reg = new StandardServiceRegistryBuilder()

                                .applySettings(con.getProperties())

                                .build();

      SessionFactory sf = con.buildSessionFactory(reg);

      Session session = sf.openSession();

      Transaction tx = session.beginTransaction();

      Student student1 = session.get(Student.class, 1);

      Laptop laptop1 = session.get(Laptop.class, 1);

      System.out.println(student1);       // Done before closing the session

      System.out.println(laptop1);        // Done before closing the session

      // laptop1.getStudents().size;      // It's a good altenative. Here, the ".size()" is crucial because ".getStudents()" on its own returns the proxy but the ".size()" forces hibernate to fetch the actual student objects

      tx.commit();

      session.close();                    // Closing the session

      sf.close();

    }

}

1. Fetch the child entity (e.g., Laptops) eagerly at the same time as you fetch the parent entity (e.g., Student). However, this should be done with caution, as eager fetching can lead to performance issues, especially if the collection of child entities is large

@Entity

@Table(name = "students")

public class Student {

    @ManyToMany(fetch = FetchType.EAGER)

    private List<Laptop> laptops;

}

@Entity

@Table(name="laptops")

public class Laptop {

    @ManyToMany(mappedBy = "laptops", fetch = FetchType.EAGER)

    private List<Student> students;

}

public class App {

    public static void main(String[] args) {

      Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class).addAnnotatedClass(Laptop.class).addAnnotatedClass(Student.class);

      ServiceRegistry reg = new StandardServiceRegistryBuilder()

                                .applySettings(con.getProperties())

                                .build();

      SessionFactory sf = con.buildSessionFactory(reg);

      Session session = sf.openSession();

      Transaction tx = session.beginTransaction();

      Student student1 = session.get(Student.class, 1);

      Laptop laptop1 = session.get(Laptop.class, 1);

      tx.commit();

      session.close();                    //    The session is closed

      sf.close();

      System.out.println(student1);       //    The operations will still work because the children entities were fetched eagerly

      System.out.println(laptop1);

    }

}

## **Hibernate Caching**

Hibernate does not only provide ORM mapping but also provides caching facilities. Imagine having a session on your server that runs a query like “select \* from students” that may return 10000 records. Running this query multiple times directly on the database will be very computationally expensive and slow. For this reason, it is a good idea to store this result set in a temporary storage location, the cache, so that whenever this query is called, instead of running the query on the database directly, this cache can be used.

There are two kinds of cache:

### **Level 1 Cache**

This cache is unique to each individual session, i.e. every session has its own cache. This cache cannot be shared across sessions.

public class App {

  public static void main(String[] args) {

    Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class).addAnnotatedClass(Laptop.class).addAnnotatedClass(Student.class);

    ServiceRegistry reg = new StandardServiceRegistryBuilder()

            .applySettings(con.getProperties())

            .build();

    SessionFactory sf = con.buildSessionFactory(reg);

    Session session = sf.openSession();       // Session starting

    Transaction tx = session.beginTransaction();

    Developer dev1 = session.get(Developer.class, 1);         // Query triggered

    Developer dev2 = session.get(Developer.class, 1);         // Query should be triggered but none is triggered

    System.out.println(dev1);

    System.out.println(dev2);

    tx.commit();

    session.close();

  }

}

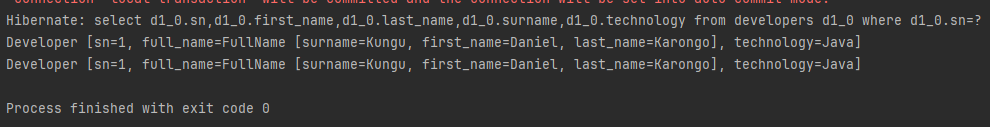


Figure 7: The second "dev2" object is initialised from the L1 cache

### **Level 2 Cache**

This cache can be shared amongst multiple sessions. However, it is disabled, by default, on Hibernate.

public class App {

  public static void main(String[] args) {

    Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class).addAnnotatedClass(Laptop.class).addAnnotatedClass(Student.class);

    ServiceRegistry reg = new StandardServiceRegistryBuilder()

            .applySettings(con.getProperties())

            .build();

    SessionFactory sf = con.buildSessionFactory(reg);

    Session session = sf.openSession();       // First Session starting

    Transaction tx = session.beginTransaction();

    Developer dev1 = session.get(Developer.class, 1);         // Query triggered

    System.out.println(dev1);

    tx.commit();

    session.close();                          // First Session Closed

    Session session2 = sf.openSession();      // Second Session starting

    Transaction tx2 = session2.beginTransaction();

    Developer dev2 = session2.get(Developer.class, 1);        // Same query triggered

    System.out.println(dev2);

    tx2.commit();

    session2.close();                         // Second Session Closed

    sf.close();

  }

}

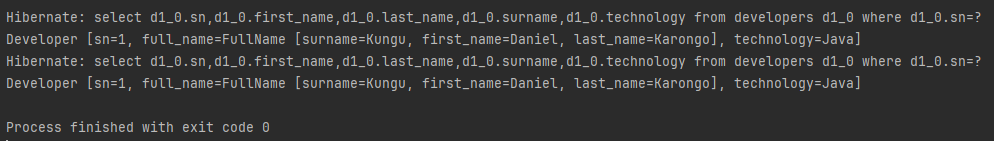


Figure 8: The second "dev2" is initialised after fetching data from the database even though the same data is in the first session's L1 cache

For this reason, to activate it there are several requirements:

* A third-party provider, such as JCache, Hazelcast, OSCache or swamp. This dependency can be imported via pom.xml.
* Update to the hibernate.cfg.xml configuration file.
* Update to the entities themselves adding two annotations:
  + @Cachable
  + @Cache

<dependencies>

    <!-- Hibernate Core Dependency -->

    <!-- Provides the core ORM functionality required to work with Hibernate, including managing entities, sessions, transactions, and database connections. -->

    <dependency>

        <groupId>org.hibernate.orm</groupId>

        <artifactId>hibernate-core</artifactId>

        <version>6.6.0.Final</version>

    </dependency>

    <!-- Hibernate JCache Integration -->

    <!-- Integrates Hibernate with the JCache (JSR 107) caching standard, allowing you to use a standardized cache API across different cache providers. -->

    <dependency>

        <groupId>org.hibernate.orm</groupId>

        <artifactId>hibernate-jcache</artifactId>

        <version>6.6.0.Final</version>

        <!-- Ensure this version matches the Hibernate-core version to avoid compatibility issues. -->

    </dependency>

    <!-- Hazelcast Caching Provider -->

    <!-- Hazelcast is an in-memory data grid that provides distributed caching. By adding this dependency, Hazelcast is used as the JCache provider, enabling distributed caching across multiple nodes.

    This allows for enhanced performance and scalability, especially in clustered environments, as the cached data is available across all nodes in the cluster. -->

    <dependency>

        <groupId>com.hazelcast</groupId>

        <artifactId>hazelcast</artifactId>

        <version>5.2.0</version>

    </dependency>

</dependencies>

The pom.xml file

<?xml version="1.0" encoding="UTF-8"?>

<!DOCTYPE hibernate-configuration PUBLIC

      "-//Hibernate/Hibernate Configuration DTD 3.0//EN"

      "http://www.hibernate.org/dtd/hibernate-configuration-3.0.dtd">

<hibernate-configuration>

    <session-factory>

        <!-- Database connection settings -->

        <!-- Specifies the JDBC driver class for MySQL, the connection URL, and the username for the database connection. -->

        <property name="hibernate.connection.driver\_class">com.mysql.cj.jdbc.Driver</property>

        <property name="hibernate.connection.url">jdbc:mysql://localhost:3306/javarefresher</property>

        <property name="hibernate.connection.username">root</property>

        <!-- Dialect settings -->

        <!-- Hibernate dialect specifies how Hibernate should translate HQL (Hibernate Query Language) to the underlying SQL dialect. -->

        <property name="hibernate.dialect">org.hibernate.dialect.MySQLDialect</property>

        <!-- Schema generation settings -->

        <!-- Automatically updates the database schema to match the entity mappings. 'update' creates and updates tables as needed. -->

        <property name="hbm2ddl.auto">update</property>

        <!-- SQL Logging settings -->

        <!-- Enables logging of SQL statements generated by Hibernate. Useful for debugging purposes. -->

        <property name="show\_sql">true</property>

        <!-- <property name="hibernate.format\_sql">true</property> -->

        <!-- Uncomment 'format\_sql' to pretty-print the SQL in the logs. -->

        <!-- Caching settings -->

        <!-- Enables Hibernate’s second-level cache, which stores entity data across sessions, reducing the need for repeated database access. -->

        <property name="hibernate.cache.use\_second\_level\_cache">true</property>

        <property name="hibernate.cache.use\_query\_cache">true</property>

        <!-- JCache provider settings -->

        <!-- Specifies that Hibernate should use JCache (JSR 107) as the caching API, allowing for a standardized cache provider integration. -->

        <property name="hibernate.cache.region.factory\_class">

            org.hibernate.cache.jcache.internal.JCacheRegionFactory

        </property>

        <!-- Cache provider configuration -->

        <!-- Configures Hazelcast as the JCache provider, enabling distributed caching across a cluster of servers.

             Hazelcast manages cache entries in memory and can replicate them across nodes, ensuring high availability and scalability. -->

        <property name="hibernate.javax.cache.provider">

            com.hazelcast.cache.impl.HazelcastServerCachingProvider

        </property>

    </session-factory>

</hibernate-configuration>

The hibernate.cfg.xml file

@Cacheable  // Enables second-level caching for this entity

@Cache(usage = CacheConcurrencyStrategy.READ\_ONLY)  // Specifies that the entity should be cached with a read-only cache strategy - indicates that the cached entity data will not change once it is loaded into the cache. In other words, the data is considered immutable from the perspective of the application.

public class Developer {

}

The entity made cachable

public class App {

  public static void main(String[] args) {

    Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class).addAnnotatedClass(Laptop.class).addAnnotatedClass(Student.class);

    ServiceRegistry reg = new StandardServiceRegistryBuilder()

            .applySettings(con.getProperties())

            .build();

    SessionFactory sf = con.buildSessionFactory(reg);

    Session session = sf.openSession();       // First Session starting

    Transaction tx = session.beginTransaction();

    Developer dev1 = session.get(Developer.class, 1);         // Query triggered

    System.out.println(dev1);

    tx.commit();

    session.close();                          // First Session Closed

    Session session2 = sf.openSession();      // Second Session starting

    Transaction tx2 = session2.beginTransaction();

    Developer dev2 = session2.get(Developer.class, 1);        // Same query should be triggered

    System.out.println(dev2);

    tx2.commit();

    session2.close();                         // Second Session Closed

    sf.close();

  }

}

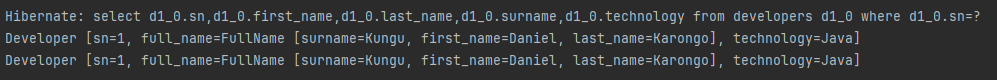


Figure 9: The second "dev2" object, even though its from another session, is initialised from the L2 cache populated during session1

## **Hibernate Query Language (HQL)**

Hibernate provides its own querying language that has several advantages and features:

1. Column names are replaced with class attributes(properties)
2. Table names are replaced with the class name.

E.g. “select rollno from students” -> “select rollno from Student.

1. To fetch a whole table, we do not need to write the “select \* part of the sql query”. E.g. “select \* from students” -> “from Student”
2. Fetching in sql results a result set that has to be looped over using a while loop and rs.next. In HQL, the results can be initialised into a list that can then be looped over using an enhanced for loop.

However, it is still possible to write regular queries, known as native queries. **Example HQL Queries**

public class App {

  public static void main(String[] args) {

    Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class);

    ServiceRegistry reg = new StandardServiceRegistryBuilder()

            .applySettings(con.getProperties())

            .build();

    SessionFactory sf = con.buildSessionFactory(reg);

    Session session = sf.openSession();

    Transaction tx = null;

    try {

      tx = session.beginTransaction();

      // To create some records in the database

            /\*

            Random r = new Random();

            for (int i = 0; i < 50; i++) {

                Developer dev = new Developer("Name " + i, r.nextInt(100));

                session.persist(dev);

            }

            \*/

      // Query to fetch all developers

      System.out.println();

      System.out.println("All Devs");

      System.out.println();

      Query<Developer> q = session.createQuery("from Developer", Developer.class);    // This "Developer.class" is to make the query result type-safe by restricting the casting to type "Develeper"

      List<Developer> devs = q.list();

      for (Developer dev : devs) {

        System.out.println(dev);

      }

      // Query to fetch developers with marks > 50

      System.out.println();

      System.out.println("Above Average Devs");

      System.out.println();

      Query<Developer> q1 = session.createQuery("from Developer where marks > 50", Developer.class);

      List<Developer> aboveAverageDevs = q1.list();

      for (Developer dev : aboveAverageDevs) {

        System.out.println(dev);

      }

      // Query to fetch a specific developer with serial number (sn) = 25

      System.out.println();

      System.out.println("Specific Dev");

      System.out.println();

      Query<Developer> q2 = session.createQuery("from Developer where sn = 25", Developer.class);

      Developer dev = q2.uniqueResult();

      System.out.println(dev);

      // Query to fetch a non-existent developer with serial number (sn) = 100

      System.out.println();

      System.out.println("Non-existent Dev");

      System.out.println();

      Query<Developer> q3 = session.createQuery("from Developer where sn = 100", Developer.class);

      Optional<Developer> dev2 = Optional.ofNullable(q3.uniqueResult());

      dev2.ifPresent(developer -> System.out.println(developer));

      if (!dev2.isPresent()) {

        System.out.println("No such dev");

      }

      // Query to fetch specific columns for one record. Here, each of the column values is treated as an individual object.

      System.out.println();

      System.out.println("Specific columns for one record");

      System.out.println();

      Query<Object[]> q4 = session.createQuery("select full\_name, marks from Developer where sn = 25");

      Object[] specDevProperties = q4.uniqueResult();

//      for(Object column : specDevProperties) {        One option for rendering the columns

//        System.out.println(column);

//      }

      System.out.println(specDevProperties[0] + " : " + specDevProperties[1]);

      // Query to fetch specific columns for multiple records

      System.out.println();

      System.out.println("Specific columns for multiple records");

      System.out.println();

      Query q5 = session.createQuery("select full\_name, marks from Developer where marks > 50");

      List<Object[]> devsEachWithSpecificProperties = (List<Object[]>) q5.list();

      for(Object[] developer : devsEachWithSpecificProperties) {

        System.out.println(developer[0] + " : " + developer[1]);

      }

      // Query to fetch an aggregated/ calculated values

      System.out.println();

      System.out.println("aggregated/ calculated value");

      System.out.println();

      Query<Double> q6 = session.createQuery("select avg(marks) from Developer", Double.class);

      Double averageMark = q6.uniqueResult();

      System.out.println(averageMark);

      // Prepared Statement in HQL

      System.out.println();

      System.out.println("Prepared Statement in HQL");

      System.out.println();

      int b = 50;

      Query<Double> q7 = session.createQuery("select avg(marks) from Developer where marks > :b", Double.class);

      q7.setParameter("b", b);

      Double averageMarkForAboveAverageDevs = q7.uniqueResult();

      System.out.println(averageMarkForAboveAverageDevs);

      // Commit the transaction

      tx.commit();

    } catch (Exception e) {

      if (tx != null) {

        tx.rollback();

      }

      e.printStackTrace();

    } finally {

      session.close();

      sf.close();

    }

  }

}

### **Native Queries (SQL)**

This are the normal SQL queries made to work with Hibernate.

package com.housesearchKE.DemoHibernate;

import jakarta.persistence.criteria.CriteriaBuilder;

import org.hibernate.Session;

import org.hibernate.SessionFactory;

import org.hibernate.Transaction;

import org.hibernate.boot.registry.StandardServiceRegistryBuilder;

import org.hibernate.cfg.Configuration;

import org.hibernate.query.NativeQuery;

import org.hibernate.service.ServiceRegistry;

import java.util.List;

public class App {

  public static void main(String[] args) {

    Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class);

    ServiceRegistry reg = new StandardServiceRegistryBuilder()

            .applySettings(con.getProperties())

            .build();

    SessionFactory sf = con.buildSessionFactory(reg);

    Session session = sf.openSession();

    Transaction tx = null;

    try {

      tx = session.beginTransaction();

      // Query to fetch all above-average developers

      System.out.println();

      System.out.println("All above-average devs");

      System.out.println();

      // SQLQuery q = session.createSQLQuery("select \* from developer where marks > 50");          - Deprecated

      NativeQuery q = session.createNativeQuery("select \* from developers where marks > 50", Developer.class);

      List<Developer> developers = q.getResultList();

      for (Developer dev : developers) {

        System.out.println(dev);

      }

      // Query to fetch some fields for all the above-average developers

      System.out.println();

      System.out.println("Some fields for all the above-average devs");

      System.out.println();

      NativeQuery<Object[]> q1 = session.createNativeQuery("select full\_name, marks from developers where marks > 50");

//      q1.setResultTransformer(Criteria.ALIAS\_ENTITY\_MAP);       - Deprecated

      List<Object[]> devs = q1.list();

      for (Object[] dev : devs) {

        System.out.println(dev[0] + " : " + dev[1]);

      }

      tx.commit();

    } catch (Exception e) {

      if (tx != null) {

        tx.rollback();

      }

      e.printStackTrace();

    } finally {

      session.close();

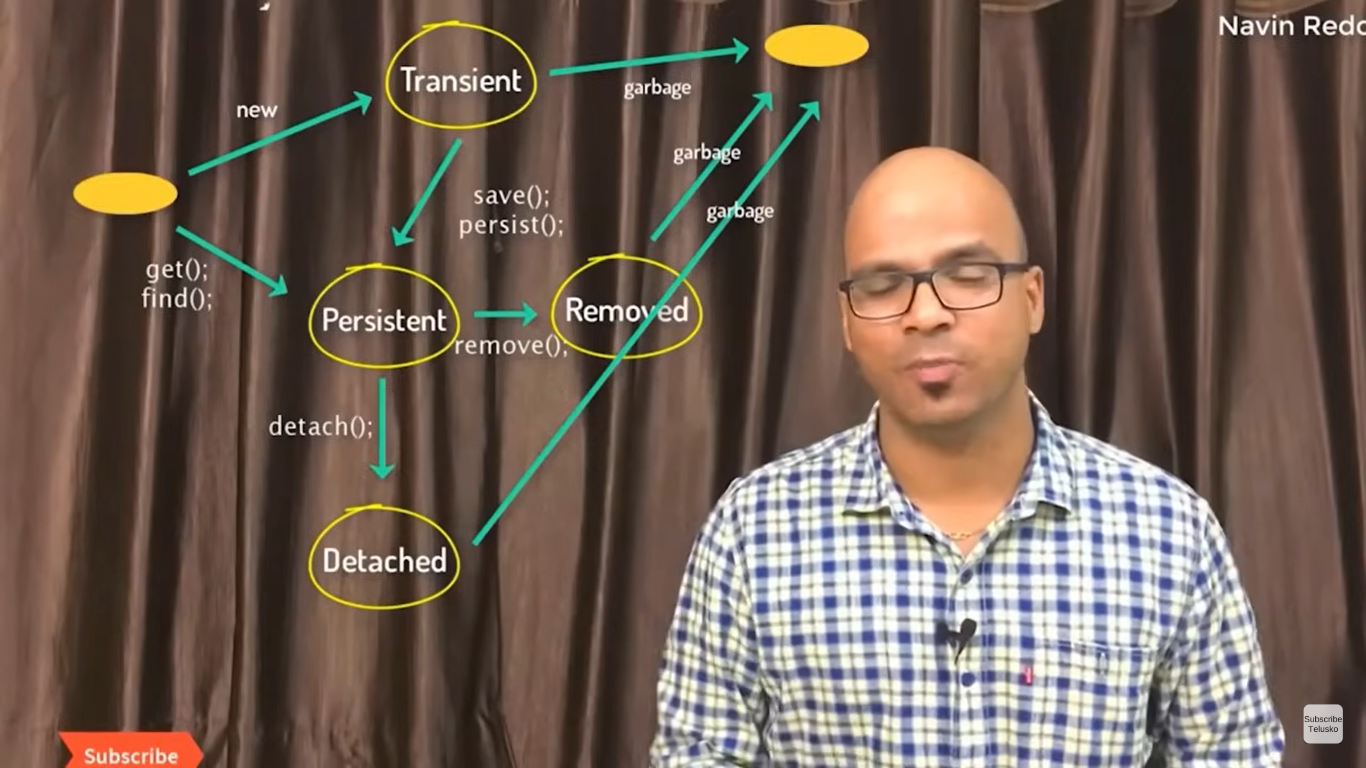
      sf.close();

    }

  }

}

## **Hibernate Object States**



public class App {

  public static void main(String[] args) {

    Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class);

    ServiceRegistry reg = new StandardServiceRegistryBuilder()

            .applySettings(con.getProperties())

            .build();

    SessionFactory sf = con.buildSessionFactory(reg);

    Session session = sf.openSession();

    Transaction tx = null;

    try {

      tx = session.beginTransaction();

      // Creating a Developer instance (Transient state)

      Developer dev = new Developer("Daniel Karongo", 64);

      // Persisting the Developer instance (Persistent state)

      session.persist(dev);

      // Modifying the Developer instance while still in Persistent state

      dev.setMarks(70); // This change will be reflected in the database

      // Committing the transaction

      tx.commit();

      // After commit, the Developer instance is in Detached state

      dev.setMarks(80); // This change will not affect the database since the object is detached

      // Evict the Developer instance from the session (remains in Detached state because on commit, the object is detached automatically)

      session.detach(dev);            // "session.detach()" is an equivalent

      // Deleting the Developer instance

      session.delete(dev); // This won't work in Detached state. The object should be attached first, i.e, It should be done when the object is still in the transient. This reattachment can be done using methods such as: "session.update(dev)" or "session.merge(dev)"

    } catch (Exception e) {

      if (tx != null) {

        tx.rollback();

      }

      e.printStackTrace();

    } finally {

      // Ensure the session and session factory are closed

      session.close();

      sf.close();

    }

  }

}

Hibernate states example when saving a new record.

public class App {

  public static void main(String[] args) {

    Configuration con = new Configuration().configure().addAnnotatedClass(Developer.class);

    ServiceRegistry reg = new StandardServiceRegistryBuilder()

            .applySettings(con.getProperties())

            .build();

    SessionFactory sf = con.buildSessionFactory(reg);

    Session session = sf.openSession();

    Transaction tx = null;

    try {

      tx = session.beginTransaction();

      // Getting a specific record from the database. (Transient and persistent state)

      Developer dev = session.get(Developer.class, 1);

      // Modifying the Developer instance while still in Persistent state

      dev.setMarks(70); // This change will be reflected in the database

      // Committing the transaction

      tx.commit();

    } catch (Exception e) {

      if (tx != null) {

        tx.rollback();

      }

      e.printStackTrace();

    } finally {

      // Ensure the session and session factory are closed

      session.close();

      sf.close();

    }

  }

}

Hibernate states example when record from the database

# **JAVA PERSISTENT API**

This is a convention that was developed so that different ORM tools such as Hibernate, TopLink, iBetis can exist and follow a standard such that migrating between any of these can be easy.

## **Procedure For Creating a JPA project**

1. Create a maven project
2. Add the ORM dependencies, say, Hibernate, as well as that ORM’s “entity-manager” dependency.
3. Add the DBMS connector dependencies as well. This is done in the “pom.xml” file.

<dependency>

      <groupId>org.hibernate.orm</groupId>

      <artifactId>hibernate-core</artifactId>

      <version>6.6.0.Final</version>

    </dependency>

    <dependency>

      <groupId>com.mysql</groupId>

      <artifactId>mysql-connector-j</artifactId>

      <version>9.0.0</version>

    </dependency>

1. Create a configuration file for your database, in the “src/main/resources/META-INF” folder, called, “persistence.xml”.

<persistence xmlns="http://java.sun.com/xml/ns/persistence" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://java.sun.com/xml/ns/persistence persistence\_1\_0.xsd" version="1.0">

    <persistence-unit name="my-app" transaction-type="RESOURCE\_LOCAL">

        <properties>

            <property name="javax.persistence.jdbc.driver" value="com.mysql.cj.jdbc.Driver"/>

            <property name="javax.persistence.jdbc.url" value="jdbc:mysql://localhost:3306/javarefresher"/>

            <property name="javax.persistence.jdbc.user" value="root"/>

            <property name="javax.persistence.jdbc.password" value=""/>

            <!-- Hibernate Dialect -->

            <property name="hibernate.dialect" value="org.hibernate.dialect.MySQLDialect"/>

            <!-- Schema generation settings -->

            <property name="hibernate.hbm2ddl.auto" value="update"/>

            <!-- SQL Logging settings -->

            <property name="hibernate.show\_sql" value="true"/>

            <property name="hibernate.format\_sql" value="false"/>

            <!-- Caching settings -->

            <property name="hibernate.cache.use\_second\_level\_cache" value="false"/>

            <property name="hibernate.cache.use\_query\_cache" value="false"/>

            <!-- JCache provider settings (if needed) -->

            <!-- Uncomment and configure if using JCache -->

            <!-- <property name="hibernate.cache.region.factory\_class" value="org.hibernate.cache.jcache.JCacheRegionFactory"/> -->

            <!-- <property name="hibernate.javax.cache.provider" value="com.hazelcast.cache.impl.HazelcastServerCachingProvider"/> -->

        </properties>

    </persistence-unit>

</persistence>

1. Create the entity classes.

package org.housesearchke;

import jakarta.persistence.\*;

@Entity

@Table(name="aliens")

public class Alien {

    @Id

    @GeneratedValue(strategy = GenerationType.IDENTITY)

    private int aid;

    private String aname;

    public Alien(String aname, String atech) {

        this.aname = aname;

        this.atech = atech;

    }

    public Alien() {

    }

    private String atech;

    public int getAid() {

        return aid;

    }

    public void setAid(int aid) {

        this.aid = aid;

    }

    public String getAname() {

        return aname;

    }

    public void setAname(String aname) {

        this.aname = aname;

    }

    public String getAtech() {

        return atech;

    }

    public void setAtech(String atech) {

        this.atech = atech;

    }

    @Override

    public String toString() {

        return "Alien{" +

                "aid=" + aid +

                ", aname='" + aname + '\'' +

                ", atech='" + atech + '\'' +

                '}';

    }

}

1. Create a Main class to run the application.
2. Within this class:
   1. Create a EntityManagerFactory object.
   2. Create a EntityManager object.
   3. Use this EntityManager object to find and persist objects in the database.

package org.housesearchke;

import jakarta.persistence.EntityManager;

import jakarta.persistence.EntityManagerFactory;

import jakarta.persistence.Persistence;

public class App

{

    public static void main(String[] args) {

        Alien a = new Alien("Daniel Karongo", "Java");

        System.out.println(a);

        EntityManagerFactory emf = Persistence.createEntityManagerFactory("my-app");

        EntityManager em = emf.createEntityManager();

        em.getTransaction().begin(); // Start transaction

        em.persist(a);

        em.getTransaction().commit(); // Commit transaction

        em.getTransaction().begin(); // Start transaction

        Alien b = em.find(Alien.class, 1);

        em.getTransaction().commit(); // Commit transaction

        em.close();

        emf.close();

        System.out.println(b);

    }

}

# **REST (REPRESENTATIONAL STATE TRANSFER) API**

RESTful API (Representational State Transfer API) is a widely adopted architectural style for building web services that is rooted in the principles of REST architecture, introduced by Roy Fielding in his 2000 doctoral dissertation.

Below are the key components and principles of REST architecture:

* Resource-Based

Treats every piece of data or functionality as a "resource". These resources are identified by unique URLs (Uniform Resource Locators), making them easily accessible via standard HTTP methods such as GET, POST, PUT, DELETE, and PATCH.

* Statelessness

One of the defining characteristics of RESTful APIs is their statelessness. In a stateless system, each request from a client to the server must contain all the information needed to understand and process that request. Consequently, the server does not store any session data between requests, allowing it to handle multiple requests efficiently and independently. This stateless nature enhances the scalability of the system, as servers do not need to track client sessions, reducing the complexity and overhead.

* Uniform Interface

Requests from the clients in Restful APIs are uniform in that they all leverage HTTP's built-in methods. Responses, on the other hand, often represent data in formats like JSON or XML, making them easily readable and parsable by a variety of clients across different platforms.

Now, given Rest APIs are a concept, to implement the same, there are several various frameworks and libraries available. Two popular ones are: Jersey and Spring

## **Jersey**

Jersey is an open-source framework for developing RESTful web services in Java. It is like a dedicated tool specifically designed for one job: building REST APIs. It’s straightforward and focuses on making it easy to create APIs using the official Java standard (JAX-RS). If you want a simple, focused way to build a REST API, Jersey is like a handy tool that does exactly what you need with minimal setup.

### **Procedure for creating a sample project using the Jersey library**

Create a maven project and choose the “jersey-quickstart-webapp” archetype.

Add a server the project, say, Tomcat.

Here, ensure the projects “.war” file is in the “webapps” folder of your tomcat server.

<project xmlns="http://maven.apache.org/POM/4.0.0"

         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/maven-v4\_0\_0.xsd">

    <!-- Maven model version -->

    <modelVersion>4.0.0</modelVersion>

    <!-- Group ID of the project -->

    <groupId>com.housesearchKE</groupId>

    <!-- Artifact ID of the project -->

    <artifactId>JerseyRestDemo</artifactId>

    <!-- Packaging type for the project -->

    <packaging>war</packaging>

    <!-- Version of the project -->

    <version>0.0.1-SNAPSHOT</version>

    <!-- Name of the project -->

    <name>JerseyRestDemo</name>

    <build>

        <!-- Final name of the built WAR file -->

        <finalName>JerseyRestDemo</finalName>

        <plugins>

            <!-- Maven Compiler Plugin for compiling Java sources -->

            <plugin>

                <groupId>org.apache.maven.plugins</groupId>

                <artifactId>maven-compiler-plugin</artifactId>

                <version>3.8.1</version>

                <configuration>

                    <!-- Java source and target versions -->

                    <source>17</source>

                    <target>17</target>

                </configuration>

            </plugin>

            <!-- Maven WAR Plugin for packaging the application as a WAR file -->

            <plugin>

                <groupId>org.apache.maven.plugins</groupId>

                <artifactId>maven-war-plugin</artifactId>

                <version>3.4.0</version>

            </plugin>

        </plugins>

    </build>

    <dependencyManagement>

        <dependencies>

            <!-- Jersey BOM (Bill of Materials) to manage Jersey dependencies versions -->

            <dependency>

                <groupId>org.glassfish.jersey</groupId>

                <artifactId>jersey-bom</artifactId>

                <version>${jersey.version}</version>

                <type>pom</type>

                <scope>import</scope>

            </dependency>

        </dependencies>

    </dependencyManagement>

    <dependencies>

        <!-- Jersey Servlet Container core dependency -->

        <dependency>

            <groupId>org.glassfish.jersey.containers</groupId>

            <artifactId>jersey-container-servlet-core</artifactId>

        </dependency>

        <!-- Jersey HK2 dependency for dependency injection -->

        <dependency>

            <groupId>org.glassfish.jersey.inject</groupId>

            <artifactId>jersey-hk2</artifactId>

        </dependency>

        <!-- Uncomment the following dependency to include JSON support -->

        <!--

        <dependency>

            <groupId>org.glassfish.jersey.media</groupId>

            <artifactId>jersey-media-json-binding</artifactId>

        </dependency>

        -->

    </dependencies>

    <!-- Project properties -->

    <properties>

        <!-- Jersey version to use -->

        <jersey.version>2.34</jersey.version>

        <!-- Project source encoding -->

        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>

    </properties>

</project>

The pom.xml file

<?xml version="1.0" encoding="UTF-8"?>

<!-- Web application deployment descriptor -->

<web-app version="3.1" xmlns="http://xmlns.jcp.org/xml/ns/javaee"

    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

    xsi:schemaLocation="http://xmlns.jcp.org/xml/ns/javaee

                        http://xmlns.jcp.org/xml/ns/javaee/web-app\_3\_1.xsd">

    <!-- Servlet configuration -->

    <servlet>

        <servlet-name>Jersey Web Application</servlet-name>

        <!-- Jersey Servlet Container class -->

        <servlet-class>org.glassfish.jersey.servlet.ServletContainer</servlet-class>

        <init-param>

            <!-- Package where Jersey will scan for resources -->

            <param-name>jersey.config.server.provider.packages</param-name>

            <param-value>com.housesearchKE.JerseyRestDemo</param-value>

        </init-param>

        <!-- Load the servlet on startup -->

        <load-on-startup>1</load-on-startup>

    </servlet>

    <!-- Servlet mapping -->

    <servlet-mapping>

        <servlet-name>Jersey Web Application</servlet-name>

        <!-- URL pattern for Jersey resources -->

        <url-pattern>/webapi/\*</url-pattern>

    </servlet-mapping>

</web-app>

The web.xml deployment,descriptor

<html>

<body>

    <h2>Jersey RESTful Web Application!</h2>

    <p><a href="webapi/myresource">Jersey resource</a>

    <p>Visit <a href="http://jersey.java.net">Project Jersey website</a>

    for more information on Jersey!

</body>

</html>

The index.jsp file

package com.housesearchKE.JerseyRestDemo;

import javax.ws.rs.GET;

import javax.ws.rs.Path;

import javax.ws.rs.Produces;

import javax.ws.rs.core.MediaType;

/\*\*

 \* Root resource class exposed at the "myresource" path.

 \*/

@Path("myresource")

public class MyResource {

    /\*\*

     \* Handles HTTP GET requests. The returned object will be sent to the client

     \* as a "text/plain" media type.

     \*

     \* @return A string that will be returned as a text/plain response.

     \*/

    @GET

    @Produces(MediaType.TEXT\_PLAIN)

    public String getIt() {

        return "Got it!";

    }

}

The “myresource” servlet called

### **Creating a Custom Resource**

Create a Model class.

package com.houseSearchKE;

import jakarta.xml.bind.annotation.XmlRootElement;

@XmlRootElement

public class Alien {

    private String name;

    private int points;

    public String getName() {

        return name;

    }

    public void setName(String name) {

        this.name = name;

    }

    public int getPoints() {

        return points;

    }

    public void setPoints(int points) {

        this.points = points;

    }

    public Alien(String name, int points) {

        this.name = name;

        this.points = points;

    }

    public Alien() {

    }

    @Override

    public String toString() {

        return "Alien{" +

                "name='" + name + '\'' +

                ", points=" + points +

                '}';

    }

}

Create a resource class.

package com.houseSearchKE;

import jakarta.ws.rs.GET;

import jakarta.ws.rs.Path;

import jakarta.ws.rs.Produces;

import jakarta.ws.rs.core.MediaType;

@Path("alien")

public class AlienResource {

    @GET

    @Produces(MediaType.APPLICATION\_XML)

    public Alien getAlien() {

        Alien a1 = new Alien("Daniel Karongo", 60);

        return a1;

    }

}

Add all the necessary annotations, and dependencies for the same to work:

        <!-- JAXB Dependencies for XML support -->

        <dependency>

            <groupId>jakarta.xml.bind</groupId>

            <artifactId>jakarta.xml.bind-api</artifactId>

            <version>3.0.1</version>

        </dependency>

        <dependency>

            <groupId>org.glassfish.jaxb</groupId>

            <artifactId>jaxb-runtime</artifactId>

            <version>3.0.2</version>

        </dependency>

        <dependency>

            <groupId>org.glassfish.jersey.media</groupId>

            <artifactId>jersey-media-jaxb</artifactId>

            <version>4.0.0-M1</version>

        </dependency>

    </dependencies>

    <properties>

        <jersey.version>4.0.0-M1</jersey.version>

        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>

    </properties>

### **Repositories in the REST Architecture**

Recall the DAO concept in JDBC. Repositories are the equivalents of the DAO in REST. Here, the resource controllers get/ post/ put/ delete data from/to classes, that are, conventionally called and named Repositories. E.g. For an “AlienResource”, the data can be coming from a class known as “AlienRepository”.

package com.houseSearchKE;

import org.hibernate.Session;

import org.hibernate.SessionFactory;

import org.hibernate.Transaction;

import org.hibernate.boot.registry.StandardServiceRegistryBuilder;

import org.hibernate.cfg.Configuration;

import org.hibernate.query.Query;

import org.hibernate.service.ServiceRegistry;

import java.util.ArrayList;

import java.util.Arrays;

import java.util.List;

public class AlienRepository {

    Configuration con = null;

    ServiceRegistry reg = null;

    SessionFactory sf = null;

    public AlienRepository() {

        con = new Configuration().configure().addAnnotatedClass(Alien.class);

        reg = new StandardServiceRegistryBuilder()

                .applySettings(con.getProperties())

                .build();

        sf = con.buildSessionFactory(reg);

    }

    public List<Alien> getAliens() {

        List<Alien> aliens = new ArrayList<>();

        Session session = sf.openSession();

        Transaction tx = null;

         try{

             tx = session.beginTransaction();

             Query<Alien> q = session.createQuery("from Alien", Alien.class);

             aliens = q.list();

             tx.commit();

         } catch (Exception e) {

             if (tx != null) {

                 tx.rollback();

             }

             e.printStackTrace();

         } finally {

             session.close();

             return aliens;

         }

    }

    public Alien getAlien(int id) {

        Alien alien = new Alien();

        Session session = sf.openSession();

        Transaction tx = null;

        try{

            tx = session.beginTransaction();

            Query<Alien> q = session.createQuery("from Alien where id =:id", Alien.class);

            q.setParameter("id", id);

            alien = q.uniqueResult();

            tx.commit();

        } catch (Exception e) {

            if (tx != null) {

                tx.rollback();

            }

            e.printStackTrace();

        } finally {

            session.close();

            return alien;

        }

    }

    public List<Alien> createAlien(Alien a) {

        List<Alien> aliens = new ArrayList<>();

        Session session = sf.openSession();

        Transaction tx = null;

        try{

            tx = session.beginTransaction();

            session.persist(a);

            tx.commit();

            aliens = this.getAliens();

        } catch (Exception e) {

            if (tx != null) {

                tx.rollback();

            }

            e.printStackTrace();

        } finally {

            session.close();

            return aliens;

        }

    }

    public List<Alien> updateAlien(Alien a) {

        List<Alien> aliens = new ArrayList<>();

        Session session = sf.openSession();

        Transaction tx = null;

        try{

            tx = session.beginTransaction();

            session.saveOrUpdate(a);        // Updates if the entity is present in the database, else, it creates a new record

//            session.update(a);            - Only works for entities that are already existing in the database.

            tx.commit();

            aliens = this.getAliens();

        } catch (Exception e) {

            if (tx != null) {

                tx.rollback();

            }

            e.printStackTrace();

        } finally {

            session.close();

            return aliens;

        }

    }

    public void deleteAlien(int id) {

        Session session = sf.openSession();

        Transaction tx = null;

        try{

            tx = session.beginTransaction();

            Query<?> q = session.createQuery("delete from Alien where id =:id");

            q.setParameter("id", id);

            q.executeUpdate();

            tx.commit();

        } catch (Exception e) {

            if (tx != null) {

                tx.rollback();

            }

            e.printStackTrace();

        } finally {

            session.close();

        }

    }

}

The AlienRepository

package com.houseSearchKE;

import jakarta.ws.rs.\*;

import jakarta.ws.rs.core.MediaType;

import java.util.Arrays;

import java.util.List;

@Path("aliens")

public class AlienResource {

    AlienRepository repo = new AlienRepository();

    @GET

    @Produces({MediaType.APPLICATION\_JSON, MediaType.APPLICATION\_XML})

    public List<Alien> getAliens() {

        return repo.getAliens();

    }

    @GET

    @Path("alien/{id}")

    @Produces({MediaType.APPLICATION\_JSON, MediaType.APPLICATION\_XML})

    public Alien getAlien(@PathParam("id") int id) {

        return repo.getAlien(id);

    }

    @POST

    @Path("alien")

    @Consumes({MediaType.APPLICATION\_JSON, MediaType.APPLICATION\_XML})

    public List<Alien> createAlien(Alien a) {

        return repo.createAlien(a);

    }

    @PUT

    @Path("alien")

    @Consumes({MediaType.APPLICATION\_JSON, MediaType.APPLICATION\_XML})

    public List<Alien> updateAlien(Alien a) {

        return repo.updateAlien(a);

    }

    @DELETE

    @Path("alien/{id}")

    @Consumes({MediaType.APPLICATION\_JSON, MediaType.APPLICATION\_XML})    public Alien deleteAlien(@PathParam("id") int id) {

        Alien a = repo.getAlien(id);

        if(a.getId() != 0) {

            repo.deleteAlien(id);

        }

        return a;

    }

}

The resource/controller

package com.houseSearchKE;

import jakarta.persistence.\*;

import jakarta.xml.bind.annotation.XmlRootElement;

@XmlRootElement

@Entity

@Table(name = "aliens")

public class Alien {

    @Id

    @GeneratedValue(strategy = GenerationType.IDENTITY)

    private int id;

    @Column(name = "name")

    private String name;

    @Column(name = "points")

    private int points;

    public int getId() {

        return id;

    }

    public void setId(int id) {

        this.id = id;

    }

    public String getName() {

        return name;

    }

    public void setName(String name) {

        this.name = name;

    }

    public int getPoints() {

        return points;

    }

    public void setPoints(int points) {

        this.points = points;

    }

    public Alien(String name, int points) {

        this.name = name;

        this.points = points;

    }

    public Alien() {

    }

    @Override

    public String toString() {

        return "Alien{" +

                "id=" + id +

                ", name='" + name + '\'' +

                ", points=" + points +

                '}';

    }

}

The Alien model/ class

# **SPRING**

Spring is a powerful framework that not only facilitates the implementation of REST APIs but also offers advanced features like dependency injection. To illustrate these concepts, consider a laptop manufacturer like HP. HP produces laptops, which are made up of various components such as processors, hard drives, screens, and batteries. These components are sourced from different manufacturers.

If HP has a restrictive agreement with Intel that prevents them from using processors from another company like AMD, they face a potential problem. For example, if Intel starts supplying sub-standard processors, HP will be adversely affected.

In programming, such issues of tight coupling can be addressed by using abstract classes. For instance, a Laptop class might have attributes of abstract types. Imagine an abstract class Processor, which is extended by concrete classes like Intel and Amd. When creating a Laptop object, its processor attribute could be instantiated as either an Intel or Amd object, since you cannot instantiate the abstract Processor class directly.

Spring Framework addresses tight coupling differently, without relying on abstract classes. Instead, it uses annotations such as @Autowired and @Component. In this case, the Processor attribute of the Laptop class would be annotated with @Autowired, and the Intel and Amd classes would be annotated with @Component. This approach eliminates the need for the Processor abstract class, allowing Spring to manage dependencies and promote loose coupling through its powerful dependency injection capabilities.

Additionally, Spring provides several other features such as modular testing

## **Spring Core and Spring Context**

### **Procedure for creating your first spring project**

1. Create a simple maven project.
2. Add the “spring-core” and “spring-context” dependencies.

<dependency>

  <groupId>org.springframework</groupId>

  <artifactId>spring-core</artifactId>

  <version>6.1.12</version>

</dependency>

<dependency>

  <groupId>org.springframework</groupId>

  <artifactId>spring-context</artifactId>

  <version>6.1.12</version>

</dependency>

1. Create some entity classes.

package org.housesearchKE;

import org.springframework.stereotype.Component;

// @Component     - For annotation-based dependency injection

public class Car implements Vehicle{

    public void drive() {

        System.out.println("Driving the car");

    }

}

package org.housesearchKE;

import org.springframework.stereotype.Component;

// @Component     - For annotation-based dependency injection

public class Bike implements Vehicle {

    public void drive() {

        System.out.println("Riding the bike");

    }

}

package org.housesearchKE;

public interface Vehicle {

    void drive();

}

1. Configure a file that will hold the configuration information of your project. Note, you can use one of three/ or a mixture of configuration types:

#### **Using spring.xml configuration file**

For instance, create a “spring.xml” configuration file within “src/main/resources”. Here, you can configure two of the three configuration types:

##### **XML-based dependency injection**

<?xml version="1.0" encoding="UTF-8"?>

<beans xmlns="http://www.springframework.org/schema/beans"

       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

       xsi:schemaLocation="http://www.springframework.org/schema/beans http://www.springframework.org/schema/beans/spring-beans.xsd">

    <bean id="car" class="org.housesearchKE.Car"></bean>

    <bean id="bike" class="org.housesearchKE.Bike"></bean>

</beans>

##### **Annotation-based dependency injection.**

The classes being configured need to be annotated with “@Component” annotation.

<?xml version="1.0" encoding="UTF-8"?>

<beans xmlns="http://www.springframework.org/schema/beans"

       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

       xmlns:context="http://www.springframework.org/schema/context"

       xsi:schemaLocation="http://www.springframework.org/schema/beans

                           http://www.springframework.org/schema/beans/spring-beans.xsd

                           http://www.springframework.org/schema/context

                           http://www.springframework.org/schema/context/spring-context.xsd">

    <!-- Enable component scanning -->

    <context:component-scan base-package="org.housesearchKE"/>

</beans>

#### **Using an “AppConfig” class file**

Here there is no “spring.xml” file to configure. Instead, a class, with an arbitrary name, say “AppConfig”, is used to handle the dependencies. This class is marked by a “@Configuration” annotation. Within this class, methods, whose return types are objects of the various types of classes available in your project, are defined. These methods are then annotated with “@Bean” annotation. For these reason, the classes themselves, liable for dependency injection, do not need to be marked with “@Component”.

##### **Java-based dependency injection**

This type of configuration is known as the java-based dependency injection configuration

package org.housesearchKE;

import org.springframework.context.annotation.Bean;

import org.springframework.context.annotation.Configuration;

@Configuration

public class AppConfig {

    @Bean

    public Car getCar() {

        return new Car();

    }

    @Bean

    public Bike getBike() {

        return new Bike();

    }

    @Bean

    public Tyre getTyre() {

        return new Tyre("Yana", 5000);

    }

}

1. Run the application from some main class and call the components from within the same. For the XML-based and Annotation-based configurations:

package org.housesearchKE;

import org.springframework.context.ApplicationContext;

import org.springframework.context.support.ClassPathXmlApplicationContext;

public class App

{

    public static void main( String[] args )

    {

        ApplicationContext context = new ClassPathXmlApplicationContext("spring.xml");

        Vehicle v = (Vehicle) context.getBean("car"); // The car is in small letters because: in the XML-based configuration, that is how the “id” is wriiten; in the Annotation-based configuration, that is how it is configured such that if the class name, marked by @Component, is “Car”, then the class’s bean will be called using “car”.

        v.drive();

    }

}

For the Java-based annotations:

package org.housesearchKE;

import org.springframework.context.ApplicationContext;

import org.springframework.context.annotation.AnnotationConfigApplicationContext;

import org.springframework.context.support.ClassPathXmlApplicationContext;

public class App

{

    public static void main( String[] args )

    {

        ApplicationContext context = new AnnotationConfigApplicationContext(AppConfig.class);

        Car car = (Car) context.getBean(Car.class);

        car.drive();

        Bike bike = (Bike) context.getBean(Bike.class);

        bike.drive();

        Tyre tyre = (Tyre) context.getBean(Tyre.class);

        System.out.println(tyre);

    }

}

### **Parameterised Dependency Injection**

In dependency injection, an object is injected into a class, and this object has various attributes or fields. To properly utilize dependency injection, the injected object must be instantiated with appropriate values for its properties at creation time.

The way in which these values are assigned depends on the configuration approach used in the project, which could be XML-based, annotation-based, or Java-based. It’s important to be consistent with the configuration method you choose.

Regardless of the configuration approach, value assignment to an object's properties typically occurs through one of two methods: using the individual fields’ setters (setter injection) or the class’s constructor (constructor injection). To choose between them, consider the instance variables. Do they need to be initialized, compulsorily, at bean creation? If yes you can use the constructor injection. If the attributes can optionally be initialized, then you have to use the setter injection because if you try to use the constructor injection, it will return an error.

Also. It is generally considered good practice to declare class fields as private to maintain encapsulation and ensure controlled access.

public class App

{

    public static void main( String[] args )

    {

        ApplicationContext context = new ClassPathXmlApplicationContext("spring.xml");

        Car car = (Car) context.getBean("car");

        System.out.println(car);

    }

}

#### **XML-Based DP**

This is fully-configured in the “spring.xml” file.

##### **Setter Injection**

The classes being injected do not need a constructor.

<?xml version="1.0" encoding="UTF-8"?>

<beans xmlns="http://www.springframework.org/schema/beans"

       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

       xsi:schemaLocation="http://www.springframework.org/schema/beans http://www.springframework.org/schema/beans/spring-beans.xsd">

    <bean id="car" class="org.housesearchKE.Car">

        <property name="tyre" ref="tyre"/> <!-- We use “ref” because “value” require that we enter a primitive value ->

    </bean>

    <bean id="bike" class="org.housesearchKE.Bike"></bean>

    <bean id="tyre" class="org.housesearchKE.Tyre">

        <property name="brand" value="YANA"></property>

        <property name="price" value="5000"></property>

    </bean>

</beans>

public class Car implements Vehicle{

    private Tyre tyre;

}

public class Tyre {

    private String brand;

    private int price;

    public void setPrice(int price) { // The necessary setter

        this.price = price;

    }

    public void setBrand(String brand) { // The necessary setter

        this.brand = brand;

    }

}



##### **Constructor Injection**

The classes being injected need parameterized constructors.

<?xml version="1.0" encoding="UTF-8"?>

<beans xmlns="http://www.springframework.org/schema/beans"

       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

       xsi:schemaLocation="http://www.springframework.org/schema/beans http://www.springframework.org/schema/beans/spring-beans.xsd">

    <bean id="bike" class="org.housesearchKE.Bike"></bean>

    <bean id="car" class="org.housesearchKE.Car">

        <property name="tyre" ref="tyre"/>

    </bean>

    <bean id="tyre" class="org.housesearchKE.Tyre">

        <constructor-arg name="brand" value="YANA"></constructor-arg>

        <constructor-arg name="price" value="5000"></constructor-arg>

    </bean>

</beans>

public class Car implements Vehicle{

    private Tyre tyre;

}

public class Tyre {

    private String brand;

    private int price;

    public Tyre(String brand, int price) { // The necessary constructor

        this.brand = brand;

        this.price = price;

    }

    public Tyre() {

    }

}



#### **Annotation-Based DP**

This makes use of the “@Autowired” and “@Component” annotation.

<beans xmlns="http://www.springframework.org/schema/beans"

       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

       xmlns:context="http://www.springframework.org/schema/context"

       xsi:schemaLocation="http://www.springframework.org/schema/beans

                           http://www.springframework.org/schema/beans/spring-beans.xsd

                           http://www.springframework.org/schema/context

                           http://www.springframework.org/schema/context/spring-context.xsd">

    <!-- Enable component scanning -->

    <context:component-scan base-package="org.housesearchKE"/>

</beans>

@Component

public class Car implements Vehicle{

    @Autowired

    private Tyre tyre;

}

##### **Setter Injection**

@Component

public class Tyre {

    private String brand;

    private int price;

    public int getPrice() {

        return price;

    }

    @Value("5000")

    public void setPrice(int price) {

        this.price = price;

    }

    public String getBrand() {

        return brand;

    }

    @Value("YANA")

    public void setBrand(String brand) {

        this.brand = brand;

    }

}

##### **Constructor Injection**

@Component

public class Tyre {

    private String brand;

    private int price;

    @Autowired

    public Tyre(@Value("Yana") String brand, @Value("5000") int price) {

        this.brand = brand;

        this.price = price;

    }

}

#### **Java-Based DP**

This is set up in the “@Configuration” marked class.

public class App

{

    public static void main( String[] args )

    {

        ApplicationContext context = new AnnotationConfigApplicationContext(AppConfig.class);

        Car car = (Car) context.getBean(Car.class);

        System.out.println(car);

    }

}

##### **Setter Injection**

@Configuration

public class AppConfig {

    @Bean

    public Tyre getTyre() {

        Tyre tyre = new Tyre();

        tyre.setBrand("YANA");

        tyre.setPrice(5000);

        return tyre;

    }

    @Bean

    public Car getCar(Tyre tyre) {

        Car car = new Car();

        car.setTyre(tyre);

        return car;

    }

    @Bean

    public Bike getBike() {

        return new Bike();

    }

}

##### **Constructor Injection**

public class Car implements Vehicle{

    @Autowired

    private Tyre tyre;

    public Car(Tyre tyre) {

        this.tyre = tyre;

    }

}

public class Tyre {

    private String brand;

    private int price;

    public Tyre(String brand, int price) {

        this.brand = brand;

        this.price = price;

    }

}

@Configuration

public class AppConfig {

    @Bean

    public Tyre getTyre() {

        return new Tyre("YANA", 5000);

    }

    @Bean

    public Car getCar(Tyre tyre) {

        return new Car(tyre);

    }

    @Bean

    public Bike getBike() {

        return new Bike();

    }

}

### **@ComponentScan**

As discussed, there are three ways to configure dependency injection: XML, Annotations and Java-based configuration. With the java-based configuration, it is essentially a hybrid of the two former; with the “@Bean” representing XML’s “<bean>”, and the other annotations representing the annotation-based DP.

However it is possible to extend this java-based DP so that you don’t even have to declare “@Bean” methods in the “AppConfig” class.

Here, we annotate the classes we want to inject with “@Component” and add a “@ComponentScan” annotation to the already annotated “@Configuration” class.

Also, if you want to have parameterized DP, we have to use the “@Value” annotation

package org.housesearchKE;

import org.springframework.context.annotation.ComponentScan;

import org.springframework.context.annotation.Configuration;

@Configuration

@ComponentScan(basePackages = "org.housesearchKE")

public class AppConfig {

}

#### **Setter Injection**

package org.housesearchKE;

import org.springframework.beans.factory.annotation.Value;

import org.springframework.stereotype.Component;

@Component

public class Tyre {

    private String brand;

    private int price;

    public Tyre(String brand,  int price) {

        this.brand = brand;

        this.price = price;

    }

    public Tyre() {

    }

    public int getPrice() {

        return price;

    }

    @Value("5000")

    public void setPrice(int price) {

        this.price = price;

    }

    public String getBrand() {

        return brand;

    }

    @Value("YANA")

    public void setBrand(String brand) {

        this.brand = brand;

    }

    @Override

    public String toString() {

        return "Tyre{" +

                "brand='" + brand + '\'' +

                ", price=" + price +

                '}';

    }

}

#### **Constructor Injection**

package org.housesearchKE;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.beans.factory.annotation.Value;

import org.springframework.stereotype.Component;

@Component

public class Tyre {

    private String brand;

    private int price;

    @Autowired

    public Tyre(@Value("YANA") String brand, @Value("5000") int price) {

        this.brand = brand;

        this.price = price;

    }

    public Tyre() {

    }

    public int getPrice() {

        return price;

    }

    public void setPrice(int price) {

        this.price = price;

    }

    public String getBrand() {

        return brand;

    }

    public void setBrand(String brand) {

        this.brand = brand;

    }

    @Override

    public String toString() {

        return "Tyre{" +

                "brand='" + brand + '\'' +

                ", price=" + price +

                '}';

    }

}

### **“@Primary” and “@Qualifier”**

Recall the spring introduction where we discussed the issue of tight coupling and how spring handles the same. However, challenges may arise when injecting dependencies that are defined as interfaces with multiple implementations. When Spring encounters an interface with multiple @Component implementations, it cannot decide which implementation to inject, potentially resulting in a NoQualifyingBean exception.

To resolve this ambiguity, Spring provides two powerful annotations:

* @Primary: This annotation is used on a component class to designate it as the default choice when multiple beans of the same type are available. By marking a bean with @Primary, you signal to Spring that it should prefer this bean over others when performing automatic injection.
* @Qualifier: When you need to specify which bean should be injected from a set of options, you use @Qualifier on the injection point. This annotation allows you to precisely control which bean to inject, ensuring that the correct implementation is used.

Note, in the event that both of these are used, “@Qualifier” takes precedence over “@Primary”

Consider a manager class with an attribute of type vehicle, an interface

package org.housesearchKE;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.beans.factory.annotation.Qualifier;

import org.springframework.stereotype.Component;

//@Component("manager")     - default id = "manager"

@Component      // Nonqualified (no package information, e.g, "com.housesearch.Manager") and de-capitalised by default

public class Manager {

    @Autowired

@Qualifier("bike")

    private Vehicle vehicle;

    public Vehicle getVehicle() {

        return vehicle;

    }

    public void setVehicle(Vehicle vehicle) {

        this.vehicle = vehicle;

    }

    public Manager(Vehicle vehicle) {

        this.vehicle = vehicle;

    }

    @Override

    public String toString() {

        return "Manager{" +

                "vehicle=" + vehicle +

                '}';

    }

}

The “Vehicle” interface

package org.housesearchKE;

@Component

public interface Vehicle {

    void drive();

}

The Car, “Vehicle” implementation

import org.springframework.stereotype.Component;

import org.springframework.context.annotation.Primary;

@Component

@Primary        // Will eventually be ignored because the Manager specifies the @Qualifier

public class Car implements Vehicle{

}

The Bike, “Vehicle” implementation

package org.housesearchKE;

import org.springframework.stereotype.Component;

@Component

public class Bike implements Vehicle {

}

The main method class

package org.housesearchKE;

import org.springframework.context.ApplicationContext;

import org.springframework.context.annotation.AnnotationConfigApplicationContext;

public class App

{

    public static void main( String[] args )

    {

        ApplicationContext context = new AnnotationConfigApplicationContext(AppConfig.class);

        Manager manager = (Manager) context.getBean(Manager.class);

        System.out.println(manager);

    }

}



### **Using “autowire” in the XML-based DP**

This works in the same way as “@Autowired”. However it is configured in the XML configuration file. It is a property of every bean, similar to “id” and “class”. Using it, you can how you want spring to look up the bean(s) you want to inject, either by name or by its type.

E.g. to inject a vehicle to a manager, the vehicle being an interface with car and bike class implementations:

public class Manager {

    private Vehicle vehicle;

    public Vehicle getVehicle() {

        return vehicle;

    }

    public void setVehicle(Vehicle vehicle) {

        this.vehicle = vehicle;

    }

    public Manager(Vehicle vehicle) {

        this.vehicle = vehicle;

    }

    public Manager() {

    }

}

public interface Vehicle {

    void drive();

}

public class Bike implements Vehicle {

    public void drive() {

        System.out.println("Riding the bike");

    }

}

public class Car implements Vehicle{

    public void drive() {

        System.out.println("Car driving");

    }

}

<?xml version="1.0" encoding="UTF-8"?>

<beans xmlns="http://www.springframework.org/schema/beans"

       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

       xsi:schemaLocation="http://www.springframework.org/schema/beans http://www.springframework.org/schema/beans/spring-beans.xsd">

    <bean id="manager" class="org.housesearchKE.Manager" autowire="byType">

    </bean>

    <bean id="bike" class="org.housesearchKE.Bike" primary="true"></bean>

    <bean id="car" class="org.housesearchKE.Car"></bean>

</beans>

### **Singleton vs Prototype Beans**

Spring is a java framework. Everything on java runs on the JVM. Within this JVM, when working with spring, is a spring container. This container is where all the beans are held. Beans, essentially, are objects of various types. It is from this container that spring gets the beans that are injected during dependency injection, which is a good feature as the size of the project increases, making it difficult to manage the objects.

However, in spring the default configuration involves the injection of the same bean in spite of the number of references created. E.g. in the following example, both alien1 and alien2 will have an age of 10 even though this assignment of age only happens on alien1. This is because, both alien1 and alien2 refer to the same object/ bean. This is what is called a **singleton bean.**

public class Alien {

    private int age;

    public int getAge() {

        return age;

    }

    public void setAge(int age) {

        this.age = age;

    }

}

package org.housesearchKE;

import org.springframework.context.ApplicationContext;

import org.springframework.context.annotation.AnnotationConfigApplicationContext;

import org.springframework.context.support.ClassPathXmlApplicationContext;

import javax.lang.model.element.TypeElement;

public class App

{

    public static void main( String[] args )

    {

        ApplicationContext context = new ClassPathXmlApplicationContext("spring.xml");

        Alien alien1 = (Alien) context.getBean("alien");

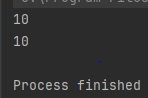
        alien1.setAge(10);

        System.out.println(alien1.getAge());

        Alien alien2 = (Alien) context.getBean("alien");

        System.out.println(alien2.getAge());

}



<beans xmlns="http://www.springframework.org/schema/beans"

       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

       xmlns:context="http://www.springframework.org/schema/context"

       xsi:schemaLocation="http://www.springframework.org/schema/beans

                           http://www.springframework.org/schema/beans/spring-beans.xsd

                           http://www.springframework.org/schema/context

                           http://www.springframework.org/schema/context/spring-context.xsd">

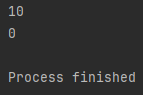
    <bean id="alien" class="org.housesearchKE.Alien" scope="singleton"></bean>

    <!-- Unnecessary to specify the scope as "singleton" because that is its default value -->

</beans>

In cases when we want every bean being injected to be distinct we can set the scope as “prototype”. Each of the distinct beans injected are what are known as **prototype beans.**

<bean id="alien" class="org.housesearchKE.Alien" scope="prototype"></bean>



To change the scope in the annotation-based and java-based configurations, we use the “@Scope” annotation:

Annotation-based and “@ComponentScan” java-based configuration:

@Component

@Scope("prototype")

public class Alien {

    int age;

    public int getAge() {

        return age;

    }

    public void setAge(int age) {

        this.age = age;

    }

}

Regular java-based configuration:

@Configuration

public class AppConfig {

    @Bean

    @Scope("prototype")

    public Alien getAlien() {

        return new Alien();

    }

}

## **Spring MVC**

Refer to the Springboot MVC introduction. Spring MVC is essesntailly the same thing but with the missing pre-configuration. For example, there is no embedded tomcat server.

### **Procedure for creating and configuring a spring MVC project**

1. Create a simple web project with the “webapp” archetype.
2. Add the spring mvc dependency. This will add the spring core and context dependencies as well.
3. Manually add a tomcat server to the project.
4. Modify the project’s web.xml file to add the dispatcher servlet as the first servlet called by any request. The class for this servlet is “org.springframework.web.servlet.DispatcherServlet”.

<!DOCTYPE web-app PUBLIC

 "-//Sun Microsystems, Inc.//DTD Web Application 2.3//EN"

 "http://java.sun.com/dtd/web-app\_2\_3.dtd" >

<web-app>

  <servlet>

    <servlet-name>dispatcher</servlet-name>

    <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-class>

  </servlet>

  <servlet-mapping>

    <servlet-name>dispatcher</servlet-name>

    <url-pattern>/</url-pattern>    <!-- Makes this the first servlet to be called -->

  </servlet-mapping>

</web-app>

1. Create a configuration file for this servlet within the same directory as the web.xml file. Name this file as “<servlet name in the web.xml file>-servlet.xml”, say “dispatcher-servlet.xml”.
2. Within the “dispatcher-servlet.xml”, create a beans tag and set it to use the component-scan to find the project’s controllers (annotated by “@Controller”).
3. Also create, if necessary (if you have moved the views to a different folder, say, “/WEB-INF/views/”), a bean of the class “org.springframework.web.servlet.view.InternalResourceViewResolver” to specify the prefix and suffix properties describing the relative (to “src/main/webapp/”) location and extension of the views respectively.

<?xml version="1.0" encoding="UTF-8"?>

<beans xmlns="http://www.springframework.org/schema/beans"

       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

       xmlns:context="http://www.springframework.org/schema/context"

       xsi:schemaLocation="http://www.springframework.org/schema/beans http://www.springframework.org/schema/beans/spring-beans.xsd http://www.springframework.org/schema/context https://www.springframework.org/schema/context/spring-context.xsd">

    <context:component-scan base-package="com.housesearchke"/>

    <bean class="org.springframework.web.servlet.view.InternalResourceViewResolver">

        <property name="prefix" value="/WEB-INF/views/"></property>

        <property name="suffix" value=".jsp"></property>

    </bean>

</beans>

1. Create the controllers in the base package you provided in step vi, the model class in a model package and run the project. Note the index.jsp is the first run.

## **Spring ORM**

This is the module of the spring framework that deals with object relational mapping. It is similar to Hibernate except it is the API using which the spring framework can connect with an ORM tool like Hibernate.

For this reason, a spring project that seeks to make use of the spring ORM library needs some extra dependencies:

* The actual ORM tool’s library, say, Hibernate core
* Spring ORM – To link spring core with the ORM
* Spring TX – To handle transactions so that they do not have to be manually managed by the programmer.
* The DBMS connector
* A connection pooling library, say HikariCP or c3p0

### **Procedure for Creating a Spring ORM project**

1. Add the dependencies described above to the pom.xml file.

  <project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/maven-v4\_0\_0.xsd">

  <modelVersion>4.0.0</modelVersion>

  <groupId>com.housesearchKE</groupId>

  <artifactId>SpringORM</artifactId>

  <packaging>war</packaging>

  <version>1.0-SNAPSHOT</version>

  <name>SpringORM Maven Webapp</name>

  <url>http://maven.apache.org</url>

  <dependencies>

    <dependency>

      <groupId>junit</groupId>

      <artifactId>junit</artifactId>

      <version>3.8.1</version>

      <scope>test</scope>

    </dependency>

    <dependency>

      <groupId>org.springframework</groupId>

      <artifactId>spring-webmvc</artifactId>

      <version>6.1.12</version>

    </dependency>

    <dependency>

      <groupId>org.hibernate.orm</groupId>

      <artifactId>hibernate-core</artifactId>

      <version>6.6.0.Final</version>

    </dependency>

    <dependency>

      <groupId>org.springframework</groupId>

      <artifactId>spring-orm</artifactId>

      <version>6.1.12</version>

    </dependency>

    <dependency>

      <groupId>org.springframework</groupId>

      <artifactId>spring-tx</artifactId>

      <version>6.1.12</version>

    </dependency>

    <dependency>

      <groupId>com.mysql</groupId>

      <artifactId>mysql-connector-j</artifactId>

      <version>9.0.0</version>

    </dependency>

<!--    <dependency>-->

<!--      <groupId>org.hibernate.orm</groupId>-->

<!--      <artifactId>hibernate-hikaricp</artifactId>-->

<!--      <version>6.6.0.Final</version>-->

<!--    </dependency>-->

<!--    <dependency>-->

<!--      <groupId>com.mchange</groupId>-->

<!--      <artifactId>c3p0</artifactId>-->

<!--      <version>0.9.5.3</version>-->

<!--    </dependency>-->

    <dependency>

      <groupId>com.zaxxer</groupId>

      <artifactId>HikariCP</artifactId>

      <version>5.1.0</version>

    </dependency>

    <!-- SLF4J Binding (Choose one) -->

    <!-- Option 1: Using Logback -->

<!--    <dependency>-->

<!--      <groupId>ch.qos.logback</groupId>-->

<!--      <artifactId>logback-classic</artifactId>-->

<!--      <version>1.4.11</version>-->

<!--    </dependency>-->

    <!-- Option 2: Using SLF4J Simple -->

    <dependency>

        <groupId>org.slf4j</groupId>

        <artifactId>slf4j-simple</artifactId>

        <version>2.0.7</version>

    </dependency>

  </dependencies>

  <build>

    <finalName>SpringORM</finalName>

  </build>

</project>

1. Create the entity classes as well as the DAO classes.

package com.housesearchke.springormdemo.model;

import jakarta.persistence.\*;

@Entity

@Table(name = "aliens")

public class Alien {

    @Id

    @GeneratedValue(strategy = GenerationType.IDENTITY)

    private int id;

    @Column(name = "name")

    private String name;

    @Column(name = "technology")

    private String technology;

        .

        .

        .

}

package com.housesearchke.springormdemo.dao;

import com.housesearchke.springormdemo.model.Alien;

import jakarta.transaction.Transactional;

import org.hibernate.Session;

import org.hibernate.SessionFactory;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.stereotype.Component;

import java.util.List;

@Component

public class AlienDAO {

    @Autowired          // Autowired because the bean is defined in the dispatcher-servlet.xml

    private SessionFactory sessionFactory;

    @Transactional          // Instead of having to open, close, commit rollback the transactions manually

    public List<Alien> addAlien(Alien a) {

        Session session = sessionFactory.getCurrentSession();

        session.persist(a);

        return getAliens();

    }

    @Transactional

    public List<Alien> getAliens() {

        Session session = sessionFactory.getCurrentSession();

        List<Alien> aliens = session.createQuery("from Alien", Alien.class).list();

        return aliens;

    }

@Transactional

    public Alien getAlien(int aid) {

        Session session = sessionFactory.getCurrentSession();

        Alien alien = session.get(Alien.class, aid);

        return alien;

    }

}

1. Configure the home controller (spring MVC) to work with the entity and DAO classes.

package com.housesearchke.springormdemo;

import com.housesearchke.springormdemo.dao.AlienDAO;

import com.housesearchke.springormdemo.model.Alien;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.stereotype.Controller;

import org.springframework.ui.Model;

import org.springframework.ui.ModelMap;

import org.springframework.web.bind.annotation.\*;

@Controller

public class HomeController {

    @Autowired

    private AlienDAO alienDAO;

    @RequestMapping("/")

    public String home() {

        return "index";

    }

    @RequestMapping("addAlien")

    public String addAlien(@ModelAttribute("alien") Alien alien, Model m) {

        m.addAttribute("aliens", alienDAO.addAlien(alien));     // Add the alien to the database, return the list of all the aliens and add the same to the model so that they can be viewed in the result.jsp page

        return "result";

    }

    @RequestMapping("getAliens")

    public String getAliens(Model m) {

        m.addAttribute("aliens", alienDAO.getAliens());

        return "result";

    }

@RequestMapping("getAlien")

// When using @RequestParam, all the parameters must be provided in the request

    public String getAliens(@RequestParam("aid") int aid, Model m) {

        m.addAttribute("aliens", alienDAO.getAlien(aid));

        return "result";

    }

}

1. Modify the dispatcher-servlet.xml to include the hibernate-specific configurations such as the session-factory, datasource, connection pool and transaction manager (spring tx). You can also use the java-based configuration (@Configuration) as well, and instead, if you like.

<beans xmlns="http://www.springframework.org/schema/beans"

       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

       xmlns:mvc="http://www.springframework.org/schema/mvc"

       xmlns:context="http://www.springframework.org/schema/context"

       xmlns:tx="http://www.springframework.org/schema/tx"

       xsi:schemaLocation="http://www.springframework.org/schema/beans

       http://www.springframework.org/schema/beans/spring-beans.xsd

       http://www.springframework.org/schema/mvc

       http://www.springframework.org/schema/mvc/spring-mvc.xsd

       http://www.springframework.org/schema/context

       http://www.springframework.org/schema/context/spring-context.xsd

       http://www.springframework.org/schema/tx

       http://www.springframework.org/schema/tx/spring-tx.xsd">

    <!-- Scans the specified package for Spring components (e.g., @Controller, @Service, etc.) -->

    <context:component-scan base-package="com.housesearchke"/>

    <context:annotation-config/>

    <mvc:annotation-driven></mvc:annotation-driven>

    <!-- DataSource bean using HikariCP for connection pooling -->

    <bean id="myDataSource" class="com.zaxxer.hikari.HikariDataSource" destroy-method="close">

        <property name="driverClassName" value="com.mysql.cj.jdbc.Driver"/>

        <property name="jdbcUrl" value="jdbc:mysql://localhost:3306/javarefresher?createDatabaseIfNotExist=true"/>

        <property name="username" value="root"/>

        <property name="password" value=""/>

        <!-- HikariCP-specific settings -->

        <property name="minimumIdle" value="5"/>

        <property name="maximumPoolSize" value="10"/>

        <property name="idleTimeout" value="30000"/>

        <property name="dataSourceProperties">

            <props>

                <prop key="dataSource.logWriter">java.util.logging.ConsoleHandler</prop>

            </props>

        </property>

    </bean>

    <!-- SessionFactory bean for Hibernate, used to create sessions for interacting with the database -->

    <bean id="sessionFactory" class="org.springframework.orm.hibernate5.LocalSessionFactoryBean" depends-on="myDataSource">

        <property name="dataSource" ref="myDataSource"/>

        <property name="packagesToScan" value="com.housesearchke.springormdemo.model"/>

        <property name="hibernateProperties">

            <props>

                <prop key="hibernate.dialect">org.hibernate.dialect.MySQLDialect</prop>

                <prop key="hibernate.show\_sql">true</prop>

                <prop key="hibernate.hbm2ddl.auto">update</prop>

            </props>

        </property>

    </bean>

    <!-- Transaction manager bean to manage database transactions using Hibernate -->

    <bean id="myTransactionManager" class="org.springframework.orm.hibernate5.HibernateTransactionManager" depends-on="sessionFactory">

        <property name="sessionFactory" ref="sessionFactory"/>

    </bean>

    <!-- Enables annotation-driven transaction management (@Transactional) -->

    <tx:annotation-driven transaction-manager="myTransactionManager"/>

    <!-- ViewResolver bean to map view names to actual JSP files -->

    <bean class="org.springframework.web.servlet.view.InternalResourceViewResolver">

        <property name="prefix" value="/WEB-INF/views/"/>

        <property name="suffix" value=".jsp"/>

    </bean>

</beans>

Java-based configuration

package com.housesearchke.springormdemo;

import com.zaxxer.hikari.HikariConfig;

import com.zaxxer.hikari.HikariDataSource;

import org.hibernate.cfg.Environment;

import org.springframework.context.annotation.Bean;

import org.springframework.context.annotation.Configuration;

import org.springframework.context.annotation.DependsOn;

import org.springframework.orm.hibernate5.HibernateTransactionManager;

import org.springframework.orm.hibernate5.LocalSessionFactoryBean;

import org.springframework.transaction.PlatformTransactionManager;

import org.springframework.transaction.annotation.EnableTransactionManagement;

import javax.sql.DataSource;

import java.util.Properties;

@Configuration

@EnableTransactionManagement

public class AppConfig {

   @Bean

   public DataSource dataSource() {

       HikariConfig config = new HikariConfig();

       config.setDriverClassName("com.mysql.cj.jdbc.Driver");

       config.setJdbcUrl("jdbc:mysql://localhost:3306/javarefresher?createDatabaseIfNotExist=true");

       config.setUsername("root");

       config.setPassword("");

       config.setMinimumIdle(5);

       config.setMaximumPoolSize(10);

       config.setIdleTimeout(30000);

       return new HikariDataSource(config);

   }

   @Bean

   @DependsOn("dataSource")

   public LocalSessionFactoryBean sessionFactory() {

       System.out.println("Creating session factory");

       LocalSessionFactoryBean sessionFactory = new LocalSessionFactoryBean();

       sessionFactory.setDataSource(dataSource());

       sessionFactory.setPackagesToScan("com.housesearchke.springormdemo.model");

       Properties hibernateProperties = new Properties();

       hibernateProperties.put(Environment.DIALECT, "org.hibernate.dialect.MySQLDialect");

       hibernateProperties.put(Environment.SHOW\_SQL, "true");

       hibernateProperties.put(Environment.HBM2DDL\_AUTO, "update");

       sessionFactory.setHibernateProperties(hibernateProperties);

       System.out.println("Session factory created");

       return sessionFactory;

   }

   @Bean

   @DependsOn("sessionFactory")

   public PlatformTransactionManager transactionManager() {

       HibernateTransactionManager transactionManager = new HibernateTransactionManager();

       transactionManager.setSessionFactory(sessionFactory().getObject());

       return transactionManager;

   }

}

1. Run the project.

# **SPRINGBOOT**

Spring Boot is a framework designed to simplify the development of Spring applications by providing a convention-over-configuration approach. It builds on the Spring framework, which is a comprehensive ecosystem for building enterprise-grade applications in Java. While Spring offers powerful tools and libraries e.g. for dependency injection (IoC – Inversion of control), aspect-oriented programming, and transaction management, configuring a Spring application can be complex and time-consuming.

Spring Boot addresses these challenges by offering a set of pre-configured templates and auto-configuration features that eliminate much of the boilerplate code required in traditional Spring applications. It also includes an embedded server, such as Tomcat or Jetty, allowing developers to run their applications independently without needing to deploy them to an external server. This makes Spring Boot particularly well-suited for creating microservices and standalone applications, allowing developers to focus on business logic rather than infrastructure setup.

In essence, Spring Boot enhances the productivity and ease of use of the Spring framework, making it more accessible and faster to develop robust Java applications.

## **Procedure for creating your first springboot project**

This project will be a basic spring project with no developer-added dependencies.

1. Open intellij.
2. Go to “File > New > Project”
3. From the “generators” choose “Spring Initialiser”.
4. Provide the project details such as the group id, project name, language (java), build tool (maven) etc.
5. Click on next.
6. Do not choose any dependencies. Click on finish and open the project.
7. Let maven download all the dependencies.
8. Open the pom.xml file.

<?xml version="1.0" encoding="UTF-8"?>

<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 https://maven.apache.org/xsd/maven-4.0.0.xsd">

    <modelVersion>4.0.0</modelVersion>

    <parent>

        <groupId>org.springframework.boot</groupId>

        <artifactId>spring-boot-starter-parent</artifactId>

        <version>3.3.3</version>

        <relativePath/> <!-- lookup parent from repository -->

    </parent>

    <groupId>com.housesearchKE</groupId>

    <artifactId>SpringbootDemo</artifactId>

    <version>0.0.1-SNAPSHOT</version>

    <name>SpringbootDemo</name>

    <description>SpringbootDemo</description>

    <url/>

    <licenses>

        <license/>

    </licenses>

    <developers>

        <developer/>

    </developers>

    <scm>

        <connection/>

        <developerConnection/>

        <tag/>

        <url/>

    </scm>

    <properties>

        <java.version>17</java.version>

    </properties>

    <dependencies>

        <dependency>

            <groupId>org.springframework.boot</groupId>

            <artifactId>spring-boot-starter</artifactId>

        </dependency>

        <dependency>

            <groupId>org.springframework.boot</groupId>

            <artifactId>spring-boot-starter-test</artifactId>

            <scope>test</scope>

        </dependency>

    </dependencies>

    <build>

        <plugins>

            <plugin>

                <groupId>org.springframework.boot</groupId>

                <artifactId>spring-boot-maven-plugin</artifactId>

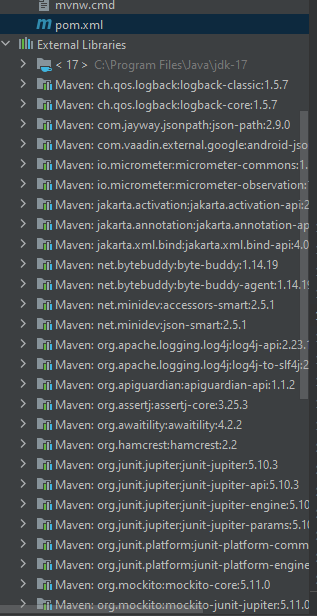
            </plugin>

        </plugins>

    </build>

</project>

1. It will only have the “spring-boot-…” dependencies but you will notice that the number of jar files downloaded is large.



1. Run the “src/main/java/<package>/SpringbootDemoApplication.java” main file

package com.housesearchke.springbootdemo;

import org.springframework.boot.SpringApplication;

import org.springframework.boot.autoconfigure.SpringBootApplication;

import org.springframework.context.ApplicationContext;

@SpringBootApplication

public class SpringbootDemoApplication {

    public static void main(String[] args) {

        SpringApplication.run(SpringbootDemoApplication.class, args);

    }

}

## **Springboot JDBC**

Spring Boot JDBC simplifies the process of working with relational databases by providing a streamlined approach to database interactions using the JDBC API. Central to this setup is the `DataSource`, which manages database connections efficiently through connection pooling, ensuring optimal performance.

Spring Boot automatically configures a `DataSource` based on properties defined in your application, allowing you to connect to your database seamlessly. Along with this, Spring Boot provides the `JdbcTemplate`, a powerful tool that abstracts away much of the boilerplate code involved in executing SQL queries, making it easier to interact with your database.

In a typical Spring Boot JDBC application, your data access logic is organized into repository packages, where classes are annotated with `@Repository`. These classes act as the data access layer, handling CRUD operations on your database models. By using `@Repository`, you enable Spring to recognize these classes as repositories and to manage exceptions in a consistent way.

This setup allows developers to efficiently manage database operations while keeping the code clean and maintainable, making Spring Boot JDBC an ideal choice for applications that require direct interaction with a relational database.

#### **Sample Project demonstrating the Springboot JDBC**

1. Google spring initializer.
2. Generate a springboot project with the following dependencies:
   1. Spring jdbc
   2. H2 database – This is an in-memory database that, as the description suggests, runs on RAM and whose state is volatile.
3. Extract the zip file generated and downloaded from the spring initializer and open the resultant project (template) in an IDE, say intellij.
4. Let maven resolve all the dependencies.

The sample project project will invove one kind of entity, known as models in springboot, and the goal is to save a few objects of the same into the database.

1. Create the model class and place it in a package called “model”.

package com.housesearchKE.SpringBootJdbcH2Demo.model;

import org.springframework.context.annotation.Scope;

import org.springframework.stereotype.Component;

@Component

@Scope("prototype")

public class Alien {

    private int id;

    private String name;

    private String technology;

    public int getId() {

        return id;

    }

    public void setId(int id) {

        this.id = id;

    }

    public String getName() {

        return name;

    }

    public void setName(String name) {

        this.name = name;

    }

    public String getTechnology() {

        return technology;

    }

    public void setTechnology(String technology) {

        this.technology = technology;

    }

    @Override

    public String toString() {

        return "Alien{" +

                "id=" + id +

                ", name='" + name + '\'' +

                ", technology='" + technology + '\'' +

                '}';

    }

}

1. Create a repository class for the model class and place it within a package called repo.
2. Annotate the class with the “@Repository” annotation.
3. Within this repository, define the methods that will be used to interact with the database.

package com.housesearchKE.SpringBootJdbcH2Demo.repo;

import com.housesearchKE.SpringBootJdbcH2Demo.model.Alien;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.jdbc.core.JdbcTemplate;

import org.springframework.jdbc.core.ResultSetExtractor;

import org.springframework.jdbc.core.RowMapper;

import org.springframework.stereotype.Repository;

import java.sql.ResultSet;

import java.sql.SQLException;

import java.util.ArrayList;

import java.util.List;

@Repository

public class AlienRepo {

    private JdbcTemplate template;

    public JdbcTemplate getTemplate() {

        return template;

    }

    @Autowired      // Get an instance of the JDBCTemplate class and set it to the repo class

    public void setTemplate(JdbcTemplate template) {

        this.template = template;

    }

    // To save a new Alien objevy into the database.

    public void save(Alien alien) {

        String query = "insert into aliens (id, name, technology) values (?, ?, ?)";    // This is a prepared statement

        template.update(query, alien.getId(), alien.getName(), alien.getTechnology());

        // Pass the query first then the parameters

    }

    // To get all the records in the "aliens" table.

    public List<Alien> findAll() {

        List<Alien> aliens = new ArrayList<>();

        String query = "select \* from aliens";

        RowMapper<Alien> mapper = new RowMapper<Alien>() {      // To map the records in the result set into objects of type "Alien"

            @Override

            public Alien mapRow(ResultSet rs, int rowNum) throws SQLException {

                Alien alien = new Alien();

                alien.setId(rs.getInt("id"));

                alien.setName(rs.getString("name"));

                alien.setTechnology(rs.getString("technology"));

                return alien;

            }

        };

        aliens = template.query(query, mapper);     // template.query returns a List

        return aliens;

    }

}

1. Write some logic into the main file to interact with the database:

package com.housesearchKE.SpringBootJdbcH2Demo;

import com.housesearchKE.SpringBootJdbcH2Demo.model.Alien;

import com.housesearchKE.SpringBootJdbcH2Demo.repo.AlienRepo;

import org.springframework.boot.SpringApplication;

import org.springframework.boot.autoconfigure.SpringBootApplication;

import org.springframework.context.ApplicationContext;

import java.util.List;

@SpringBootApplication

public class SpringBootJdbcH2DemoApplication {

    public static void main(String[] args) {

        ApplicationContext context = SpringApplication.run(SpringBootJdbcH2DemoApplication.class, args);

        System.out.println();

        AlienRepo repo = context.getBean(AlienRepo.class);

        Alien alien = context.getBean(Alien.class);

        alien.setId(4);

        alien.setName("Daniel Karongo");

        alien.setTechnology("Java");

        repo.save(alien);

        List<Alien> aliens = repo.findAll();

        for(Alien a: aliens) {

            System.out.println(a);

        }

        System.out.println();

    }

}

1. Given you are using h2 database, you need not configure the database connection in the “src/main/resources/application.properties” or “src/main/resources/application.yml” files. Note, both files are supported by default. However, the “application.properties” file takes precedence over the .yml file.
2. Create a file known as “schema.sql” in the “src/main/resources” directory to hold the table-creation DDL queries that will be run on the application’s startup.

create table aliens (

    id int primary key,

    name varchar(50),

    technology varchar(20)

);

1. Create another file known as “data.sql” in the same directory to hold some queries that populate the database table(s) with some some default values.

insert into aliens (id, name, technology)

values (1,'Victor Maina', 'Blockchain');

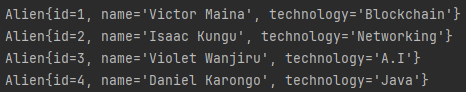
insert into aliens (id, name, technology)

values (2,'Isaac Kungu', 'Networking');

insert into aliens (id, name, technology)

values (3,'Violet Wanjiru', 'A.I');

1. Run the application



Note, however, if you want to link the project with a real dbms such as mysql, you have to configure the connectivity in the application.properties or application.yml files (and link the dbms connector dependency in the pom.xml file):

Application.properties:

spring.application.name=SpringBootJdbcH2Demo

# MySQL Database Configuration

spring.datasource.url=jdbc:mysql://localhost:3306/javarefresher?createDatabaseIfNotExist=true

spring.datasource.username=root

spring.datasource.password=

spring.datasource.driver-class-name=com.mysql.cj.jdbc.Driver

# To configure the application to run the "schema.sql" and "data.sql" scrpts on startup as well.

spring.sql.init.mode=always

spring.sql.init.schema-locations=classpath:schema.sql

spring.sql.init.data-locations=classpath:data.sql

# Similar to "<property name="show\_sql">true</property>" in hibernate

logging.level.org.springframework.jdbc.core=DEBUG

logging.level.org.springframework.jdbc.core.JdbcTemplate=DEBUG

Application.yml:

spring:

  application:

    name: SpringBootJdbcH2Demo

  datasource:

    url: jdbc:mysql://localhost:3306/javarefresher?createDatabaseIfNotExist=true

    username: root

    password:

    driver-class-name: com.mysql.cj.jdbc.Driver

  sql:

    init:

      mode: always

      schema-locations: classpath:schema.sql

      data-locations: classpath:data.sql

logging:

  level:

    org.springframework.jdbc.core: DEBUG

    org.springframework.jdbc.core.JdbcTemplate: DEBUG

## **Springboot MVC**

This is the configuration of springboot that allows for the creation of web applications. Recall the JSPs, servlets and MVC architecture. Recall the use of the web.xml file as the deployment descriptor. Springboot MVC provides its own dispatcher controller/ servlet that you do not need to configure manually. Instead all you need to do is to annotate your custom controllers (like servlets) with “@Controller” and configure some paths (like the URLs of the servlets) within this controllers with the “@RequestMapping” annotation.

### **Simple sample spring MVC project**

Create a new springboot project using any IDE or the online spring initializer, adding “web” as a dependency to the same.

This project comes with an embedded tomcat server as one of its dependencies so you will not need to add one. All you need to do to make use of the same is to “run the application as a springboot app”, say, on eclipse.

Also, to render the jsp files on the browser, you need to add a “tomcat-jasper” dependency in the pom.xml file of the same version as the embedded tomcat in the project. Without this, the browser will download the .jsp file rather than display it.

<dependencies>

    <dependency>

        <groupId>org.springframework.boot</groupId>

        <artifactId>spring-boot-starter-web</artifactId>

    </dependency>

    <dependency>

        <groupId>org.springframework.boot</groupId>

        <artifactId>spring-boot-starter-test</artifactId>

        <scope>test</scope>

    </dependency>

    <dependency>

        <groupId>org.apache.tomcat</groupId>

        <artifactId>tomcat-jasper</artifactId>

        <version>10.1.28</version>

    </dependency>

</dependencies>

package com.housesearchke.springbootmvcdemo;

import org.springframework.stereotype.Controller;

import org.springframework.web.bind.annotation.RequestMapping;

@Controller

public class HomeController {

    @RequestMapping("/")

    public String home() {

        return "index.jsp";

    }

}

<%@ page contentType="text/html;charset=UTF-8" language="java" %>

<html>

<head>

    <title>insert title here</title>

</head>

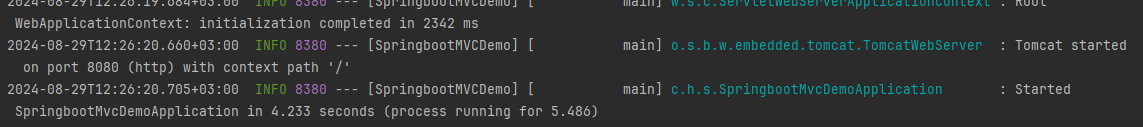
<body>

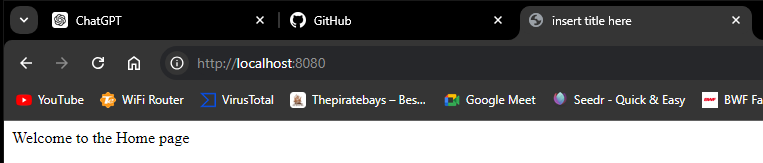
    Welcome to the Home page

</body>

</html>

Place this file in the “src/main/webapp” folder. Create one if there isn’t any.





### **Sample project involving some processing of user input and return some response view**

Given springboot mvc comes with tomcat, and tomcat provides HttpServletRequest and HttpServletResponse objects by default, it is possible to use the same concepts as servlets. However, springboot mvc has several features that replace the old servlet concepts:

* @RequestParam – This provides the parameters passed in the Http Request from the client.
* ModelAndView – This is a class that is instantiated and that provides a concrete representation of the resonse, where you can specify the view, say the “.jsp” file to be called as well as some data to be passed along, that will be used in the view.
* Model – Similar to the above but only holding the data being passed, not the view. The view then has to be returns manually as a string.
* ModelMap – Similar to the above but the model object is a map.

Each of the above have a scope and lifecycle tied to the request.

* Spring.mvc.view.prefix – This is a property specified in the “application.properties” file that holds the path of the views in the project. Note, placing the views in the “WEB-INF” folder makes them private such that they can only be accessed from the controller.
* Spring.mvc.view.suffix – Similar to the above but holding the extension of the view files.

Note, other “application.properties “ properties can be looked up in the spring docs.

<%@ page contentType="text/html;charset=UTF-8" language="java" %>

<html>

<head>

    <title>insert title here</title>

</head>

<body>

    <form action="add" method="post">

        Enter the first number: <input type="number" name="num1"><br>

        Enter the second number: <input type="number" name="num2"><br>

        <input type="submit" value="Submit">

    </form>

</body>

</html>

The index.jsp file.

<%@ page contentType="text/html;charset=UTF-8" language="java" isELIgnored="false" %>

<html>

<head>

    <title>insert title here</title>

</head>

<body>

    The sum is : ${sum}

</body>

</html>

The result.jsp file

package com.housesearchke.springbootmvcdemo;

import jakarta.servlet.http.HttpServletRequest;

import jakarta.servlet.http.HttpSession;

import org.springframework.stereotype.Controller;

import org.springframework.ui.ModelMap;

import org.springframework.web.bind.annotation.RequestMapping;

import org.springframework.web.bind.annotation.RequestParam;

import org.springframework.web.servlet.ModelAndView;

@Controller

public class HomeController {

//    @RequestMapping("/")

//    @PostMapping("/")     // To restrict the request to be a post method

//    @RequestMapping(value="/", method=RequestMethod.POST)     // To restrict the request to be a post method

//    @GetMapping("/")     // To restrict the request to be a post method

//    @RequestMapping(value="/", method=RequestMethod.GET)     // To restrict the request to be a post method

@RequestMapping("/")

    public String home() {

        return "index";

    }

    // Using the old servlets concepts

   @RequestMapping("add")

   public String add(HttpServletRequest request) {

       int sum = Integer.parseInt(request.getParameter("num1")) + Integer.parseInt(request.getParameter("num2"));

       HttpSession session = request.getSession();

       session.setAttribute("sum", sum);

       return "result.jsp";

   }

    //    Using @RequestParam and ModelAndView

   @RequestMapping("add")

   public ModelAndView add(@RequestParam("num1") int num1, @RequestParam("num2") int num2) {

       int sum = num1 + num2;

       ModelAndView mv = new ModelAndView();//

       mv.setViewName("result.jsp");

       ModelAndView mv = new ModelAndView("result.jsp");         // Equivalent to the above

       mv.addObject("sum", sum);

       return mv;

   }

    // Using ModelMap - Here you have to return the name of the view hence the "String" return type

    @RequestMapping("add")

    public String add(@RequestParam("num1") int num1, @RequestParam("num2") int num2, ModelMap mm) {

        int sum = num1 + num2;

        mm.addAttribute("sum", sum);

        return "result";

    }

}

The Controller

spring.application.name=SpringbootMVCDemo

spring.mvc.view.prefix=/WEB-INF/views/ // Note the last “/”

spring.mvc.view.suffix=.jsp

The application.properties file

### **@ModelAttribute**

This is an annotation used to bind data from the web request to a model object. It can also add attributes to the model (as described above) that can be accessed by the view layer. There are two ways to use it:

1. **Parameter-Level**: When used as a method parameter annotation, it binds a form's data or request parameters to the specified model object. This helps in automatically populating the model object with the data received from a form submission. Note, when using @ModelAttribute at the parameter level to bind form data to a model object, the form data variables (i.e., the names of the input fields in the HTML form) should match the property names of the model class.
2. **Method-Level**: When used on a method, @ModelAttribute indicates that the method should add one or more attributes to the model. These attributes are available to the view, as well as the other @RequestMapping methods in the controller, and the method is typically invoked everytime a @RequestMapping method is called.

package com.housesearchke.springbootmvcdemo.model;

public class Alien {

    private int id;

    private String name;

    private String technology;

    public int getId() {

        return id;

    }

    public void setId(int id) {

        this.id = id;

    }

    public String getName() {

        return name;

    }

    public void setName(String name) {

        this.name = name;

    }

    public String getTechnology() {

        return technology;

    }

    public void setTechnology(String technology) {

        this.technology = technology;

    }

    @Override

    public String toString() {

        return "Alien{" +

                "id=" + id +

                ", name='" + name + '\'' +

                ", technology='" + technology + '\'' +

                '}';

    }

}

The model class

@Controller

public class HomeController {

    @RequestMapping("/")

    public String home() {

        return "index";

    }

    // Parameter level

    @RequestMapping("addAlien")

    public String addAlien(@ModelAttribute("alien") Alien alien) {

        return "result";

    }

    // Method level

    @ModelAttribute

    public void addLocation(Model model) {

        model.addAttribute("location", "Kenya");

    }

}

The controller

<%@ page contentType="text/html;charset=UTF-8" language="java" %>

<html>

<head>

    <title>insert title here</title>

</head>

<body>

    <form action="addAlien" method="post">

        Enter the id: <input type="number" name="id"><br>

        Enter the name: <input type="text" name="name"><br>

        Enter the technology: <input type="text" name="technology"><br>

        <input type="submit" value="Submit">

    </form>

</body>

</html>

The form view

<%@ page contentType="text/html;charset=UTF-8" language="java" isELIgnored="false" %>

<html>

<head>

    <title>insert title here</title>

</head>

<body>

<%--    The sum is : ${sum}--%>

    <br>

    ${alien}

    <br>

    Located at ${location}

</body>

</html>

The view showing the mapped model object and the Model attribute

## **Springboot JPA**

This is similar to the spring ORM but whose configuration as well as the DAO layer’s functionalities are taken off by the spring data JPA library added to the spring boot application. It is a higher level database connectivity abstraction compared to springboot JDBC.

* The database connectivity details such as the database URL still need to be provided. This is done in the application.properties or application.yml files. The Hiberanate dialect also.
* The entity class’s DAO class is replaced by an interface that extends the “JPARepository” interface and this repo need not defined any new methods (unless unique to the project).
* The repo interface can then be autowired to where it needs to be used and the JPARepository methods called directly.

### **Procedure for creating a springboot JPA project**

Use the spring initializer to generate the project adding the following dependencies in the process:

* Spring data JPA
* Mysql connector
* Tomcat-jasper (for rendering the .jsp files)
* Spring mvc

The pom.xml file will look something like:  
<?xml version="1.0" encoding="UTF-8"?>

<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

    xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 https://maven.apache.org/xsd/maven-4.0.0.xsd">

    <modelVersion>4.0.0</modelVersion>

    <parent>

        <groupId>org.springframework.boot</groupId>

        <artifactId>spring-boot-starter-parent</artifactId>

        <version>3.3.3</version>

        <relativePath/> <!-- lookup parent from repository -->

    </parent>

    <groupId>com.housesearchKE</groupId>

    <artifactId>SpringbootJPADemo</artifactId>

    <version>0.0.1-SNAPSHOT</version>

    <packaging>war</packaging>

    <name>SpringbootJPADemo</name>

    <description>Demo project for Spring Boot JPA</description>

    <url/>

    <licenses>

        <license/>

    </licenses>

    <developers>

        <developer/>

    </developers>

    <scm>

        <connection/>

        <developerConnection/>

        <tag/>

        <url/>

    </scm>

    <properties>

        <java.version>17</java.version>

    </properties>

    <dependencies>

        <dependency>

            <groupId>org.springframework.boot</groupId>

            <artifactId>spring-boot-starter-data-jpa</artifactId>

        </dependency>

        <dependency>

            <groupId>org.springframework.boot</groupId>

            <artifactId>spring-boot-starter-web</artifactId>

        </dependency>

        <dependency>

            <groupId>com.mysql</groupId>

            <artifactId>mysql-connector-j</artifactId>

            <scope>runtime</scope>

        </dependency>

        <dependency>

            <groupId>org.springframework.boot</groupId>

            <artifactId>spring-boot-starter-tomcat</artifactId>

            <scope>provided</scope>

        </dependency>

        <dependency>

            <groupId>org.springframework.boot</groupId>

            <artifactId>spring-boot-starter-test</artifactId>

            <scope>test</scope>

        </dependency>

        <dependency>

            <groupId>org.apache.tomcat.embed</groupId>

            <artifactId>tomcat-embed-jasper</artifactId>

        </dependency>

    </dependencies>

    <build>

        <plugins>

            <plugin>

                <groupId>org.springframework.boot</groupId>

                <artifactId>spring-boot-maven-plugin</artifactId>

            </plugin>

        </plugins>

    </build>

</project>

The application.properties will look something like this. Note, adding the spring data JPA will force you to provide the database-specific details without which the application will refuse to start.

spring.application.name=SpringbootJPADemo

# Hibernate properties

spring.jpa.hibernate.dialect=org.hibernate.dialect.MySQLDialect

spring.jpa.show-sql=true

spring.jpa.hibernate.ddl-auto=update

# MySQL database connection properties

spring.datasource.driver-class-name=com.mysql.cj.jdbc.Driver

spring.datasource.url=jdbc:mysql://localhost:3306/javarefresher?createDatabaseIfNotExist=true

spring.datasource.username=root

spring.datasource.password=

# Project Views

spring.mvc.view.prefix=/WEB-INF/views/

spring.mvc.view.suffix=.jsp

The entity class will look like:

package com.housesearchKE.SpringbootJPADemo.model;

import jakarta.persistence.\*;

@Entity

@Table(name = "aliens")

public class Alien {

    @Id

    @GeneratedValue(strategy = GenerationType.IDENTITY)

    private int id;

    @Column(name = "name")

    private String name;

    @Column(name = "technology")

    private String technology;

    // This constructor must be present for Hibernate

    public Alien() {

    }

    public Alien(String name, String technology) {

        this.name = name;

        this.technology = technology;

    }

    public int getId() {

        return id;

    }

    public void setId(int id) {

        this.id = id;

    }

    public String getName() {

        return name;

    }

    public void setName(String name) {

        this.name = name;

    }

    public String getTechnology() {

        return technology;

    }

    public void setTechnology(String technology) {

        this.technology = technology;

    }

    @Override

    public String toString() {

        return "Alien{" +

                "id=" + id +

                ", name='" + name + '\'' +

                ", technology='" + technology + '\'' +

                '}';

    }

}

The repository interface will look like:

package com.housesearchKE.SpringbootJPADemo.repo;

import com.housesearchKE.SpringbootJPADemo.model.Alien;

import org.springframework.data.jpa.repository.JpaRepository;

@Repository

public interface AlienRepo extends JpaRepository<Alien, Integer> {

}

The HomeController will look like:

package com.housesearchKE.SpringbootJPADemo;

import com.housesearchKE.SpringbootJPADemo.repo.AlienRepo;

import com.housesearchKE.SpringbootJPADemo.model.Alien;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.stereotype.Controller;

import org.springframework.ui.Model;

import org.springframework.web.bind.annotation.ModelAttribute;

import org.springframework.web.bind.annotation.RequestMapping;

import org.springframework.web.bind.annotation.RequestParam;

@Controller

public class HomeController {

    @Autowired      // The repo bean is injected

    private AlienRepo alienrepo;

    @RequestMapping("/")

    public String home() {

        return "index";

    }

//    The "save", "findAll", "findById" etc methods are provided by the extended "JPARepository" interface from the spring data JPA library

    @RequestMapping("addAlien")

    public String addAlien(@ModelAttribute("alien") Alien alien, Model m) {

        m.addAttribute("aliens", alienrepo.save(alien));

        return "result";

    }

    @RequestMapping("getAliens")

    public String getAliens(Model m) {

        m.addAttribute("aliens", alienrepo.findAll());

        return "result";

    }

    @RequestMapping("getAlien")

    public String getAliens(@RequestParam("aid") int aid, Model m) {

        m.addAttribute("aliens", alienrepo.findById(Integer.valueOf(aid)));

        return "result";

    }

}

### **Query Domain Specific Language**

Most of the JPA methods such as findById() only work with the primary key. However, it is possible to, while still using the JPARepositort implementation, work with other fields of the entity class.

Here you have to capitatlise the first letter of the property such that if, for example, if you want to return a list of “aliens” having a specific “name” and order them in a ascending order based on some other property such as “technology”, you can use, “findByNameOrderByTechnologyAsc”

public interface AlienRepo extends JpaRepository<Alien, Integer> {

    List<Alien> findByNameOrderByTechnologyAsc(String name);

}

@RequestMapping("getAlienByName")

    public String getAliensByName(@RequestParam("aname") String aname, Model m) {

        m.addAttribute("aliens", alienrepo.findByNameOrderByTechnologyAsc(aname));

        return "result";

    }

### **@Query**

Spring Data JPA also allows for the definition of custom queries. By default, however, @Query uses JPQL.

public interface AlienRepo extends JpaRepository<Alien, Integer> {

//    List<Alien> findByNameOrderByTechnologyAsc(String name);

//    Using JPQL (Java Persistence Query Language)

//    @Query("from Alien where name= :name")

//    List<Alien> findByName(@Param("name") String name);

    @Query(value = "select \* from aliens where name= :name", nativeQuery = true)

    List<Alien> findByName(@Param("name") String name);

}

## **Rest API using Springboot**

Recall spring MVC and springboot MVC. Both of these involved having a Model, View and Controller architecture where .jsp files were the views. However, in real world applications, jsp files are seldom used. Instead, the servers running the java applications implement REST in that they only return data, either in XML or JSON format to remote clients that make stateless request.

Working with the REST API in springboot:

* Involves having nouns as in the URIs rather than verbs. E.g. instead of “http://localhost:8080/getAliens”, we have “http://localhost:8080/aliens”,
* Involves sending and accepting HTTP request that make use of the GET, POST, PUT, DELETE etc methods.
* Can be tested using a client such as Postman or swagger.
* Comes with a JSON parser library called Jackson by default. However, this library only works with JSON not XML. To work with XML you need to add that dependency manually (same version as the Jackson-JSON-core library).
* Also uses features such as “produces”, “consumes”, “@PathVariable”, “@RequestParam” etc.
* Allows the clients and server to negotiate on the type of data being sent and/or received in between.
  + Clients use “accept” and “content-type” parameters in their http request headers to determine the type of data they want to accept and send respectively. E.g. “Accept: application/JSON”, “Content-type: application/JSON”.
  + Servers use “consumes” and “produces” properties in their Mapping URIs to determine the type of data they want to accept and send respectively. E.g. *“@PostMapping(path="alien", produces = "application/json", consumes = "application/xml")”* or *“@PostMapping(path="alien", produces = MediaType.APPLICATION\_JSON\_VALUE, consumes = MediaType.APPLICATION\_JSON\_VALUE)”*

package com.housesearchKE.SpringbootJPADemo;

import com.housesearchKE.SpringbootJPADemo.model.Alien;

import com.housesearchKE.SpringbootJPADemo.repo.AlienRepo;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.stereotype.Controller;

import org.springframework.web.bind.annotation.\*;

import java.util.List;

import java.util.Optional;

@Controller     // General-purpose - primarily used to return views (HTML/JSP pages).

// Requires that the resource methods be annotated with "@ResponseBody" so that they can return raw data rather than views.

public class AlienController {

    @Autowired

    private AlienRepo alienrepo;

    @PostMapping("alien")

    @ResponseBody

    public List<Alien> addAlien(@RequestBody Alien alien) {

        alienrepo.save(alien);

        return alienrepo.findAll();

    }

    @GetMapping("aliens")

    @ResponseBody

    public List<Alien> getAliens() {

        return alienrepo.findAll();

    }

    @GetMapping("alien/{aid}")

    @ResponseBody

    public Optional<Alien> getAlien(@PathVariable("aid") int aid) {

        return alienrepo.findById(Integer.valueOf(aid));

    }

    @GetMapping("aliens/{aname}")

    @ResponseBody

    public List<Alien> getAliensByName(@PathVariable("aname") String aname) {

        return alienrepo.findByName(aname);

    }

    @DeleteMapping("alien/{aid}")

    @ResponseBody

    public List<Alien> removeAlien(@PathVariable("aid") int aid) {

        alienrepo.deleteById(Integer.valueOf(aid));

        return alienrepo.findAll();

    }

}

Using @Controller

@RestController     // Implicitly includes @ResponseBody, so no need to add it manually

public class AlienController {

    @Autowired

    private AlienRepo alienrepo;

    @PostMapping("alien")

    public List<Alien> addAlien(@RequestBody Alien alien) {

        alienrepo.save(alien);

        return alienrepo.findAll();

    }

    @GetMapping("aliens")

    public List<Alien> getAliens() {

        return alienrepo.findAll();

    }

    @GetMapping("alien/{aid}")

    public Optional<Alien> getAlien(@PathVariable("aid") int aid) {

        return alienrepo.findById(Integer.valueOf(aid));

    }

    @GetMapping("aliens/{aname}")

    public List<Alien> getAliensByName(@PathVariable("aname") String aname) {

        return alienrepo.findByName(aname);

    }

    @DeleteMapping("alien/{aid}")

    public List<Alien> removeAlien(@PathVariable("aid") int aid) {

        alienrepo.deleteById(Integer.valueOf(aid));

        return alienrepo.findAll();

    }

}

Using @RestController

<dependency>

    <groupId>com.fasterxml.jackson.dataformat</groupId>

    <artifactId>jackson-dataformat-xml</artifactId>

    <version>2.17.2</version>

</dependency>

Jackson-XML dependency

## **Aspect Oriented Programming in Springboot**

Aspect-Oriented Programming (AOP) in Spring Boot allows developers to separate cross-cutting concerns—such as logging, security, and transaction management—from the main business logic of an application. AOP helps improve modularity by enabling the definition of aspects that can be applied across multiple points in the codebase, referred to as join points.

In Spring Boot, AOP is typically implemented using Spring AOP, which provides support for method interception via proxies. Aspects encapsulate behaviors that are shared across multiple methods, classes, or layers, allowing clean separation of concerns.

Key Concepts:

* Aspect: A module that contains cross-cutting concerns. In Spring, an aspect is a class annotated with @Aspect.
* Advice: Action taken by an aspect at a specific join point (e.g., @Before, @After, @AfterThrowing).
* Join Point: A point during execution of a program, such as a method call, where an aspect can be applied.
* Pointcut: A predicate that matches join points. The pointcut defines where advice should be applied.
* Weaving: The process of applying aspects to target objects.

### **Example of an @Aspect class**

package com.housesearchKE.SpringbootJPADemo.aspect;

import jakarta.servlet.http.HttpServletRequest;

import org.aspectj.lang.annotation.\*;

import org.slf4j.Logger;

import org.slf4j.LoggerFactory;

import org.springframework.boot.logging.LoggingSystemFactory;

import org.springframework.stereotype.Component;

import org.springframework.web.context.request.RequestContextHolder;

import org.springframework.web.context.request.ServletRequestAttributes;

@Aspect

@Component

public class LoggingAspect {

    private final Logger LOGGER = LoggerFactory.getLogger(LoggingAspect.class);

    @Before("execution(public \* com.housesearchKE.SpringbootJPADemo.controller.AlienController.\*(..))")         // For all the methods in the Target Class

    public void logAliensController() {

        // Obtain the current HttpServletRequest

        ServletRequestAttributes attributes = (ServletRequestAttributes) RequestContextHolder.getRequestAttributes();

        if (attributes != null) {

            HttpServletRequest request = attributes.getRequest();

            LOGGER.info("Http request sent by " + request.getRemoteAddr());

        } else {

            LOGGER.warn("Could not retrieve the HttpServletRequest.");

        }

    }

    @AfterReturning("execution(public \* com.housesearchKE.SpringbootJPADemo.controller.AlienController.getAliens())")       // For one method

    public void getAliensLogger() {

        LOGGER.info("Full List of Aliens obtained successfully");

    }

    @AfterThrowing(value = "execution(public \* com.housesearchKE.SpringbootJPADemo.controller.AlienController.\*(..))", throwing = "e")

    public void getAliensExceptionLogger(Exception e) {

        LOGGER.warn("Some exception occurred in one of the target class' adviced methods: " + e.getMessage());

    }

    @After(value = "execution(public \* com.housesearchKE.SpringbootJPADemo.controller.AlienController.\*(..))")

    public void getAliensFinallyLogger() {

        LOGGER.info("Always executing advice in the event of an error or not");

    }

}

This logging can be restricted to one of several levels saved in a file configured in the application.properties file as:

#Logging

logging.level.root=info

logging.file.name=app.log

### **Logging Levels in Spring Boot (from most to least detailed):**

* TRACE: Most detailed logging level, usually used for debugging at a very fine-grained level.
* DEBUG: Less detailed than TRACE, but still used for diagnostic purposes.
* INFO: General informational messages that highlight the progress of the application.
* WARN: Indicates potentially harmful situations.
* ERROR: Logs error events that might cause the application to terminate unexpectedly.
* FATAL: Very severe error events that lead to immediate application termination (usually a subset of ERROR).

## **Springboot Security**

Spring Boot Security is a powerful framework that simplifies the process of securing applications developed with Spring Boot. It provides comprehensive security services for Java applications, including authentication, authorization, and protection against common vulnerabilities.

Key Features:

* Authentication: Verifies the identity of users. Spring Boot Security supports various authentication mechanisms such as form-based login, HTTP Basic authentication, and OAuth2.
* Authorization: Controls access to resources based on user roles or permissions. Spring Boot Security enables role-based access control (RBAC), method-level security, and URL-based security.
* Integration with Spring: Seamlessly integrates with other Spring modules like Spring Data, Spring MVC, and Spring Boot. It allows for easy configuration and extension of security features within the Spring ecosystem.
* Protection Against Common Vulnerabilities: Offers built-in defenses against common security threats such as Cross-Site Request Forgery (CSRF), Cross-Site Scripting (XSS), and Clickjacking.
* Customizable Security Configuration: Allows for extensive customization of security settings. Developers can configure security filters, authentication providers, and custom security rules according to application requirements.

### **First Springboot Security Intergration**

The way to add this library to a spring boot project is simply to add its dependency.

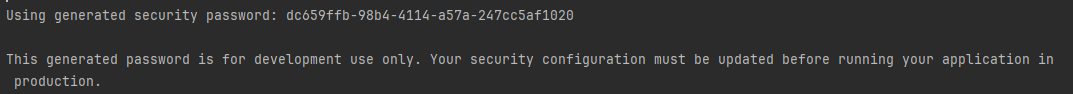
<dependency>

    <groupId>org.springframework.boot</groupId>

    <artifactId>spring-boot-starter-security</artifactId>

</dependency>

This automatically a login page that is the first thing that appears when you open the project on a browser. The username by default is “user” and the password is generated by spring, and can be gotten from the console. E.g.:



### **Procedure to add a custom user name and password**

There are two ways of doing this such that they are not from a database, (are for testing purposes only):

#### **Using the “Application.properties” file**

#user name and password manual configuration

spring.security.user.name=user

spring.security.user.password=1234

#### **Using the “UserDetailsService” interface**

1. Create a class, say “AppSecurityConfig” and annotate it with “@Configuration” as well as “EnableWebSecurity”
2. Create a method bean that returns an object of type “UserDetailsService”. This overides the application.properties user configuration.

package com.housesearchke.springbootsecuritydemo.configuration;

import org.springframework.context.annotation.Bean;

import org.springframework.context.annotation.Configuration;

import org.springframework.security.core.userdetails.User;

import org.springframework.security.core.userdetails.UserDetails;

import org.springframework.security.core.userdetails.UserDetailsService;

import org.springframework.security.provisioning.InMemoryUserDetailsManager;

import java.util.ArrayList;

import java.util.List;

@Configuration

@EnableWebSecurity

public class AppSecurityConfig {

    @Bean

    protected UserDetailsService userDetailsService() {

        List<UserDetails> users = new ArrayList<>();

        users.add(User.withDefaultPasswordEncoder().username("Daniel").password("1234").roles("USER").build());

        return new InMemoryUserDetailsManager(users);

    }

}

### **Procedure for fetching the user data from a database**

1. Add the DBMS dependency to the project.

<dependency>

    <groupId>com.mysql</groupId>

    <artifactId>mysql-connector-j</artifactId>

    <scope>runtime</scope>

</dependency>

1. Add the database configuration details to the project. If using spring JPA, do this in the application.properties file.

spring.application.name=SpringBootSecurityDemo

# Hibernate properties

spring.jpa.hibernate.dialect=org.hibernate.dialect.MySQLDialect

spring.jpa.show-sql=true

spring.jpa.hibernate.ddl-auto=update

# MySQL database connection properties

spring.datasource.driver-class-name=com.mysql.cj.jdbc.Driver

spring.datasource.url=jdbc:mysql://localhost:3306/javarefresher?createDatabaseIfNotExist=true

spring.datasource.username=root

spring.datasource.password=

1. Create the entity class

package com.housesearchke.springbootsecuritydemo.model;

import jakarta.persistence.Entity;

import jakarta.persistence.GeneratedValue;

import jakarta.persistence.GenerationType;

import jakarta.persistence.Id;

import lombok.Data;

@Entity

@Table(name = "users")

@Data

public class User {

    @Id

    @GeneratedValue(strategy = GenerationType.IDENTITY)

    private long id;

    private String username;

    private String password;

}

1. Create a method in the “@Configuration” class (removing the original “@Bean” method that returns an object of type “UserDetailsService”) that returns an object of type “AuthenticationProvider”.

package com.housesearchke.springbootsecuritydemo.configuration;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.beans.factory.annotation.Bean;

import org.springframework.context.annotation.Configuration;

import org.springframework.security.authentication.AuthenticationProvider;

import org.springframework.security.authentication.dao.DaoAuthenticationProvider;

import org.springframework.security.config.annotation.web.configuration.EnableWebSecurity;

import com.housesearchKE.SpringbootSecurityExample.service.MyUserDetailsService;

import org.springframework.security.crypto.password.NoOpPasswordEncoder;

@Configuration

//@EnableWebSecurity

public class AppSecurityConfig {

    @Autowired

    private MyUserDetailsService userDetailsService;

    @Bean

    public AuthenticationProvider authenticationProvider() {

        DaoAuthenticationProvider provider = new DaoAuthenticationProvider();

        provider.setUserDetailsService(userDetailsService);

        provider.setPasswordEncoder(NoOpPasswordEncoder.getInstance());     // Not advised

        return provider;

    }

}

1. Create a class that implements the “UserDetailsService” interface injected in (iv) above and annotate it with the “@Service” Annotation:

package com.housesearchke.springbootsecuritydemo.configuration;

import com.housesearchke.springbootsecuritydemo.model.User;

import com.housesearchke.springbootsecuritydemo.repo.UserRepository;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.security.core.userdetails.UserDetails;

import org.springframework.security.core.userdetails.UserDetailsService;

import org.springframework.security.core.userdetails.UsernameNotFoundException;

import org.springframework.stereotype.Service;

@Service

public class MyUserDetailsService implements UserDetailsService {

   @Autowired

    private UserRepository userRepository;

    @Override

    public UserDetails loadUserByUsername(String username) throws UsernameNotFoundException {

        User user = userRepository.findByUsername(username);

        if(user == null) {

            System.out.println("User is null");

            throw new UsernameNotFoundException("User 404: Not Found");

        } else {

            return new UserPrincal(user);

        }

    }

}

1. Create an interface that extends the JPARepository and that is injected (v) above:

package com.housesearchke.springbootsecuritydemo.repo;

import com.housesearchke.springbootsecuritydemo.model.User;

import org.springframework.data.jpa.repository.JpaRepository;

@Repository

public interface UserRepository extends JpaRepository<User, Long> {

    User findByUsername(String username);

}

1. Create a class that implements the “UserDetails” interface that is returned in the method in the service class in (v) above:

package com.housesearchke.springbootsecuritydemo.configuration;

import com.housesearchke.springbootsecuritydemo.model.User;

import org.springframework.security.core.GrantedAuthority;

import org.springframework.security.core.authority.SimpleGrantedAuthority;

import org.springframework.security.core.userdetails.UserDetails;

import java.util.Collection;

import java.util.Collections;

// The UserPrincipal conventionally refers to the current user trying to log in

public class UserPrincal implements UserDetails {

    private User user;

    public UserPrincal(User user) {

        this.user = user;

    }

    @Override

    public Collection<? extends GrantedAuthority> getAuthorities() {

        return Collections.singleton(new SimpleGrantedAuthority("USER"));

    }

    @Override

    public String getPassword() {

//        return "{noop}" + user.getPassword();

        return user.getPassword();

    }

    @Override

    public String getUsername() {

        return user.getUsername();

    }

    @Override

    public boolean isAccountNonExpired() {

//        return UserDetails.super.isAccountNonExpired();

        return true;

    }

    @Override

    public boolean isAccountNonLocked() {

//        return UserDetails.super.isAccountNonLocked();

        return true;

    }

    @Override

    public boolean isCredentialsNonExpired() {

//        return UserDetails.super.isCredentialsNonExpired();

        return true;

    }

    @Override

    public boolean isEnabled() {

//        return UserDetails.super.isEnabled();

        return true;

    }

}

1. Test the same by providing a valid username and password credentials combination created in the database table.

### **Password Encryption of Users stored in a Database**

As seen above, we have used the “NoOpPasswordEncoder” as the password encoder for the authentication provider of the users. This works with passwords that are stored as plain text in the database. However, this is not secure. Instead we can use an encoder that hashes the password before saving it, when registering a user, and also compares the entered password with the saved password to see if they matched when signing in.

package com.housesearchKE.SpringbootSecurityExample.config;

import com.housesearchKE.SpringbootSecurityExample.service.MyUserDetailsService;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.context.annotation.Bean;

import org.springframework.context.annotation.Configuration;

import org.springframework.security.authentication.AuthenticationProvider;

import org.springframework.security.authentication.dao.DaoAuthenticationProvider;

import org.springframework.security.config.annotation.web.builders.HttpSecurity;

import org.springframework.security.crypto.bcrypt.BCryptPasswordEncoder;

import org.springframework.security.web.SecurityFilterChain;

@Configuration

//@EnableWebSecurity

public class SecurityConfig {

    @Bean

    public SecurityFilterChain securityFilterChain(HttpSecurity http) throws Exception {

        return http

        // To test on postman without having to pass a csrf token

                .csrf(customizer -> customizer.disable())

                .build();

    }

    @Autowired

    private MyUserDetailsService userDetailsService;

    @Bean

    public AuthenticationProvider authenticationProvider() {

        DaoAuthenticationProvider provider = new DaoAuthenticationProvider();

        provider.setUserDetailsService(userDetailsService);

        provider.setPasswordEncoder(bCryptPasswordEncoder());   // Encoder when authenticating

        return provider;

    }

    @Bean       // BCryptPasswordEncoder Bean injected everywhere

    public BCryptPasswordEncoder bCryptPasswordEncoder() {

        return new BCryptPasswordEncoder(12);

    }

}

The user controller receiving and sending responses related to the “User” entity/model

package com.housesearchKE.SpringbootSecurityExample.controller;

import com.housesearchKE.SpringbootSecurityExample.model.User;

import com.housesearchKE.SpringbootSecurityExample.service.UserService;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.web.bind.annotation.GetMapping;

import org.springframework.web.bind.annotation.PostMapping;

import org.springframework.web.bind.annotation.RequestBody;

import org.springframework.web.bind.annotation.RestController;

import java.util.List;

@RestController

public class UserController {

    @Autowired

    private UserService userService;

    @PostMapping("/user/register")

    public User registerUser(@RequestBody User user) {

        return userService.registerUser(user);

    }

    @GetMapping("/users")

    public List<User> getUsers() {

        return userService.getUsers();

    }

}

package com.housesearchKE.SpringbootSecurityExample.service;

import com.housesearchKE.SpringbootSecurityExample.model.User;

import com.housesearchKE.SpringbootSecurityExample.repo.UserRepository;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.security.crypto.bcrypt.BCryptPasswordEncoder;

import org.springframework.stereotype.Service;

import java.util.List;

@Service

public class UserService {

    @Autowired

    private UserRepository userRepository;

    @Autowired

    private BCryptPasswordEncoder bCryptPasswordEncoder;

    public User registerUser(User user) {

        user.setPassword(bCryptPasswordEncoder.encode(user.getPassword()));

        return userRepository.save(user);

    }

    public List<User> getUsers() {

        return userRepository.findAll();

    }

}

The UserService encodes the password before sending the user to the “repo” to actually save the same.

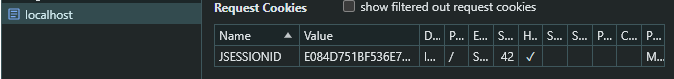
### **Sesssion ID**

You may have noticed that on logging in to spring security-enabled application, every subsequent page/ resource in the application is accessible without having to log in repeatedly per request. This is because of the session ID that the tomcat server assigns the client (browser), that is checked every time a request is made and is fouind to a valid logged-in session.

A new session ID is generated for every login (if you logout then log in again), and every browser/client (including postman), even though on the same machine.

This session ID is stored as a cookie on the browser and can be seen:

* In the “Inspect” dev tools of the browser under “Network > Cookies”, named as “JSESSIONID”.



* From the “HttpServletRequest” object that is sent to the resource on the server as:

@RestController

public class HomeController {

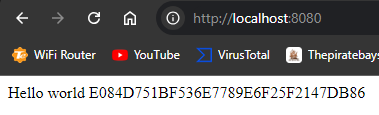
    @GetMapping("/")

    public String home(HttpServletRequest request) {

        return "Hello world " + request.getSession().getId();

    }

}



### **Cross-Site Request Forgery (CSRF) Protection**

Cross-Site Request Forgery (CSRF) attacks occur when a malicious website tricks a user into making unintended requests to another site where they are authenticated. This happens without the user's knowledge. For instance, if a user is logged into their banking site and then visits a malicious website, that site could send a hidden request (e.g., transferring money) using the user’s authentication credentials (like cookies or session tokens). Since the request appears to come from the user, the server processes it as a legitimate action, leading to unauthorized operations on the user's behalf. CSRF attacks exploit the trust a server has in the user’s browser.

There are two ways to handle CSRF: using a CSRF token, making the requests to the server stateless, i.e, implementing the REST Architecture/ API.

In Spring Security, Cross-Site Request Forgery (CSRF) protection is enabled by default to safeguard web applications from malicious attacks where unauthorized commands are transmitted from a trusted user. A CSRF token is a randomly generated value and is included in state-changing requests (such as POST, PUT, DELETE) to verify that the request comes from an authenticated and trusted source. Without this token, the server will reject the request, ensuring that attackers cannot perform actions on behalf of authenticated users. By embedding the CSRF token in forms or headers, Spring Security ensures that the client making the request is the same one who initially received the web page, mitigating potential CSRF attacks.

#### **Using the CSRF Token**

To demonstrate this:

1. Create a controller that has a postmapping resource.

@RestController

public class StudentController {

    List<Student> students = new ArrayList<>(List.of(

            new Student(1, "Daniel Karongo", 64),

            new Student(1, "Victor Maina", 73),

            new Student(1, "Violet Wanjiru", 72)

    ));

    @GetMapping("/students")

    public List<Student> getStudents() {

        return students;

    }

    @PostMapping("/student")

    public Student addStudent(@RequestBody Student student) {

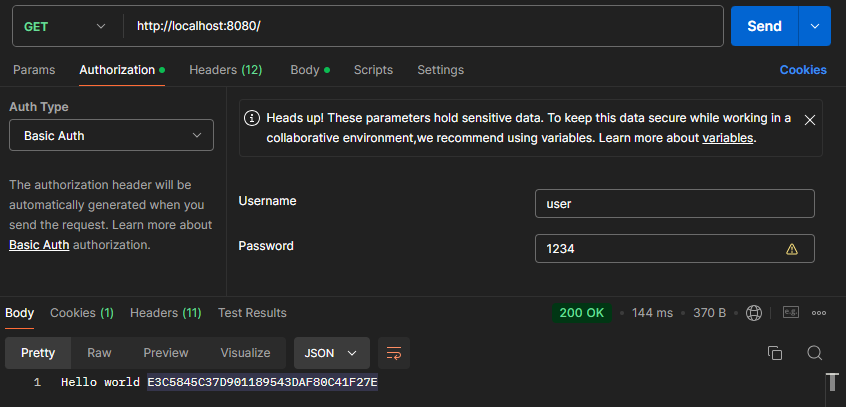
        students.add(student);

        return student;

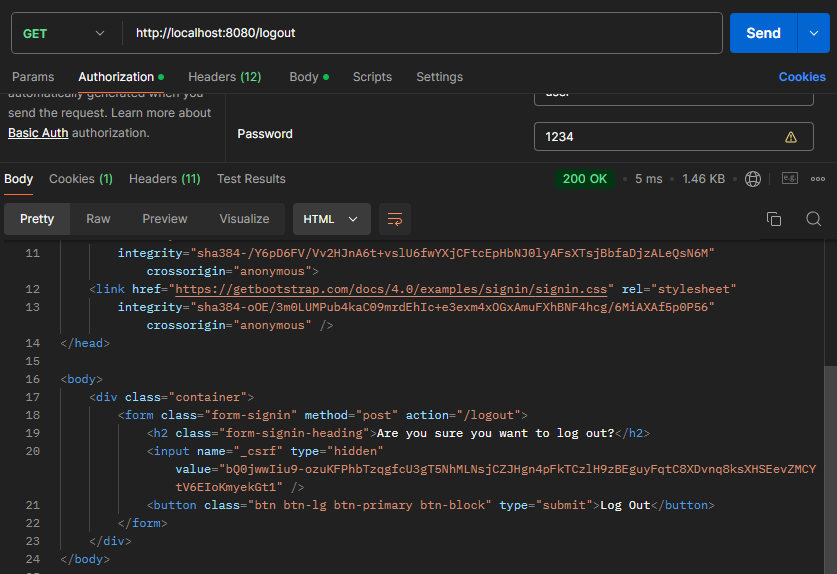
    }

}

1. Restart the application.
2. Login using postman. Here, you need to pass the username and password details under the “Authorization” tab of the request.



1. Get the csrf token. There are two ways to do this:
   * Navigate to/ send a get request to “localhost/8080/logout”. You will a receive page that asks of you are sure that you want to logout. View the page sorce, and you will find a hidden input field with a name “\_csrf” and a value of the actual csrf token.



* + Create another GetMapping resource that returns the actual csrf token, also gotten from the “HttpServletRequest” object.

@GetMapping("/csrf\_token")

public CsrfToken csrfToken(HttpServletRequest request) {

    return (CsrfToken) request.getAttribute("\_csrf");

}

1. Try making the post request first without passing the csrf token in the header of the request (X-CSRF-TOKEN). This will return a “401 Unauthorised” error response. Do the same but pass the csrf token this time.
2. You can also do this by removing the spring security dependency from your project and making the post request without the csrf token. It will work. However, adding the dependency will return an error.

#### **Implementing the REST Architecture**

@Configuration

@EnableWebSecurity

public class SecurityConfig {

    @Bean

    public SecurityFilterChain securityFilterChain(HttpSecurity http) throws Exception {

        http.csrf(customizer -> customizer.disable());

/\*

    Disabling CSRF protection is usually safe under specific conditions, such as:

        1.  For APIs: When you're building stateless REST APIs that don't use sessions or rely on cookies for authentication (e.g., using JWT or OAuth tokens), CSRF protection is often unnecessary.

        2.  Non-browser clients: When the client is not a web browser (e.g., mobile apps), CSRF protection may not be needed.

    However, for typical web applications that rely on session-based authentication, it's generally recommended to keep CSRF protection enabled for enhanced security. \*/

        http.authorizeHttpRequests(request -> request.anyRequest().authenticated());        // Configures authorization so that any incoming HTTP request requires the user to be authenticated.

        http.httpBasic(Customizer.withDefaults());      // Enables HTTP Basic authentication (sends credentials via a base64-encoded header in HTTP requests). E.g. postman

        http.sessionManagement(session -> session.sessionCreationPolicy(SessionCreationPolicy.STATELESS));

        // Configures session management to be stateless, meaning no HTTP session will be created or used.

        // Typically used in stateless applications like REST APIs where authentication is handled via tokens (e.g., JWT).

        // When using a browser as a client, the login form will be replaced by a pop up that needs only be filled once as opposed to if "http.formLogin(Customizer.withDefaults())" was enabled.

        // Every reload on a browser will return a different session ID.

/\*

    http.formLogin(Customizer.withDefaults());

    // Enables form-based login in the browser, which prompts the user to enter credentials through a login page.

    // However, if stateless session management is enabled (as seen in the sessionCreationPolicy configuration),

    // the session will not be stored between requests. This means the user will be required to log in repeatedly for every request

    // because no session state is maintained to remember their authentication.

    // Using a REST client like Postman (with stateless authentication like HTTP Basic or Bearer tokens) will work fine,

    // as those requests send credentials with each request and don’t rely on session state.

\*/

        return http.build();

        // Builds and returns the SecurityFilterChain object, which contains the configured security filters

    }

}

### **SecurityFilterChain**

In modern Spring Security, the SecurityFilterChain plays a crucial role in defining how security is applied to incoming HTTP requests. Instead of relying on the now-deprecated WebSecurityConfigurerAdapter, SecurityFilterChain is the new way to declare security configurations in applications using Spring Security 6.x and beyond.

The SecurityFilterChain works by organizing and applying a series of security-related filters that inspect and process each incoming request. These filters handle various security concerns such as authentication, authorization, session management, and request validation. When a request hits the application, it flows through a filter chain, where each filter has a distinct responsibility.

#### **Default Filters in Spring Security**

Spring Security sets up several default filters to secure your application, and these are applied automatically unless customized: Here is the correct order in which these filters are typically applied:

1. ChannelProcessingFilter**:** Manages secure/insecure channel switching (HTTP/HTTPS).
2. WebAsyncManagerIntegrationFilter: Integrates Spring Security with the Spring Web Async framework.
3. SecurityContextPersistenceFilter: Loads the security context for the current request from the session or other storage.
4. HeaderWriterFilter: Adds security-related headers to the response (like X-Content-Type-Options, X-Frame-Options, etc.).
5. CsrfFilter: Handles CSRF protection by ensuring a valid CSRF token is included in requests.
6. LogoutFilter: Manages logout functionality and session invalidation.
7. UsernamePasswordAuthenticationFilter: Processes form-based login requests (username and password).
8. BearerTokenAuthenticationFilter: Extracts and validates JWT or other bearer tokens for authentication.
9. BasicAuthenticationFilter: Provides HTTP Basic authentication for APIs.
10. RequestCacheAwareFilter: Manages the redirection to the originally requested page after successful login.
11. SecurityContextHolderAwareRequestFilter: Ensures that security context information (like the authenticated user) is available via HttpServletRequest.
12. AnonymousAuthenticationFilter: Provides anonymous authentication for users who are not logged in.
13. SessionManagementFilter: Manages session-related functionality, including session fixation protection.
14. ExceptionTranslationFilter: Handles security exceptions (e.g., redirecting to the login page or showing an access-denied page).
15. AuthorizationFilter: Ensures that authenticated users have the necessary permissions to access resources based on their roles or authorities.

This order ensures that key security processes happen in a logical sequence—for example, CSRF protection occurs early, and authorization is checked only after authentication.

#### **How to Customize the SecurityFilterChain**

You can define a custom SecurityFilterChain bean by creating a method annotated with @Bean in a Spring @Configuration class. The method should return a SecurityFilterChain object, which configures how different HTTP requests are handled.

import org.springframework.context.annotation.Bean;

import org.springframework.context.annotation.Configuration;

import org.springframework.security.config.annotation.web.builders.HttpSecurity;

import org.springframework.security.web.SecurityFilterChain;

@Configuration

public class SecurityConfig {

    @Bean

    public SecurityFilterChain securityFilterChain(HttpSecurity http) throws Exception {

        http

            // Customize CSRF protection, allow it only for specific requests

            .csrf(csrf -> csrf

                .ignoringRequestMatchers("/api/\*\*") // Disables CSRF for API endpoints

            )

            // Define URL-based access control

            .authorizeHttpRequests(authorize -> authorize

                .requestMatchers("/admin/\*\*").hasRole("ADMIN") // Only ADMIN role can access admin pages

                .requestMatchers("/user/\*\*").hasAnyRole("USER", "ADMIN") // USER and ADMIN roles can access user pages

                .requestMatchers("/public/\*\*").permitAll() // Public pages are accessible to everyone

                .anyRequest().authenticated() // All other pages require authentication

            )

            // Customize login form behavior

            .formLogin(form -> form

                .loginPage("/login") // Custom login page

                .permitAll()

            )

            // Logout behavior

            .logout(logout -> logout

                .logoutUrl("/logout")

                .logoutSuccessUrl("/login?logout")

                .invalidateHttpSession(true)

                .deleteCookies("JSESSIONID")

            );

        return http.build();

    }

}

##### **Adding Custom Filters**

If you need to add your own filters to the security chain, you can do so by inserting a custom filter at a specific point in the filter chain. For example, you might want to add a filter that logs additional information about incoming requests:

import org.springframework.security.web.authentication.UsernamePasswordAuthenticationFilter;

import javax.servlet.Filter;

import javax.servlet.FilterChain;

import javax.servlet.FilterConfig;

import javax.servlet.ServletException;

import javax.servlet.http.HttpServletRequest;

import javax.servlet.http.HttpServletResponse;

import java.io.IOException;

public class CustomLoggingFilter implements Filter {

    @Override

    public void init(FilterConfig filterConfig) throws ServletException {}

    @Override

    public void doFilter(HttpServletRequest request, HttpServletResponse response, FilterChain chain)

            throws IOException, ServletException {

        // Custom logging logic

        System.out.println("Request URL: " + request.getRequestURL());

        // Continue the filter chain

        chain.doFilter(request, response);

    }

    @Override

    public void destroy() {}

}

You can then register this custom filter in your SecurityFilterChain:

import org.springframework.security.config.annotation.web.builders.HttpSecurity;

import org.springframework.security.web.SecurityFilterChain;

import org.springframework.security.web.authentication.UsernamePasswordAuthenticationFilter;

@Configuration

public class SecurityConfig {

    @Bean

    public SecurityFilterChain securityFilterChain(HttpSecurity http) throws Exception {

        http

            .addFilterBefore(new CustomLoggingFilter(), UsernamePasswordAuthenticationFilter.class) // Add custom filter

            .authorizeHttpRequests(authorize -> authorize

                .anyRequest().authenticated()

            );

        return http.build();

    }

}

You can add filters using methods like “addFilterBefore()”, “addFilterAfter()”, or “addFilterAt()” to specify the exact location of your filter relative to existing ones.

This approach provides you with granular control over the security of your application, allowing you to fully customize how each request is processed.

##### **@EnableWebSecurity**

The “@EnableWebSecurity” annotation in Spring Security disables the default security configuration and applies the custom security configurations defined in your “@Configuration” class. By default, when you use @EnableWebSecurity, Spring Security replaces the default SecurityFilterChain with your own configuration, giving you full control over the security setup.

If you want to add to the default SecurityFilterChain rather than completely overriding it, you can achieve this by creating a custom configuration class without @EnableWebSecurity, or by using additional configuration classes that supplement the default behavior.

### **JWT (JSON Web Token)**

JWT, is a way for two parties (like a server and a user) to securely exchange information. It’s like a digital ID card that proves who you are. When you log in to a website, instead of constantly checking your username and password, the server gives you a JWT, which contains key details about you in a compact format.

This token is encoded and signed so that it can't be easily altered. Every time you make a request to the server (like visiting a new page), you include this token, and the server knows you're still authenticated without needing to log in again.

It's widely used for secure communication between web applications because it's fast and doesn't need a database lookup every time.

#### **Project Setup for JWT**

1. Add the JJWT-API, JJWT-implementation and JJWT-Jackson-Converter dependencies:

<dependency>

    <groupId>io.jsonwebtoken</groupId>

    <artifactId>jjwt-api</artifactId>

    <version>0.12.6</version>

</dependency>

<dependency>

    <groupId>io.jsonwebtoken</groupId>

    <artifactId>jjwt-impl</artifactId>

    <version>0.12.6</version>

    <scope>runtime</scope>

</dependency>

<dependency>

    <groupId>io.jsonwebtoken</groupId>

    <artifactId>jjwt-jackson</artifactId>

    <version>0.12.6</version>

    <scope>runtime</scope>

</dependency>

1. Create a bean to configure the “AuthenticationManager” yourself, rather than use spring security’s default one.

@Bean

public AuthenticationManager authenticationManager(AuthenticationConfiguration configuration) throws Exception {

    return configuration.getAuthenticationManager();

}

1. Create and configure a custom “login” resource that will be used to log users in rather than using the default SecurityFilterChain login. This resources should be accessible to all, i.e. not require authentication.

@PostMapping("/login")

public String login(@RequestBody User user) {

    return userService.verifyUser(user);

}

1. For this login resource, manually configure the authentication of the user whose details are passed. Originally, this was handled by default.

@Service

public class UserService {

    @Autowired

    private AuthenticationManager authenticationManager;

    public String verifyUser(User user) {

        Authentication authentication = authenticationManager.authenticate(new UsernamePasswordAuthenticationToken(user.getUsername(), user.getPassword()));

// This will check the user against the database as earlier configured

        if(authentication.isAuthenticated()) {

            return "Success"; // This will be replaced by the actual token generated per user later on

        } else {

            return "Fail";

        }

    }

}

#### **Procedure for Generating a JWT token**

1. Modify the “verifyUser()” method above to call another service (JWTService) that will generate and return an actual JWT token.

public String verifyUser(User user) {

    Authentication authentication = authenticationManager.authenticate(new UsernamePasswordAuthenticationToken(user.getUsername(), user.getPassword()));

    // This will check the user against the database as earlier configured

    if(authentication.isAuthenticated()) {

        return jwtService.generateToken(user.getUsername());

    } else {

        return "Fail";

    }

}

1. Create the “JWTService” Service class and define the method that will return the JWT generated.
2. The JWT is built by taking some parameters such as the username, current time, time to expire, and a key in the form of “Byte[]”, then encoding all of this to a string. Create the methods responsible for the same.

package com.housesearchKE.SpringbootSecurityExample.service;

import io.jsonwebtoken.Jwts;

import io.jsonwebtoken.io.Decoders;

import io.jsonwebtoken.security.Keys;

import org.springframework.stereotype.Service;

import javax.crypto.KeyGenerator;

import javax.crypto.SecretKey;

import java.security.Key;

import java.security.NoSuchAlgorithmException;

import java.util.Base64;

import java.util.Date;

import java.util.HashMap;

import java.util.Map;

@Service

public class JWTService {

    private String secretKey="";

    public JWTService() {

        try {

            KeyGenerator keyGenerator = KeyGenerator.getInstance("HmacSHA256");

            SecretKey sKey = keyGenerator.generateKey();

            secretKey = Base64.getEncoder().encodeToString(sKey.getEncoded());

        } catch (NoSuchAlgorithmException e) {

            throw new RuntimeException(e);

        }

    }

    public String generateToken(String username) {

        Map<String, Object> claims = new HashMap<>();

        return Jwts.builder()

                .claims(claims)

                .subject(username)

                .issuedAt(new Date(System.currentTimeMillis()))

                .expiration(new Date(System.currentTimeMillis() + 60 \* 60 \* 10))    // The token will expire after 10 minutes

                .signWith(getKey())

                .compact();

    }

    private Key getKey() {

        byte[] keyInBytes = Decoders.BASE64.decode(secretKey);

        return Keys.hmacShaKeyFor(keyInBytes);

    }

}

#### **Procedure for Validating JWT tokens**

After creating the JWT, and passing it to the client. The client will need to send this JWT along with the any other request made to the server as part of the Http Header as a (Bearer Token). This token then needs to be validated so that access to the resource requested can be allowed.

1. Configure the SecurityFilterChain to add a custom filter (JWTFilter) before the “UsernamePasswordAuthenticationFilter” filter in the “@Configuration” class.

@Configuration

//@EnableWebSecurity

public class SecurityConfig {

    @Bean

    public SecurityFilterChain securityFilterChain(HttpSecurity http) throws Exception {

        return http

                .csrf(customizer -> customizer.disable())

                .authorizeHttpRequests(request -> request

                        .requestMatchers("register", "login")

                        .permitAll()

                        .anyRequest().authenticated()

                )

                .addFilterBefore(jwtFilter, UsernamePasswordAuthenticationFilter.class)

                .build();

    }

}

1. Create the filter class and extend a class called “OncePerRequestFilter” and implement its abstract method.
2. Get the “Authorization” header from the request object. It’s a string.
3. Get the JWT token from this authorization header by splitting the string removing the “Bearer ” prefix before the JWT.
4. Create a method that extracts the username ftom the token in the JWTService class.
5. Create another method that validates the token in the JWTService class passing the token itself and the userDetails of the username returned from the method in (v) above.
6. Create a “UsernamePasswordAuthenticationToken” an add the userDetails, in (vi) above, as well as the request itself.
7. Add this token to the “SecurityContextHolder” and call for the next filter in the chain.

package com.housesearchKE.SpringbootSecurityExample.filter;

import com.housesearchKE.SpringbootSecurityExample.service.JWTService;

import com.housesearchKE.SpringbootSecurityExample.service.MyUserDetailsService;

import jakarta.servlet.FilterChain;

import jakarta.servlet.ServletException;

import jakarta.servlet.http.HttpServletRequest;

import jakarta.servlet.http.HttpServletResponse;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.context.ApplicationContext;

import org.springframework.security.authentication.UsernamePasswordAuthenticationToken;

import org.springframework.security.core.context.SecurityContextHolder;

import org.springframework.security.core.userdetails.UserDetails;

import org.springframework.security.web.authentication.WebAuthenticationDetailsSource;

import org.springframework.stereotype.Component;

import org.springframework.web.filter.OncePerRequestFilter;

import java.io.IOException;

@Component

public class JWTFilter extends OncePerRequestFilter {

    @Autowired

    private JWTService jwtService;

    @Autowired

    private MyUserDetailsService myUserDetailsService;

    @Override

    protected void doFilterInternal(HttpServletRequest request, HttpServletResponse response, FilterChain filterChain) throws ServletException, IOException {

        String authHeader = request.getHeader("Authorization");

        String JWTtoken = null;

        String username = null;

        if(authHeader != null && authHeader.startsWith("Bearer ")) {

            JWTtoken = authHeader.substring(7);

            username = jwtService.extractUserName(JWTtoken);

        }

        if(username != null && SecurityContextHolder.getContext().getAuthentication() == null) {

//            UserDetails userDetails = context.getBean(MyUserDetailsService.class).loadUserByUsername(username);

            UserDetails userDetails = myUserDetailsService.loadUserByUsername(username);

            if(jwtService.validateToken(JWTtoken, userDetails)) {

                UsernamePasswordAuthenticationToken usernamePasswordAuthenticationToken = new UsernamePasswordAuthenticationToken(userDetails, null, userDetails.getAuthorities());

                usernamePasswordAuthenticationToken.setDetails(new WebAuthenticationDetailsSource().buildDetails(request));

                SecurityContextHolder.getContext().setAuthentication(usernamePasswordAuthenticationToken);

            }

        }

        filterChain.doFilter(request, response);

    }

}

The filter class

package com.housesearchKE.SpringbootSecurityExample.service;

import io.jsonwebtoken.Claims;

import io.jsonwebtoken.Jwts;

import io.jsonwebtoken.io.Decoders;

import io.jsonwebtoken.security.Keys;

import org.springframework.security.core.userdetails.UserDetails;

import org.springframework.stereotype.Service;

import javax.crypto.KeyGenerator;

import javax.crypto.SecretKey;

import java.security.NoSuchAlgorithmException;

import java.util.Base64;

import java.util.Date;

import java.util.HashMap;

import java.util.Map;

import java.util.function.Function;

@Service

public class JWTService {

    private String secretKey="";

    public JWTService() {

        try {

            KeyGenerator keyGenerator = KeyGenerator.getInstance("HmacSHA256");

            SecretKey sKey = keyGenerator.generateKey();

            secretKey = Base64.getEncoder().encodeToString(sKey.getEncoded());

        } catch (NoSuchAlgorithmException e) {

            throw new RuntimeException(e);

        }

    }

    public String generateToken(String username) {

        Map<String, Object> claims = new HashMap<>();

        return Jwts.builder()

                .claims(claims)

                .subject(username)

                .issuedAt(new Date(System.currentTimeMillis()))

                .expiration(new Date(System.currentTimeMillis() + 60 \* 1000 \* 10))    // The token will expire after 10 minutes

                .signWith(getKey())

                .compact();

    }

    private SecretKey getKey() {

        byte[] keyInBytes = Decoders.BASE64.decode(secretKey);

        return Keys.hmacShaKeyFor(keyInBytes);

    }

    public String extractUserName(String jwTtoken) {

        return extractClaim(jwTtoken, Claims::getSubject);

    }

    private <T>T extractClaim(String jwTtoken, Function<Claims, T> claimsResolver) {

        final Claims claims = extractAllClaims(jwTtoken);

        return claimsResolver.apply(claims);

    }

    private Claims extractAllClaims(String jwTtoken) {

        return Jwts.parser()

                .verifyWith(getKey())

                .build()

                .parseSignedClaims(jwTtoken)

                .getPayload();

    }

    public boolean validateToken(String jwTtoken, UserDetails userDetails) {

        final String username = extractUserName(jwTtoken);

        return (username.equals(userDetails.getUsername()) && !isTokenExpired(jwTtoken));

    }

    private boolean isTokenExpired(String jwTtoken) {

        return extractExpiration(jwTtoken).before(new Date());

    }

    private Date extractExpiration(String jwTtoken) {

        return extractClaim(jwTtoken, Claims::getExpiration);

    }

}

The service class

## **OAuth2**

Ordinarily, as we have done user authentication is done by checking the username and password creation details against records of users stored in a database. However, it is possible to use other services’ authentication servers and take their word that a user is who they say they are. Some of this services are google, github, facebook etc.

To configure your spring boot application to work with these OAuth providers You need to:

1. Add the OAuthClient dependency in your project, it also comes with the spring security dependency within as well.

<dependency>

    <groupId>org.springframework.security</groupId>

    <artifactId>spring-security-oauth2-client</artifactId>

</dependency>

<dependency>

    <groupId>org.springframework.security</groupId>

    <artifactId>spring-security-oauth2-jose</artifactId>

</dependency>

1. Modify the Security Filter Chain to accept work with “OAuth2Login”. Also you may configure to allow for both browser-based (formLogin and OAuth2) as well as HttpBasic login. Here, you will need to create separate endpoints for the same.

@Bean

public SecurityFilterChain securityFilterChain(HttpSecurity http) throws Exception {

    return http

            .csrf(csrf -> csrf.disable())  // Disable CSRF for simplicity in APIs

            .authorizeHttpRequests(request -> request

                    .requestMatchers("/api/login", "/register", "/login").permitAll()  // Permit login/register pages

                    .anyRequest().authenticated()  // Protect all other endpoints

            )

            .formLogin(formLogin -> formLogin

                    .permitAll()  // Use default login page for browsers

            )

            .httpBasic(Customizer.withDefaults())  // Allow HTTP Basic for API login

            .oauth2Login(Customizer.withDefaults())  // OAuth2 login for external providers

            .addFilterBefore(jwtFilter, UsernamePasswordAuthenticationFilter.class)

            .build();

}

@PostMapping("/login")

public String login(@RequestBody User user) {

    return userService.verifyUser(user);

}

@PostMapping("/api/login")

public String loginViaPostman(@RequestBody User user) {

    return userService.verifyUser(user);

}

@GetMapping("/user")

public Principal getUser(Principal principal) {

    return principal;

}

1. Add the OAuth providers’ client ID and client secret to the application.properties file.

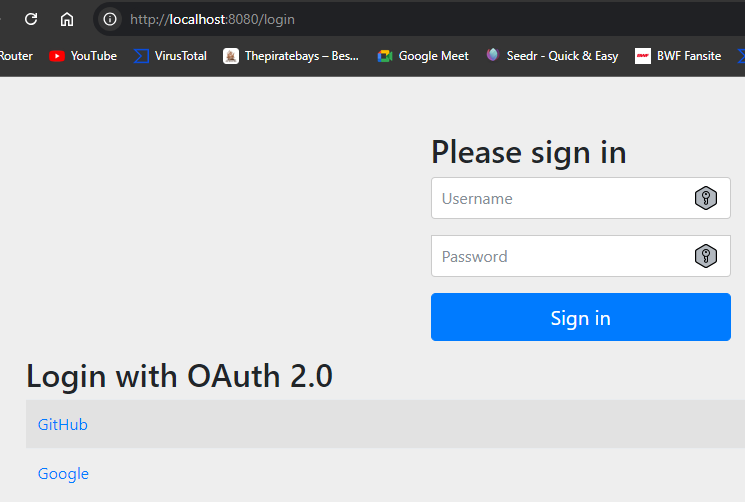
spring.security.oauth2.client.registration.google.client-id=910738833122-ulbj0sqsn7t456n923c40m9bv9jfkem9.apps.googleusercontent.com

spring.security.oauth2.client.registration.google.client-secret=GOCSPX-j\_4BU\_BHliu5s6wbVOFzOYu8KvkL

spring.security.oauth2.client.registration.google.redirect-uri=http://localhost:8080/login/oauth2/code/google

spring.security.oauth2.client.registration.github.client-id=Ov23liFe1oPctMM4j5PP

spring.security.oauth2.client.registration.github.client-secret=b75c9100a6ecb0a5c027376f06e4b7f7c2ec2dd5



# **MICROSERVICES**

Microservices is an architectural style that structures an application as a collection of loosely coupled, independently deployable services. Each microservice is designed to perform a specific business function and can be developed, deployed, and scaled independently. This approach contrasts with traditional monolithic architectures, where all components are tightly integrated into a single codebase.

One of the key advantages of microservices is their ability to enhance agility and flexibility. Teams can work on different services simultaneously, using various technologies and programming languages that best suit their needs. This allows for faster development cycles and easier maintenance, as changes in one service do not necessarily impact others.

Microservices also promote scalability; individual services can be scaled independently based on demand, optimizing resource utilization. They can communicate with each other through lightweight protocols, typically HTTP/REST or messaging queues, enabling seamless integration and data exchange.

However, this architecture comes with challenges, such as increased complexity in deployment, monitoring, and data management. Effective strategies and tools are essential to manage inter-service communication, maintain data consistency, and ensure system reliability.

Overall, microservices provide a powerful way to build resilient, scalable applications that can adapt quickly to changing business requirements.

## **Monolithic Preparatory Structure**

We will create a simple Springboot web quizzing application that allows users to create questions, create quizzes from those questions and mark the same.

### **Project dependencies:**

<dependencies>

    <dependency>

        <groupId>org.springframework.boot</groupId>

        <artifactId>spring-boot-starter-data-jpa</artifactId>

    </dependency>

    <dependency>

        <groupId>org.springframework.boot</groupId>

        <artifactId>spring-boot-starter-web</artifactId>

    </dependency>

    <dependency>

        <groupId>com.mysql</groupId>

        <artifactId>mysql-connector-j</artifactId>

        <scope>runtime</scope>

    </dependency>

    <dependency>

        <groupId>org.projectlombok</groupId>

        <artifactId>lombok</artifactId>

        <optional>true</optional>

    </dependency>

    <dependency>

        <groupId>org.springframework.boot</groupId>

        <artifactId>spring-boot-starter-test</artifactId>

        <scope>test</scope>

    </dependency>

</dependencies>

spring.application.name=QuizApplication

# Hibernate properties

spring.jpa.hibernate.dialect=org.hibernate.dialect.MySQLDialect

spring.jpa.show-sql=true

spring.jpa.hibernate.ddl-auto=update

# MySQL database connection properties

spring.datasource.driver-class-name=com.mysql.cj.jdbc.Driver

spring.datasource.url=jdbc:mysql://localhost:3306/javarefresher?createDatabaseIfNotExist=true

spring.datasource.username=root

spring.datasource.password=

One database for the whole project

### **Questions Module**

Questions controller

package com.houseSearchKE.QuizApplication.controller;

import com.houseSearchKE.QuizApplication.model.Question;

import com.houseSearchKE.QuizApplication.model.Response;

import com.houseSearchKE.QuizApplication.service.QuestionService;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.http.ResponseEntity;

import org.springframework.web.bind.annotation.\*;

import java.util.List;

@RestController

@RequestMapping("question")

public class QuestionController {

    @Autowired

    private QuestionService questionService;

    @GetMapping("allQuestions")

    public ResponseEntity<List<Question>> getAllQuestions() {

        return questionService.getAllQuestions();

    }

    @PostMapping("save")

    public ResponseEntity<List<Question>> saveQuestions(@RequestBody Question... questions) {

        return questionService.saveQuestions(questions);

    }

    @GetMapping("category/{category}")

    public ResponseEntity<List<Question>> getAllQuestions(@PathVariable("category") String category) {

        return questionService.getQuestionsByCategory(category);

    }

    @PostMapping("submit")

    public ResponseEntity<String> submitQuizForMarking(@RequestBody List<Response> responses) {

        return questionService.markQuizResponses(responses);

    }

}

Question service class

package com.houseSearchKE.QuizApplication.service;

import com.houseSearchKE.QuizApplication.model.Question;

import com.houseSearchKE.QuizApplication.model.Response;

import com.houseSearchKE.QuizApplication.repo.QuestionRepository;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.http.HttpStatus;

import org.springframework.http.ResponseEntity;

import org.springframework.stereotype.Service;

import java.util.ArrayList;

import java.util.List;

import java.util.Optional;

@Service

public class QuestionService {

    @Autowired

    private QuestionRepository questionRepository;

    public ResponseEntity<List<Question>> getAllQuestions() {

        try {

            return new ResponseEntity<>(questionRepository.findAll(), HttpStatus.OK);

        } catch(Exception e) {

            System.out.println(e.getMessage());

            e.printStackTrace();

            return new ResponseEntity<>(new ArrayList<>(), HttpStatus.INTERNAL\_SERVER\_ERROR);

        }

    }

    public ResponseEntity<List<Question>> saveQuestions(Question... questions) {

        try {

            for(Question question: questions) {

                questionRepository.save(question);

            }

            return new ResponseEntity<>(questionRepository.findAll(), HttpStatus.CREATED);

        } catch(Exception e) {

            System.out.println(e.getMessage());

            e.printStackTrace();

            return new ResponseEntity<>(new ArrayList<>(), HttpStatus.INTERNAL\_SERVER\_ERROR);

        }

    }

    public ResponseEntity<List<Question>> getQuestionsByCategory(String category) {

        try {

            return new ResponseEntity<>(questionRepository.findByCategoryOrderByDifficulty(category), HttpStatus.OK);

        } catch(Exception e) {

            System.out.println(e.getMessage());

            e.printStackTrace();

            return new ResponseEntity<>(new ArrayList<>(), HttpStatus.INTERNAL\_SERVER\_ERROR);

        }

    }

    public ResponseEntity<String> markQuizResponses(List<Response> responses) {

        int marks = 0;

        int totalMarks = responses.size();

        for(Response response: responses) {

            int questionId = response.getQuestionId();

            Optional<Question> actualQuestion = questionRepository.findById(questionId);

            String correctAnswer = actualQuestion.get().getCorrectAnswer();

            if(response.getSubmittedResponse().equals(correctAnswer)) {

                marks++;

            }

        }

        String response = marks + " / " + totalMarks;

        return new ResponseEntity<>(response, HttpStatus.OK);

    }

}

Questions Repository

package com.houseSearchKE.QuizApplication.repo;

import com.houseSearchKE.QuizApplication.model.Question;

import org.springframework.data.jpa.repository.JpaRepository;

import org.springframework.data.jpa.repository.Query;

import org.springframework.stereotype.Repository;

import java.util.List;

@Repository

public interface QuestionRepository extends JpaRepository<Question, Integer> {

    List<Question> findByCategoryOrderByDifficulty(String category);

    @Query(value = "select \* from questions where category in (:category) order by RAND() limit :nums", nativeQuery = true)

    List<Question> findQuestionsByCategory(List<String> category, int nums);

}

Questions model class

package com.houseSearchKE.QuizApplication.model;

import jakarta.persistence.\*;

import lombok.Data;

import lombok.NoArgsConstructor;

@Entity

@Table(name = "questions")

@Data

@NoArgsConstructor

public class Question {

    @Id

    @GeneratedValue(strategy = GenerationType.IDENTITY)

    private int id;

//  SQL uses snake\_casing which JPA will take care of. As such, "questionTitle" will be saved as "question\_title"

    private String questionTitle;

    private Options options;

    private String correctAnswer;

    private String category;

    private String difficulty;

}

Questions’ Options model class

package com.houseSearchKE.QuizApplication.model;

import jakarta.persistence.Embeddable;

import lombok.Data;

import lombok.NoArgsConstructor;

@Data

@Embeddable

@NoArgsConstructor

public class Options {

    private String option1;

    private String option2;

    private String option3;

    private String option4;

}

Question’s Wrapper class (questions given to the user, without the correct answer)

package com.houseSearchKE.QuizApplication.model;

import jakarta.persistence.GeneratedValue;

import jakarta.persistence.GenerationType;

import jakarta.persistence.Id;

import lombok.Data;

import lombok.NoArgsConstructor;

@Data

public class QuestionWrapper {

    private int id;

    private String questionTitle;

    private Options options;

    public QuestionWrapper(int id, String questionTitle, Options options) {

        this.id = id;

        this.questionTitle = questionTitle;

        this.options = options;

    }

}

Question’s Response class (for submission for marking)

package com.houseSearchKE.QuizApplication.model;

import lombok.Data;

@Data

public class Response {

    private int questionId;

    private String submittedResponse;

}

### **Quizes Module**

Quizes controller class:

package com.houseSearchKE.QuizApplication.controller;

import com.houseSearchKE.QuizApplication.model.Quiz;

import com.houseSearchKE.QuizApplication.model.QuestionWrapper;

import com.houseSearchKE.QuizApplication.service.QuizService;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.http.ResponseEntity;

import org.springframework.web.bind.annotation.\*;

import java.util.List;

@RestController

@RequestMapping("quiz")

public class QuizController {

    @Autowired

    private QuizService quizService;

    @PostMapping("create")

    public ResponseEntity<Quiz> createQuiz(@RequestParam("category") List<String> categories, @RequestParam("nums") int nums, @RequestParam("title") String title) {

        return quizService.createQuiz(categories, nums, title);

    }

    @GetMapping("get/{id}")

    public ResponseEntity<List<QuestionWrapper>> createQuiz(@PathVariable int id) {

        return quizService.getQuiz(id);

    }

}

Quzes Service class

package com.houseSearchKE.QuizApplication.service;

import com.houseSearchKE.QuizApplication.model.Question;

import com.houseSearchKE.QuizApplication.model.Quiz;

import com.houseSearchKE.QuizApplication.model.QuestionWrapper;

import com.houseSearchKE.QuizApplication.repo.QuestionRepository;

import com.houseSearchKE.QuizApplication.repo.QuizRepository;

import org.springframework.beans.factory.annotation.Autowired;

import org.springframework.http.HttpStatus;

import org.springframework.http.ResponseEntity;

import org.springframework.stereotype.Service;

import java.util.ArrayList;

import java.util.List;

import java.util.Optional;

@Service

public class QuizService {

    @Autowired

    private QuizRepository quizRepository;

    @Autowired

    private QuestionRepository questionRepository;

    public ResponseEntity<Quiz> createQuiz(List<String> categories, int nums, String title) {

        try {

            List<Question> questionList = questionRepository.findQuestionsByCategory(categories, nums);

            Quiz quiz = new Quiz();

            quiz.setTitle(title);

            quiz.setQuestions(questionList);

            return new ResponseEntity<>(quizRepository.save(quiz), HttpStatus.CREATED);

        } catch(Exception e) {

            System.out.println(e.getMessage());

            e.printStackTrace();

            return new ResponseEntity<>(new Quiz(), HttpStatus.INTERNAL\_SERVER\_ERROR);

        }

    }

    public ResponseEntity<List<QuestionWrapper>> getQuiz(int id) {

        try {

            Optional<Quiz> quiz = quizRepository.findById(id);

            List<Question> questions = quiz.get().getQuestions();

            List<QuestionWrapper> questionForUser = new ArrayList<QuestionWrapper>();

            for(Question question: questions) {

                QuestionWrapper questionWrapper = new QuestionWrapper(question.getId(), question.getQuestionTitle(), question.getOptions());

                questionForUser.add(questionWrapper);

            }

            return new ResponseEntity<>(questionForUser, HttpStatus.OK);

        } catch(Exception e) {

            System.out.println(e.getMessage());

            e.printStackTrace();

            return new ResponseEntity<>(new ArrayList<QuestionWrapper>(), HttpStatus.INTERNAL\_SERVER\_ERROR);

        }

    }

}

Quizes Repository

package com.houseSearchKE.QuizApplication.repo;

import com.houseSearchKE.QuizApplication.model.Quiz;

import org.springframework.data.jpa.repository.JpaRepository;

public interface QuizRepository extends JpaRepository<Quiz, Integer> {

}

Quiz model class

package com.houseSearchKE.QuizApplication.model;

import jakarta.persistence.\*;

import lombok.Data;

import lombok.NoArgsConstructor;

import java.util.List;

@Entity

@Table(name = "quizes")

@Data

@NoArgsConstructor

public class Quiz {

    @Id

    @GeneratedValue(strategy = GenerationType.IDENTITY)

    private int id;

    private String title;

    @ManyToMany

    private List<Question> questions;

}

## **Microservices Structure**

Here, every service is separated into its own project with its own depenncies, port numbers etc. To configure the microservices architecture for an application, the project is broken down into three:

1. The service registry server – that registers all the other microservices in the application
2. The api gateway –that handles all the cross-cutting concerns such as user authentication and provides a single point of access to the clients.
3. The actual microservives – these are split into projects

### **The service registry**

This is the eureka. It was developed by Netflix. To configure the same:

1. Create a project and add the following dependencies, besides the other springboot dependencies. Mainly the “eureka-server” dependency:

<dependencies>

    <dependency>

        <groupId>org.springframework.cloud</groupId>

        <artifactId>spring-cloud-starter-netflix-eureka-server</artifactId>

    </dependency>

</dependencies>

1. Configure the application.properties file:

spring.application.name=service-registry

# Defines the port on which the Eureka server will run

server.port=8761

# Sets the hostname of the Eureka instance, typically "localhost" for local development.

eureka.instance.hostname=localhost

# Disables fetching of the registry from another Eureka server (since this is the server itself)

eureka.client.fetch-registry=false

# Prevents this application from registering itself with another Eureka server (since this is the server itself)

eureka.client.register-with-eureka=false

# the "registry" is a database of all the services (or applications) that are registered with the Eureka server. Each service instance registers itself with Eureka by providing its metadata (such as host, port, health status, and application name). Eureka then maintains this information in its registry.

1. Add the “@EnableEurekaServer” annotation to the main application class file:

@SpringBootApplication

@EnableEurekaServer

public class ServiceRegistryApplication {

    public static void main(String[] args) {

        SpringApplication.run(ServiceRegistryApplication.class, args);

    }

}

### **The API Gateway**

For this, all you need to do is add the dependencies, besides the other springboot dependencies and configure the application.properties:

<dependencies>

    <dependency>

        <groupId>org.springframework.cloud</groupId>

        <artifactId>spring-cloud-starter-gateway</artifactId>

    </dependency>

    <dependency>

        <groupId>org.springframework.cloud</groupId>

        <artifactId>spring-cloud-starter-netflix-eureka-client</artifactId>

    </dependency>

</dependencies>

The application.propertes is as:

spring.application.name=api-gateway

server.port=8765

spring.cloud.gateway.discovery.locator.enabled=true

# Enables the Discovery Locator feature in Spring Cloud Gateway. This allows the API Gateway to automatically create routes for services that are registered in a service registry (like Eureka).

# When this is set to 'true', the gateway dynamically routes requests to the services registered in the discovery server (Eureka, Quiz, etc.) based on the service ID.

spring.cloud.gateway.discovery.locator.lower-case-service-id=true

# Converts all the service IDs retrieved from the service registry to lowercase.

# This ensures case-insensitive matching for service IDs, which helps avoid issues with inconsistent casing when routing requests to different services.

### **The Other Micoservices**

These are usually configured similarly except for when there is one service that is being called by another, and yet that one does not call any other service. Either way, both kinds of microservices have the “eureka-client” dependency. The service(s) that call at least one other services also need the “openFeign” dependency that simplifies this, rather than having to the spring’s “RestTemplate”.

Each microservice can also be configured to have its own database.

#### **Questions Services**

This is the service that is called by the quiz service.

This project’s dependencies, besides the other springboot dependencies, are as:

<dependencies>

    <dependency>

        <groupId>org.springframework.boot</groupId>

        <artifactId>spring-boot-starter-data-jpa</artifactId>

    </dependency>

    <dependency>

        <groupId>org.springframework.cloud</groupId>

        <artifactId>spring-cloud-starter-netflix-eureka-client</artifactId>

    </dependency>

<!-- Not needed -->

<!--        <dependency>-->

<!--            <groupId>org.springframework.cloud</groupId>-->

<!--            <artifactId>spring-cloud-starter-openfeign</artifactId>-->

<!--        </dependency>-->

<!-- To enable swagger for the project -->

    <dependency>

        <groupId>org.springdoc</groupId>

        <artifactId>springdoc-openapi-starter-webmvc-ui</artifactId>

        <version>2.1.0</version>

    </dependency>

    <dependency>

        <groupId>io.swagger.core.v3</groupId>

        <artifactId>swagger-annotations</artifactId>

        <version>2.2.23</version>

    </dependency>

    <dependency>

        <groupId>com.mysql</groupId>

        <artifactId>mysql-connector-j</artifactId>

        <scope>runtime</scope>

    </dependency>

    <dependency>

        <groupId>org.projectlombok</groupId>

        <artifactId>lombok</artifactId>

        <optional>true</optional>

    </dependency>

</dependencies>

The application.properties is as. Make note of the database name:

spring.application.name=question-service

# The default port number for the tomcat server is 8080.

# Hibernate properties

spring.jpa.hibernate.dialect=org.hibernate.dialect.MySQLDialect

spring.jpa.show-sql=true

spring.jpa.hibernate.ddl-auto=update

# MySQL database connection properties

spring.datasource.driver-class-name=com.mysql.cj.jdbc.Driver

spring.datasource.url=jdbc:mysql://localhost:3306/questions\_service\_db?createDatabaseIfNotExist=true

spring.datasource.username=root

spring.datasource.password=

The other classes and interfaces etc of the service are configured to be independent from any other service.

#### **Quizes Service**

This one calls the questions services to: get the questions for a particular quiz, and to submit the responses for marking.

Its dependencies, besides the other springboot dependencies, are as:

<dependencies>

    <dependency>

        <groupId>org.springframework.boot</groupId>

        <artifactId>spring-boot-starter-data-jpa</artifactId>

    </dependency>

    <dependency>

        <groupId>org.springframework.cloud</groupId>

        <artifactId>spring-cloud-starter-netflix-eureka-client</artifactId>

    </dependency>

    <!-- Included because this service calls the question service -->

    <dependency>

        <groupId>org.springframework.cloud</groupId>

        <artifactId>spring-cloud-starter-openfeign</artifactId>

    </dependency>

    <dependency>

        <groupId>com.mysql</groupId>

        <artifactId>mysql-connector-j</artifactId>

        <scope>runtime</scope>

    </dependency>

    <dependency>

        <groupId>org.projectlombok</groupId>

        <artifactId>lombok</artifactId>

        <optional>true</optional>

    </dependency>

    <dependency>

        <groupId>org.springdoc</groupId>

        <artifactId>springdoc-openapi-starter-webmvc-ui</artifactId>

        <version>2.1.0</version>

    </dependency>

    <dependency>

        <groupId>io.swagger.core.v3</groupId>

        <artifactId>swagger-annotations</artifactId>

        <version>2.2.23</version>

    </dependency>

</dependencies>

The project’s application.properties is as. Make note of the port number and the database name:

spring.application.name=quiz-service

server.port=8090

# Hibernate properties

spring.jpa.hibernate.dialect=org.hibernate.dialect.MySQLDialect

spring.jpa.show-sql=true

spring.jpa.hibernate.ddl-auto=update

# MySQL database connection properties

spring.datasource.driver-class-name=com.mysql.cj.jdbc.Driver

spring.datasource.url=jdbc:mysql://localhost:3306/quizes\_service\_db?createDatabaseIfNotExist=true

spring.datasource.username=root

spring.datasource.password=

Add the “@EnableFeignClients” to the main application class file:

import org.springframework.cloud.openfeign.EnableFeignClients;

@SpringBootApplication

@EnableFeignClients

public class QuizServiceApplication {

    public static void main(String[] args) {

        SpringApplication.run(QuizServiceApplication.class, args);

    }

}

Create an interface to declare the methods and paths to be targeted from the other, questions service. Annotate the class with “@FeignClient()” that takes the name of the service being targeted as a parameter. If having targeting more than one micro-service, create multiple interface files and do the same for those other micro-services.

import org.springframework.cloud.openfeign.FeignClient;

@FeignClient("QUESTION-SERVICE")

public interface QuizQuestionInterface {

    //    Generate the quiz questions

    @PostMapping("question/questions/generate")

    public ResponseEntity<List<Integer>> generateQuizQuestions(@RequestParam("category") List<String> categories, @RequestParam("nums") int nums);

    //    Get the questions and pass them to the quiz service

    @PostMapping("question/questions/get")

    public ResponseEntity<List<QuestionWrapper>> getQuizQuestions(@RequestBody List<Integer> quesionIds);

    //    Mark the quiz submission

    @PostMapping("question/mark")

    public ResponseEntity<String> submitQuizForMarking(@RequestBody List<Response> responses);

}

Inject the interface to the service class that needs to make use of the same. There, the methods are called through the injected interface’s reference. E.g:

import com.housesearchKE.quiz\_service.feign.QuizQuestionInterface;

@Service

public class QuizService {

    @Autowired

    private QuizRepository quizRepository;

    // Here is the injection

    @Autowired

    private QuizQuestionInterface quizQuestionInterface;

    public ResponseEntity<String> submitQuizForMarking(List<Response> responses) {

        return quizQuestionInterface.submitQuizForMarking(responses);

    }

}

Note, if there was an entity relation between the classes separated out ito different projects, replace the “@ManyToMany” etc annotations with “@ElementCollection” because now the class will only hold primitives rather than objects in the concerned field(s).

@Entity

@Table(name = "quizes")

@Data

@NoArgsConstructor

public class Quiz {

    @Id

    @GeneratedValue(strategy = GenerationType.IDENTITY)

    private int id;

    private String title;

    @ElementCollection

    private List<Integer> questions;

}

It is possible to create multiple instances of the same microservice. All you need to do is add a run configuration and configure a port number for the new configuration.

E.g. *“-Dserver.port=8081”.*

This new instance(s) will still be registered under the service in the eureka service registry as another instance. The API Gateway will in turn choose which instance to call by default through the load balancer.