Practice 1: Introduction to Java

Software Design (614G01015)

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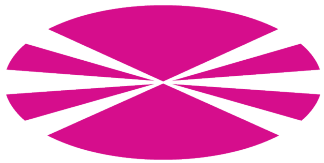

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Origin

- **Oak programming language**. Developed at **Sun** by **James Gosling** and **Peter Naughton** to manage small electronic devices.
- Aspects sought: **hardware independence**, **"pure" and robust object-oriented** programming language, **based on C++**.
- Discontinued in Spring 1994 due to lack of profit.
- Relaunched in 1995 as Java, taking advantage of the Internet's hardware independence.
- In 2009, Oracle acquired Sun and it is the proprietary of the language.

James Gosling

Design goals of the Java PL

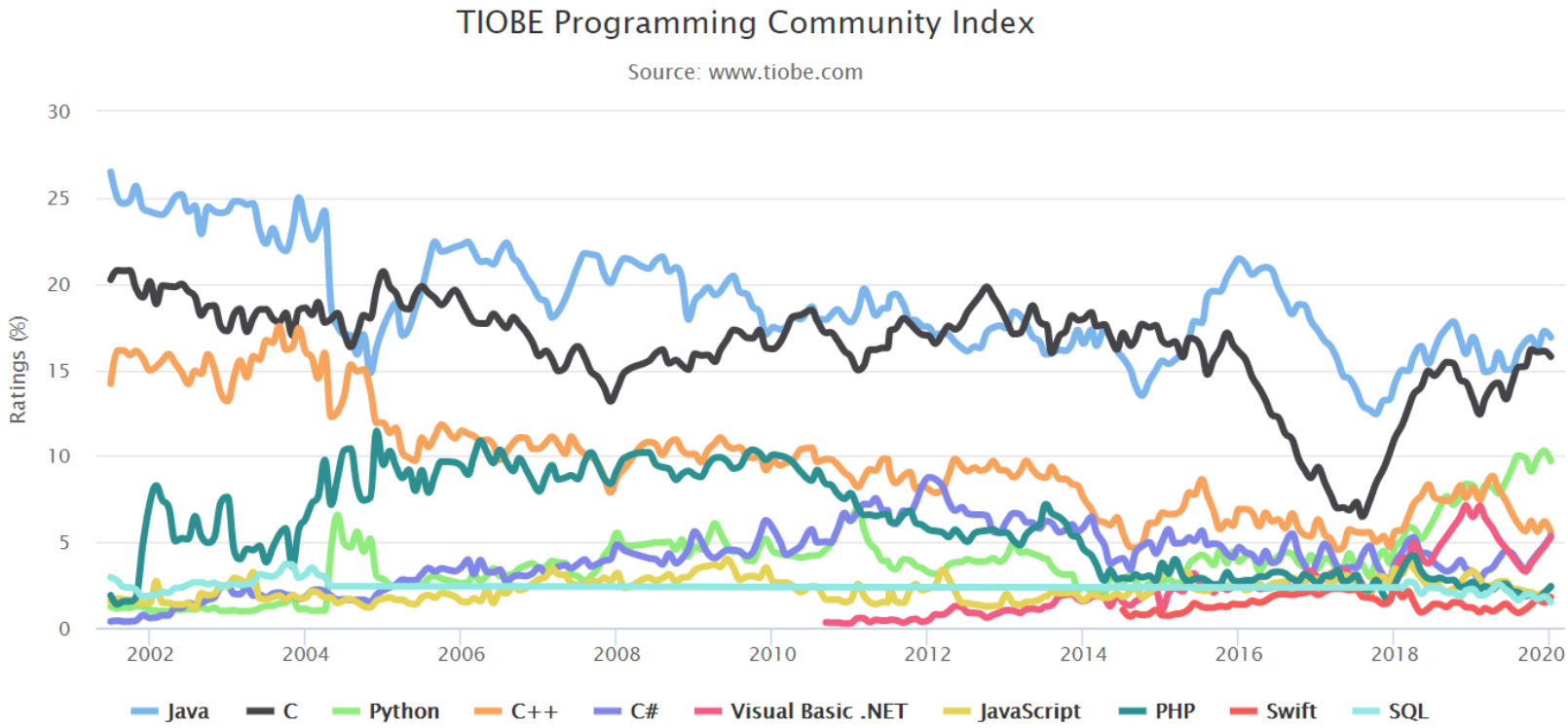
1. **Simple, object-oriented, and familiar**
   - Simple, easy to learn.
   - Pure object orientation.
   - Syntax is similar to C++. Familiar to developers.
2. **Robust and secure**
   - Multiple checks at compile time (e.g., non-initialized variables) and at runtime (e.g., out-of-bounds array indexes) to make programs more reliable and promote good programming practices.
   - Direct manipulation of pointers is not allowed, as it is a frequent source of errors.
   - Includes a *garbage collector* that frees unused memory.
   - Designed to work securely in distributed environments.

Design goals of the Java PL

3. **Architecture-neutral and portable**
   - Java applications can be run on multiple hardware/software architectures.
   - Java programs are compiled as intermediate *bytecodes*, which are later "interpreted' on each particular platform ("*write once, run everywhere*").
4. **High performance**
   - Despite being interpreted, Java performs optimizations in order to achieve high performance (*just-in-time* compilers, *HotSpot* technology, native code, etc.)
5. **Interpreted, threaded and dynamic**
   - Each platform has its corresponding *Java Virtual Machine (JVM)*, i.e., a virtual software processor that translates bytecodes to the machine code of the target architecture.
   - Java supports multi-threaded programming.
   - Even though Java is statically-typed, it supports object-oriented functionalities such as dynamic binding.

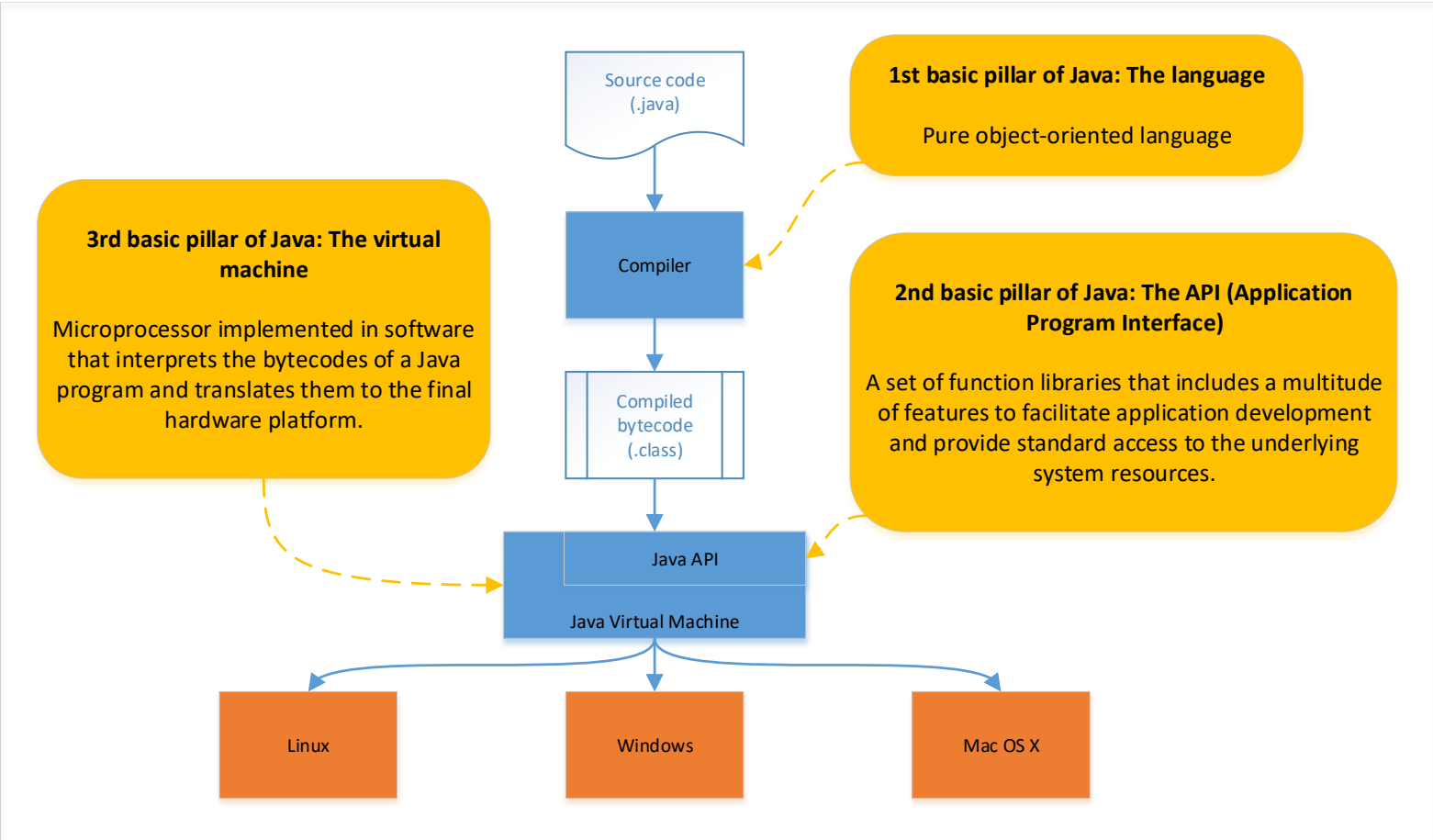
Java's popularity

- According to the TIOBE Index, Java is the most popular programming language from 2001 onwards (sometimes sharing the top spot with C).



Java Platform

- **The Java Platform**: Language, API and Virtual Machine.
- Distributed via a JDK (Java Development Kit).



Downloading the JDK

- **Oracle JDK**
  - Oracle distributes a version of the JDK under the *Oracle Technology Network (OTN)* license, which is only free for personal or non-profit use.
- **OpenJDK**
  - OpenJDK is the JDK version released under the GPL license.
  - Oracle JDK and OpenJDK are virtually equivalent. The only difference is the support offered by Oracle for its commercial version, which OpenJDK offers through other companies such as IBM.
  - **In this course we will use OpenJDK**. The most convenient source for the download is **AdoptOpenJDK:** **`https://adoptopenjdk.net/`**
  - We will also use **the latest version available**.

OpenJDK

Other PLs with the platform

- The Java Language and the Java Virtual Machine are separate entities.
- You can use other PLs to write code, which will be later interpreted by the Java Virtual Machine:
  - **Kotlin**: A statically typed language and can be also compiled to JavaScript source code.
  - **Groovy**: A scripting language.
  - **Scala**: An OOPL that supports functional programming.
  - **Clojure**: a dialect of the Lisp functional programming language .



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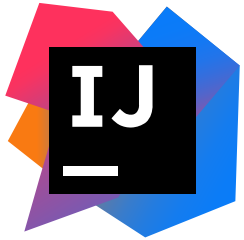
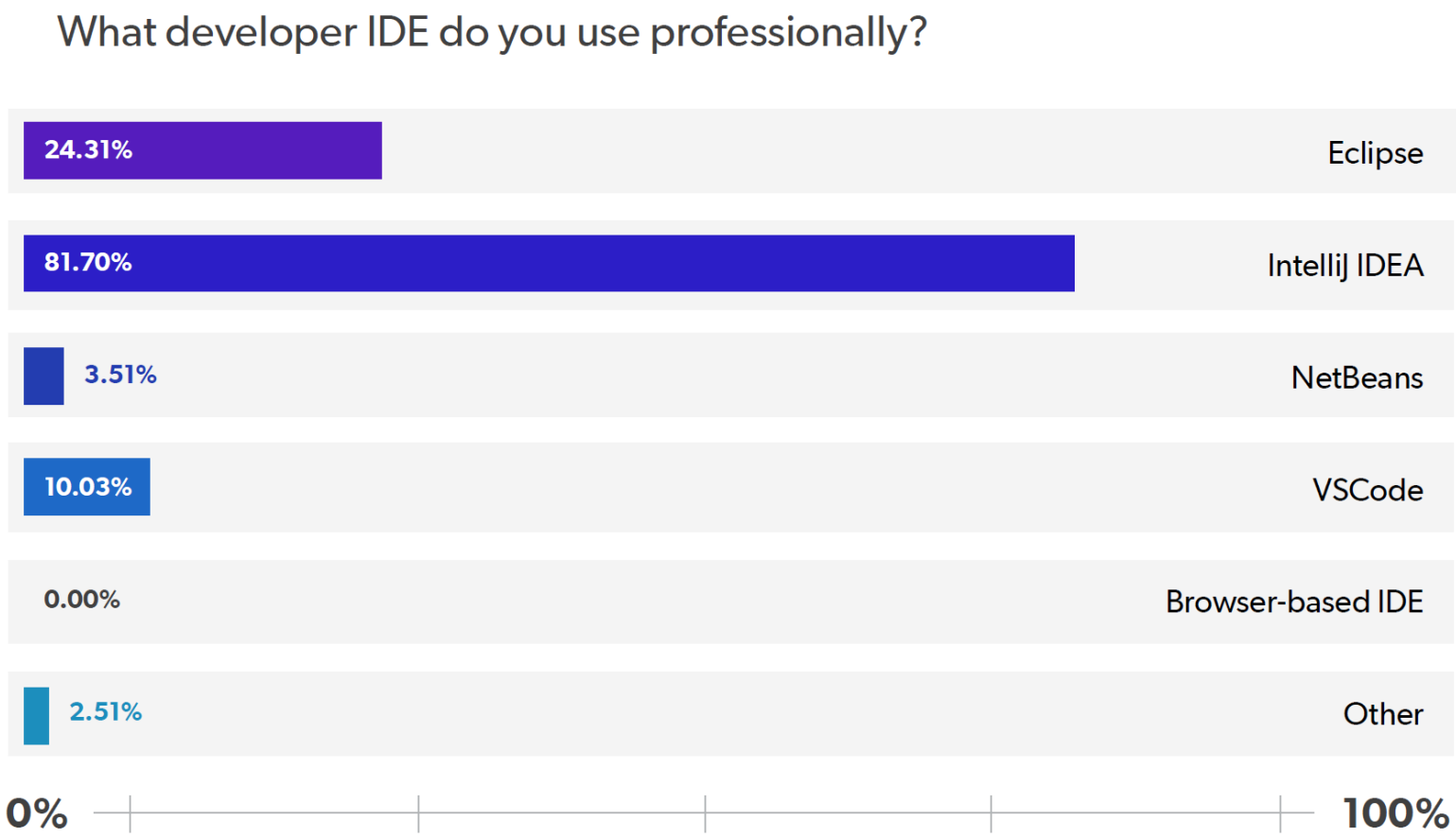
Introduction



- **IntelliJ IDEA** is an Integrated Development Environment (IDE) for Java (and other PLS for the JVM, such as Kotlin, Groovy or Scala). It was created by the JetBrains company.
- IntelliJ IDEA has **two editions**:
  - The ***Community*** edition is free and open-source (Apache 2.0 license) and is focused on basic projects for the JVM and Android development.
  - The ***Ultimate*** edition is non-free (although it can be used with an education license) and is focused on web and enterprise development.
- For this course, the ***latest Community edition*** will suffice. You can download it at:
  `https://www.jetbrains.com/es-es/idea/download/`

IntelliJ IDEA

- IntelliJ IDEA is currently the most widely used IDE for Java development[1].



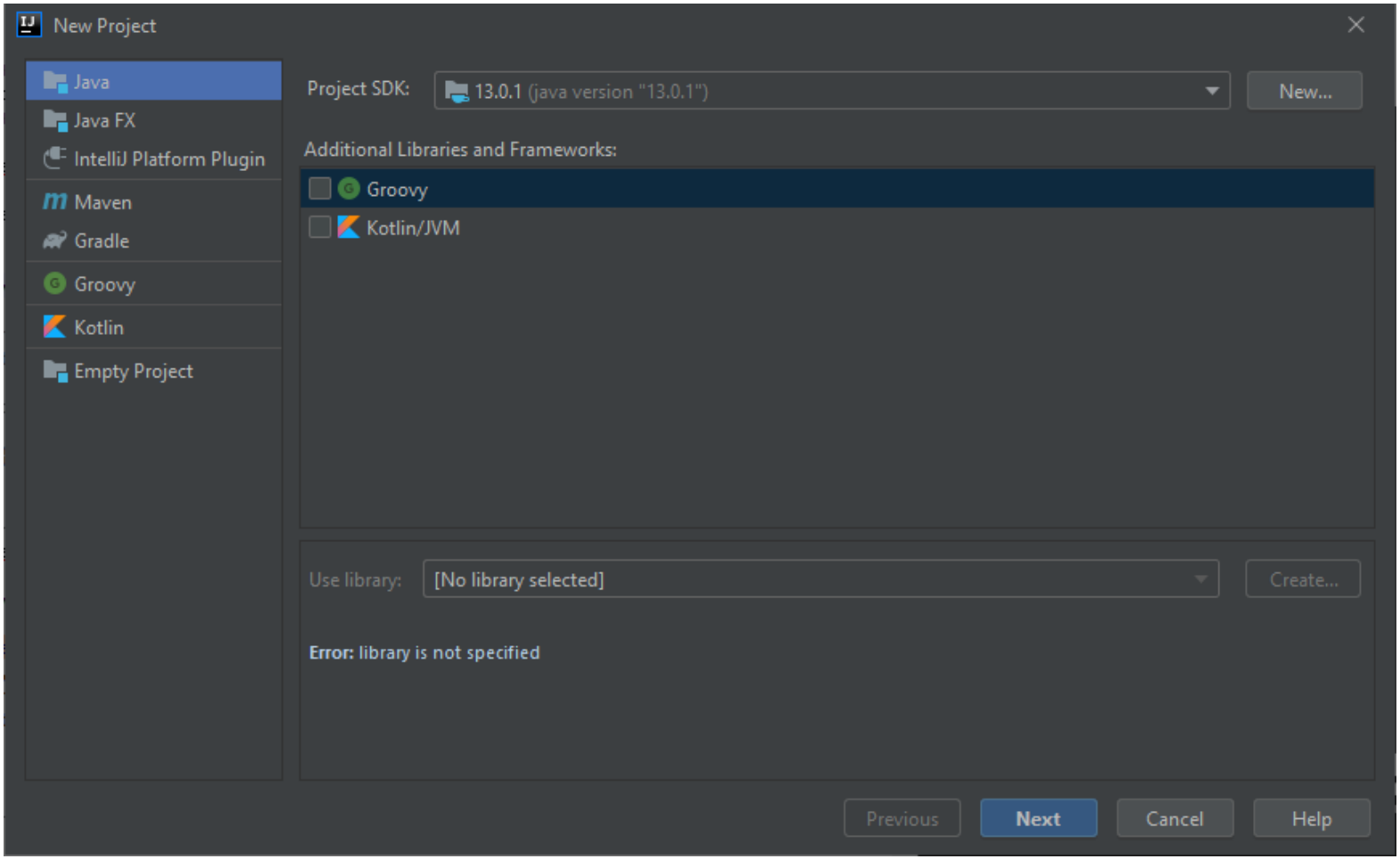
[1] Fuente: JRrebel Java Productivity Report 2020. https://www.jrebel.com/blog/2020-java-technology-report

IntelliJ IDEA

- The code is managed as projects. The first step is creating a new project.

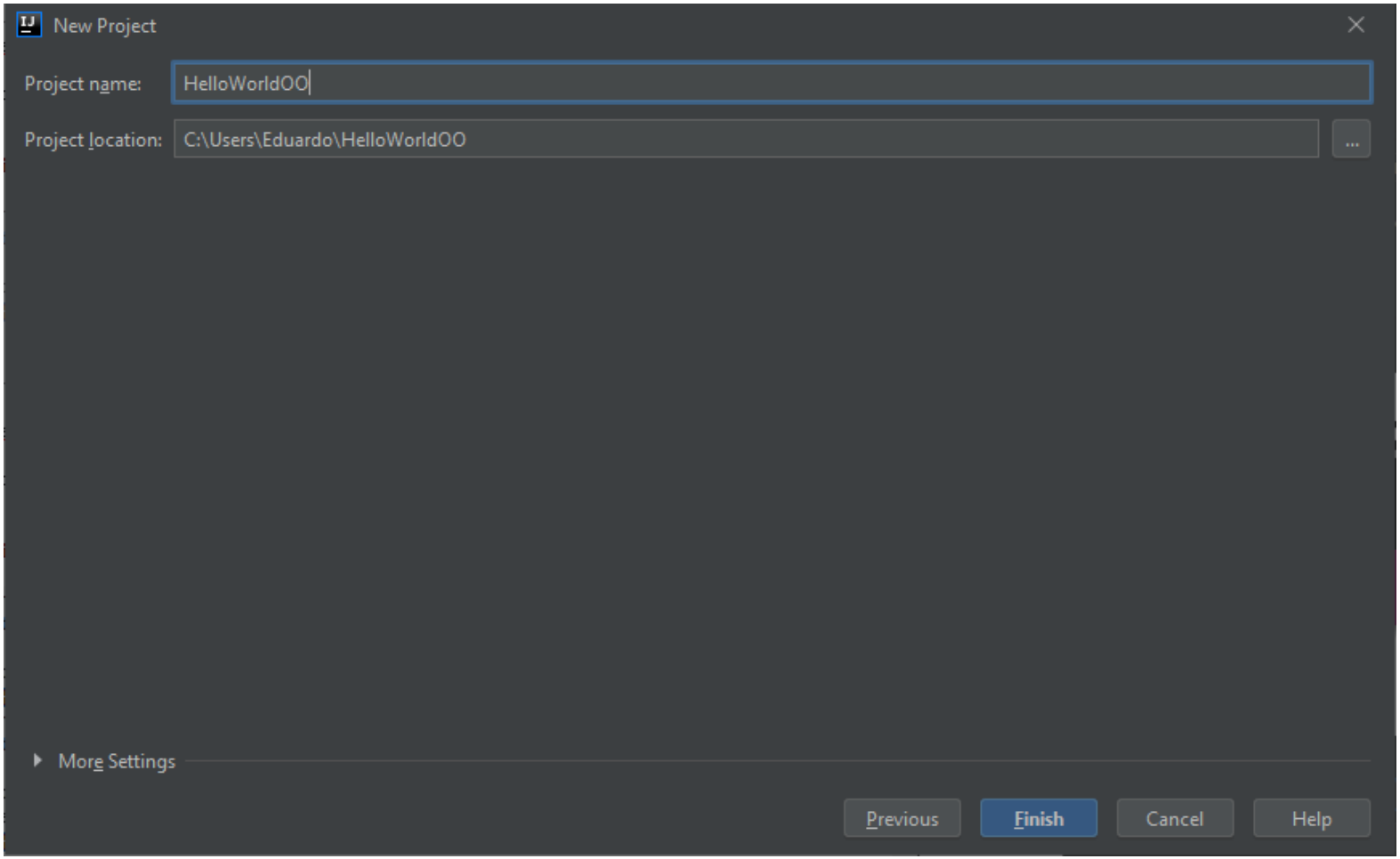
IntelliJ IDEA

- We choose creating a "Java" project, specifying the JDK.



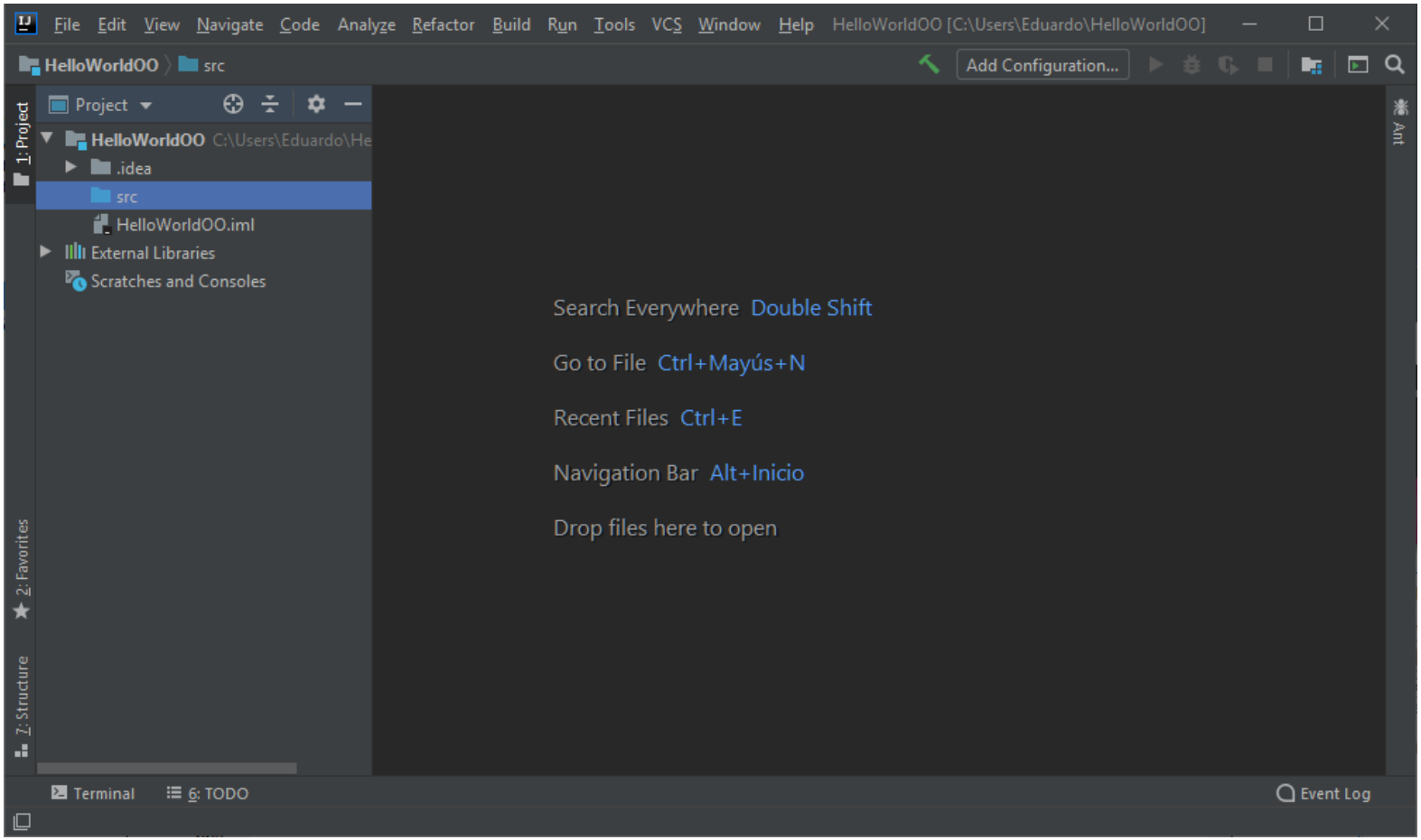
IntelliJ IDEA

- We enter the name and the location for the project.



IntelliJ IDEA

- The project is stored in the `.idea` folder, and the `.iml` file contains information about the *module* we are developing.
- The source files are stored in the `src` folder.



"Hello World" in Java

All Java code is inside a class

"Hello World" in Java

```
class HelloWorld {
    public static void main (String [] args) {
        System.out.println ("Hello World");
    }
}
```

When we run a class, we run its `main` method

Prints "Hello World" on the terminal

"Hello, World" in Java

- **Our "Hello, World" code is a bad example of Object Orientation**:
  - A class is defined, but no object is instantiated.
  - Execution is delegated to a static `main` method. Static methods can be called without instantiating objects.
  - The class writes directly to the console.
- **An object-oriented code should include**:
  - Object instantiation.
  - Calls to non-static methods (i.e., methods that manipulate an object's state).
  - Reusable, architecture-independent classes that do not write directly to the console.

Object-Oriented "Hello World"

Object-Oriented "Hello World"

```
class HelloWorldOO {
    private String message = "Hello World";
    public String returnMessage() {
        return message;
    }

    public static void main(String[] args) {
        HelloWorldOO myHello = new HelloWorldOO();
        System.out.println(myHello.returnMessage());
    }
}
```

`getMessage` is not static (it needs an object in which it is executed) and returns a `String`

We create an object of the `HelloWorldOO` class using the `new` operator

`getMessage` retuns the message of the `myHello` object, the `println` method prints it in the console

Object-Oriented "Hello World"

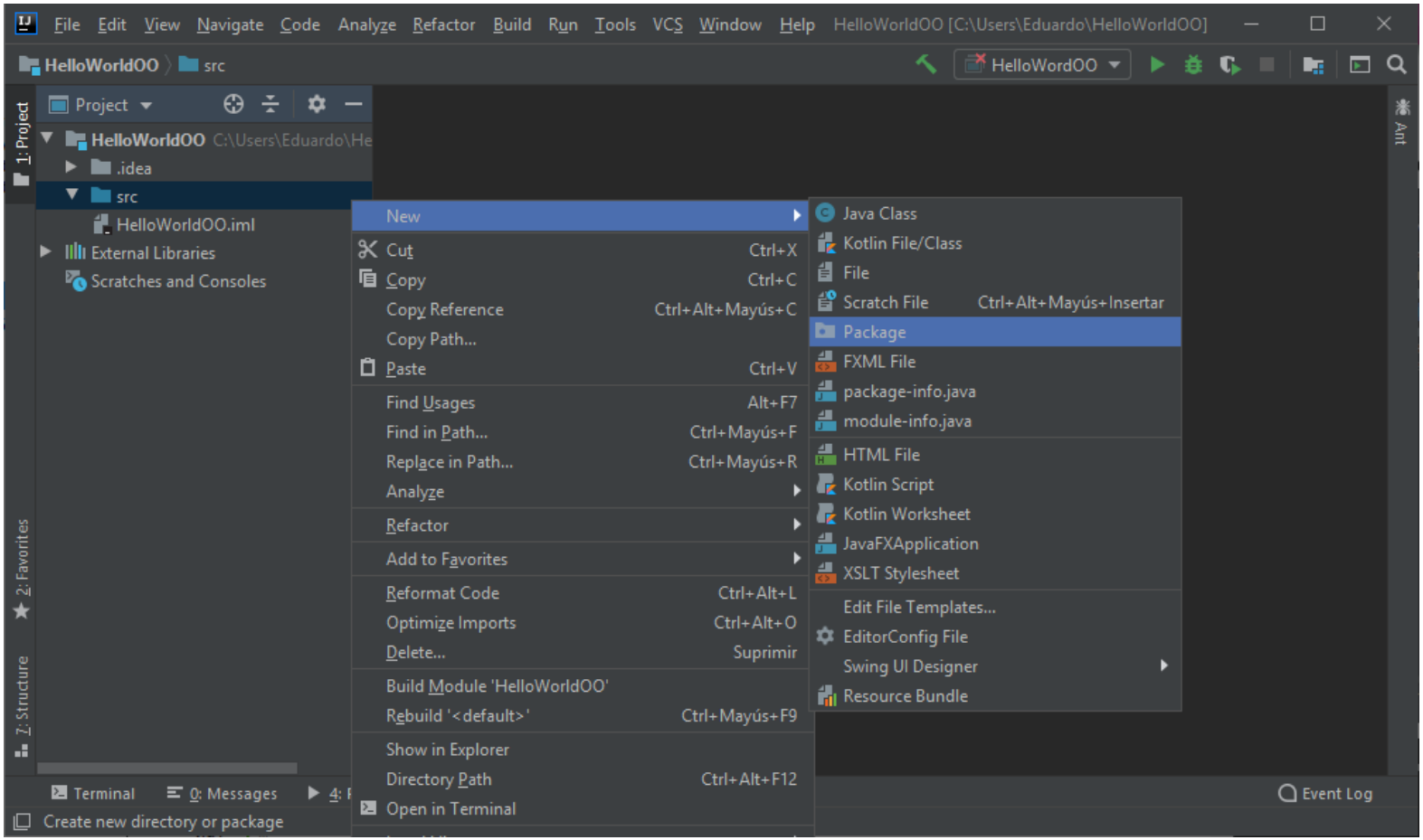
Object-Oriented "Hello World"

```
public class HelloWorldOO {
    private String message;

    public HelloWorldOO() {
        message = "Hello World";
    }

    public String returnMessage() {
        return message;
    }

    public static void main(String[] args) {
        HelloWorldOO myHello = new HelloWorldOO();
        System.out.println(myHello.returnMessage());
    }
}
```

Initialization can be done in constructor methods, that have the same name as the class and do not declare a return type

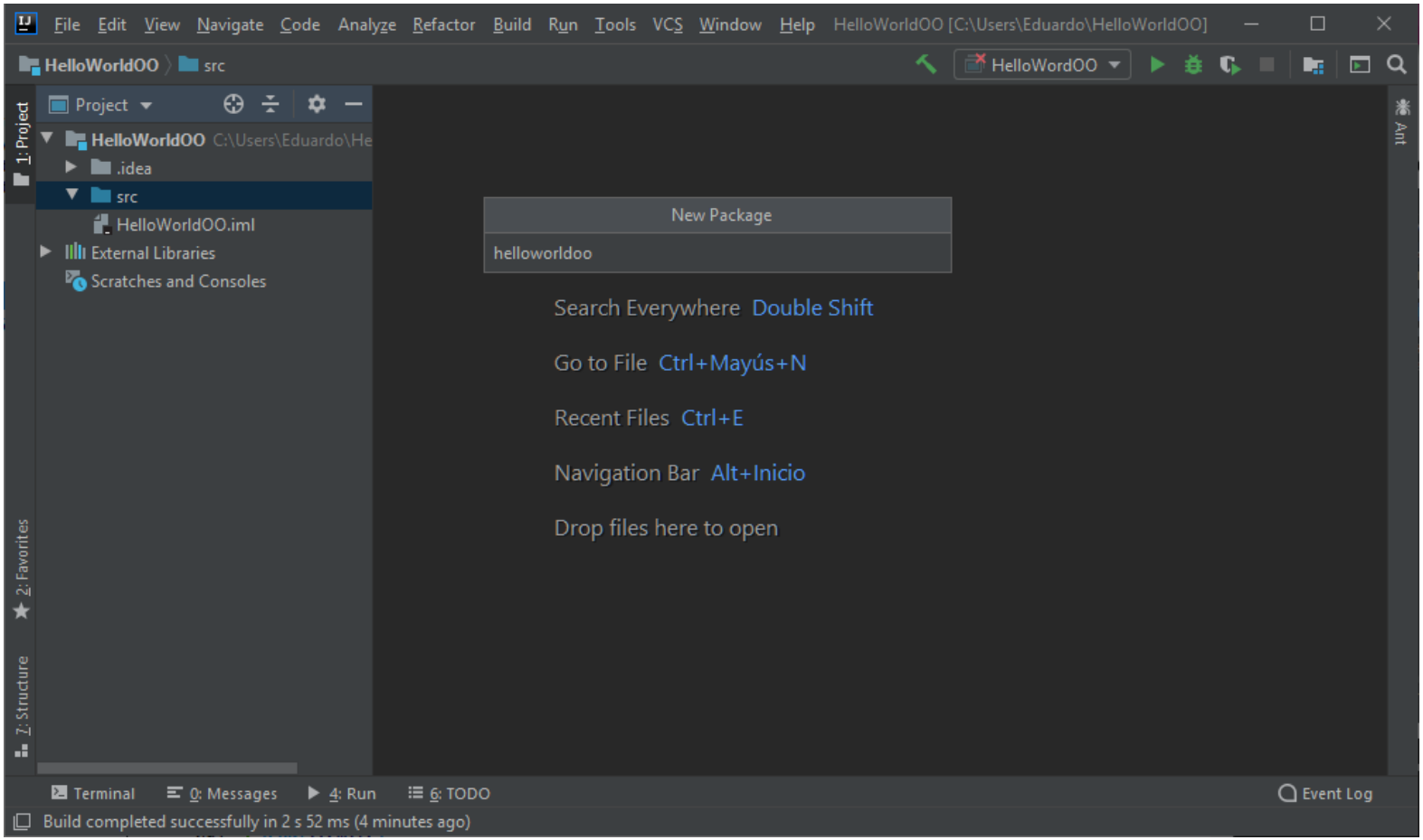
"Hello World" on IntelliJ IDEA

- It is recommended to arrange the source files into packages. Therefore, the first step will be creating one...



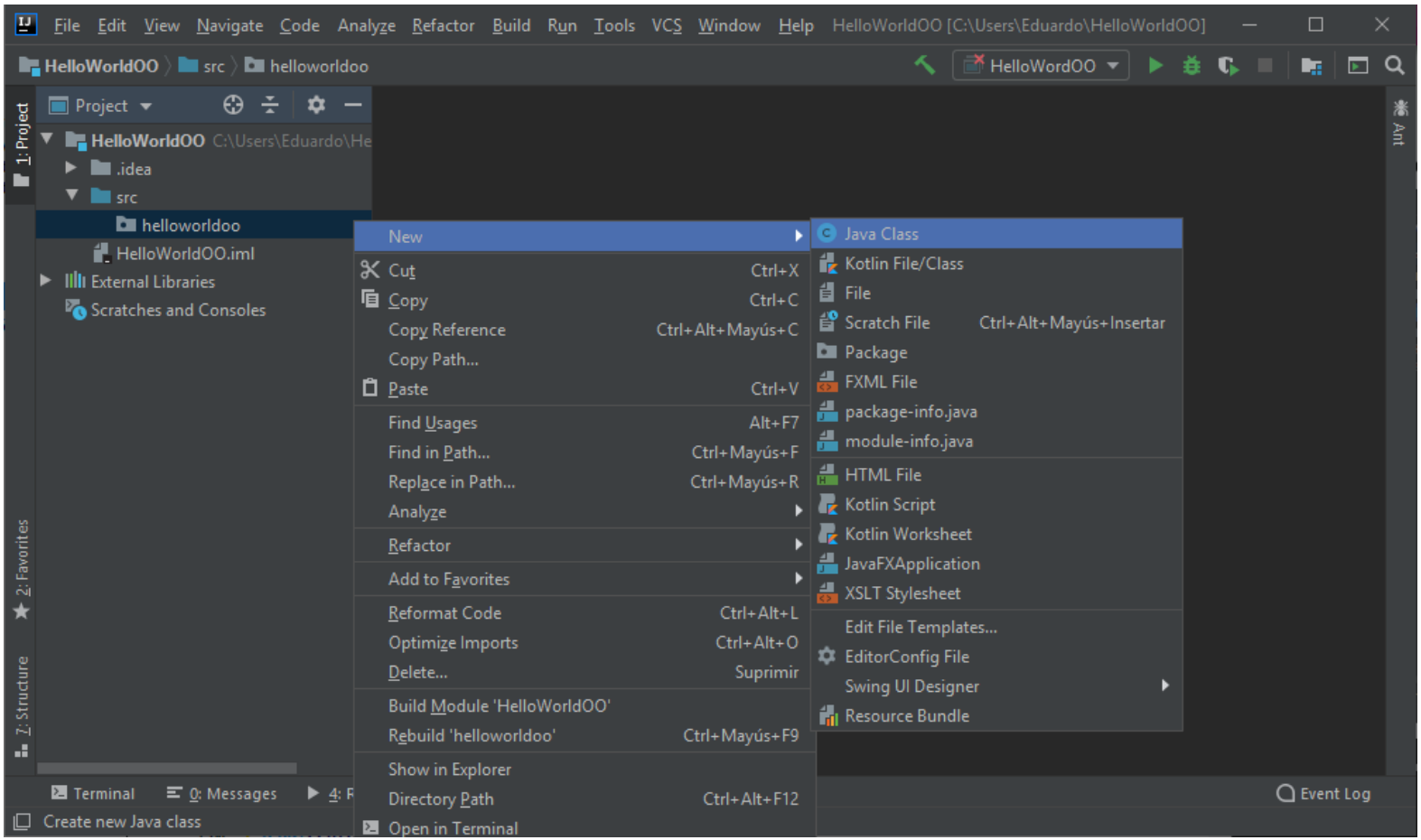
"Hello World" on IntelliJ IDEA

- ...which we will call `helloworldoo`.



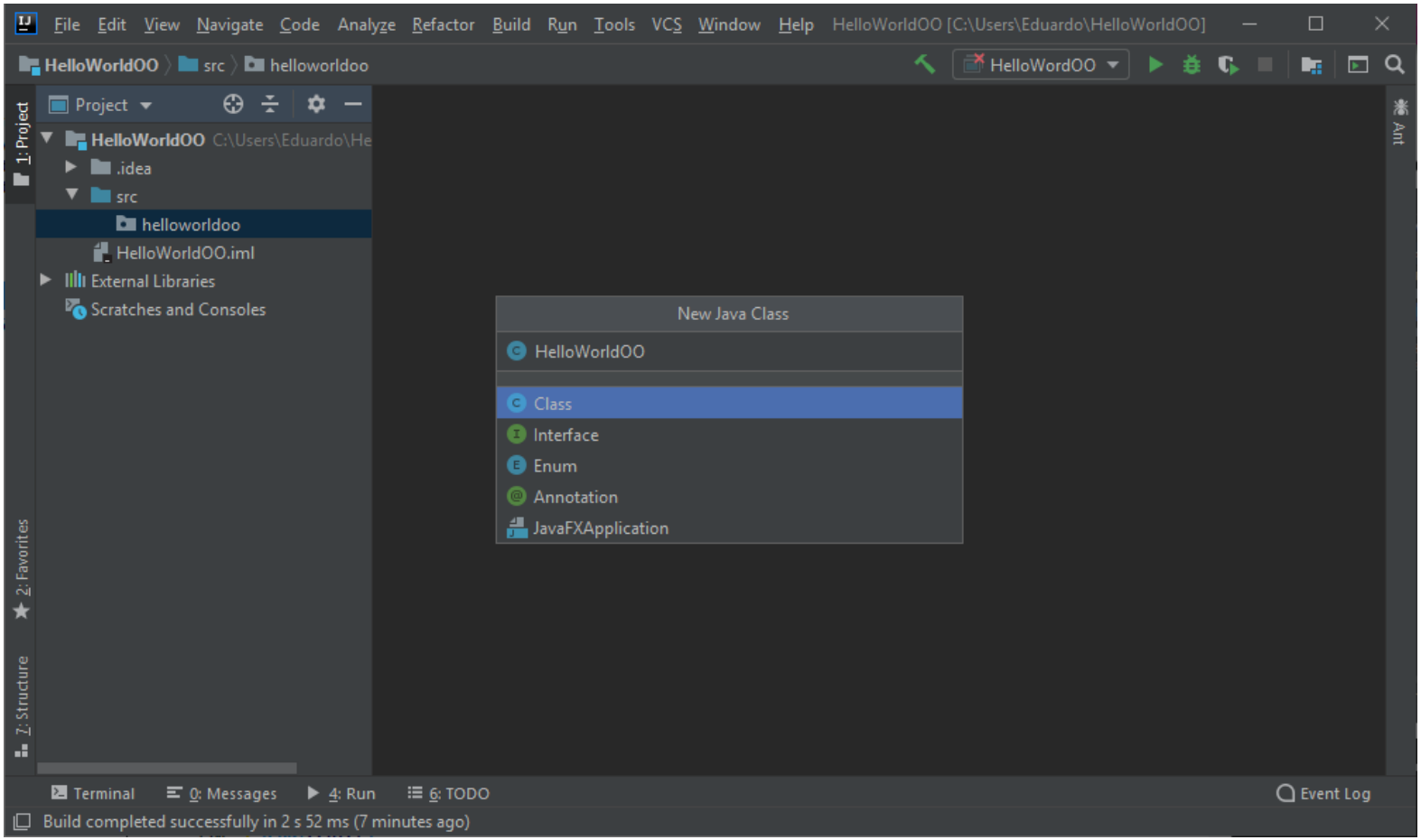
"Hello World" on IntelliJ IDEA

- Inside the `helloworldoo` package, we will create a new Java class...



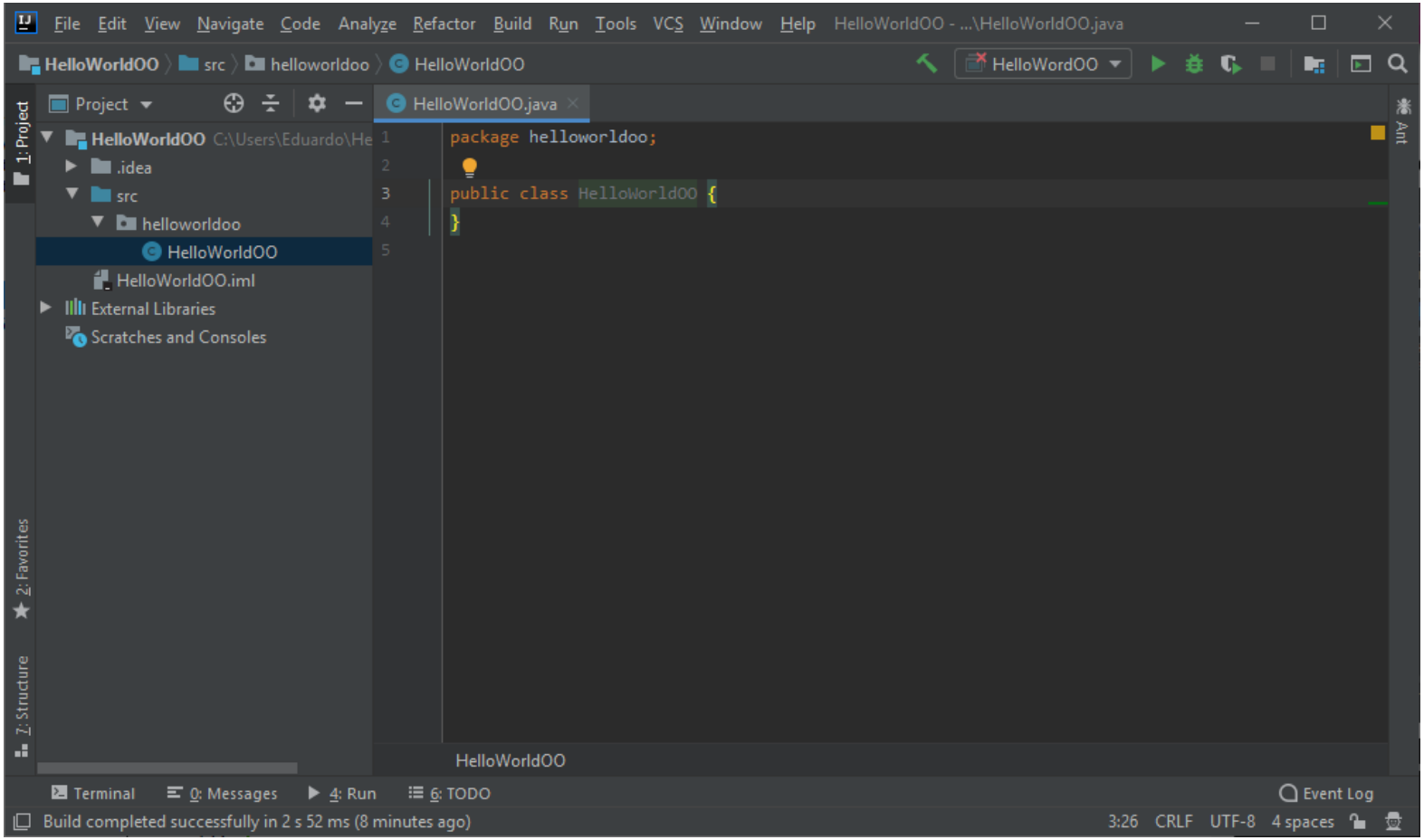
"Hello World" on IntelliJ IDEA

- ...which we will call `HelloWorldOO`.



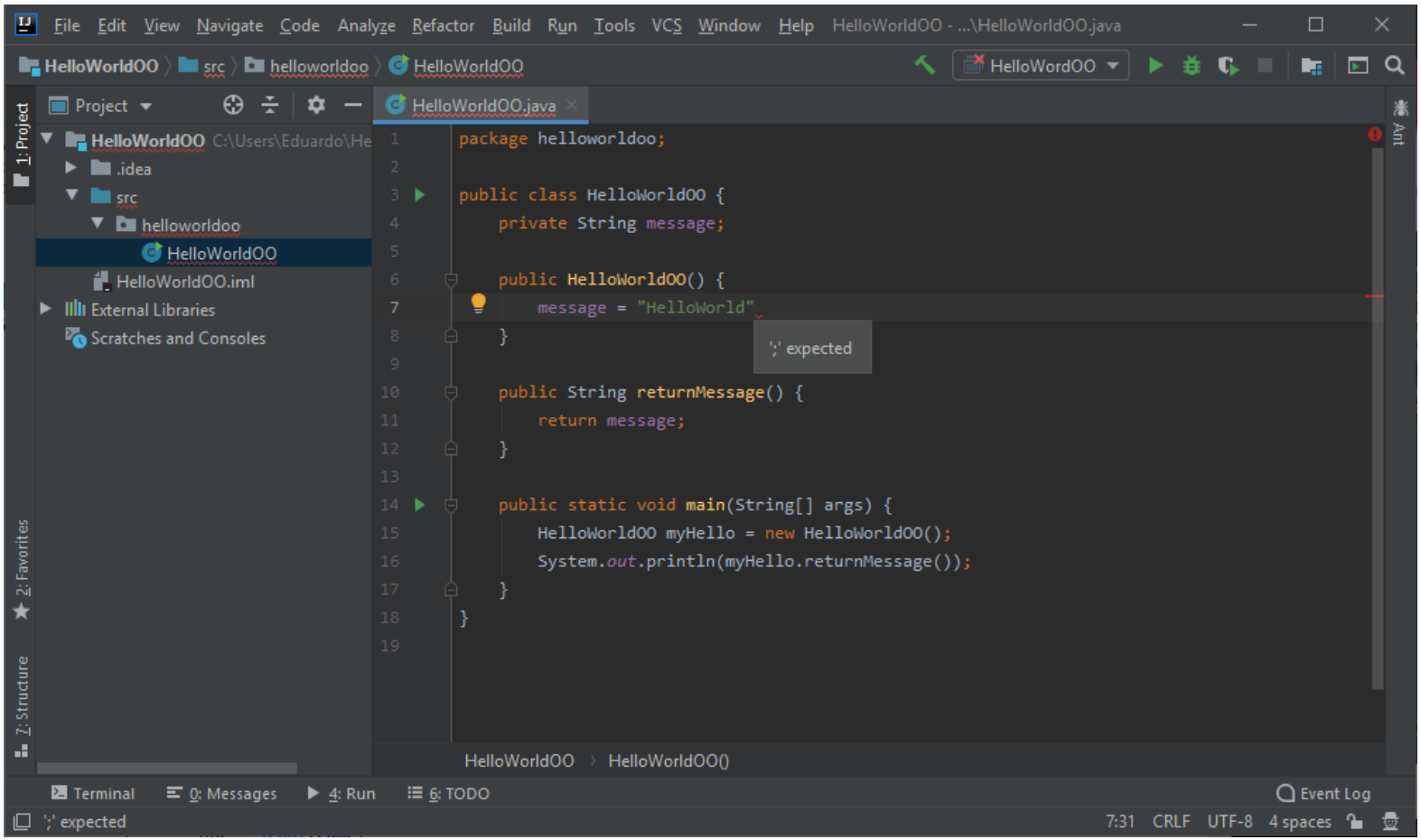
"Hello World" on IntelliJ IDEA

- The class is saved as the `HelloWorldOO.java` file.



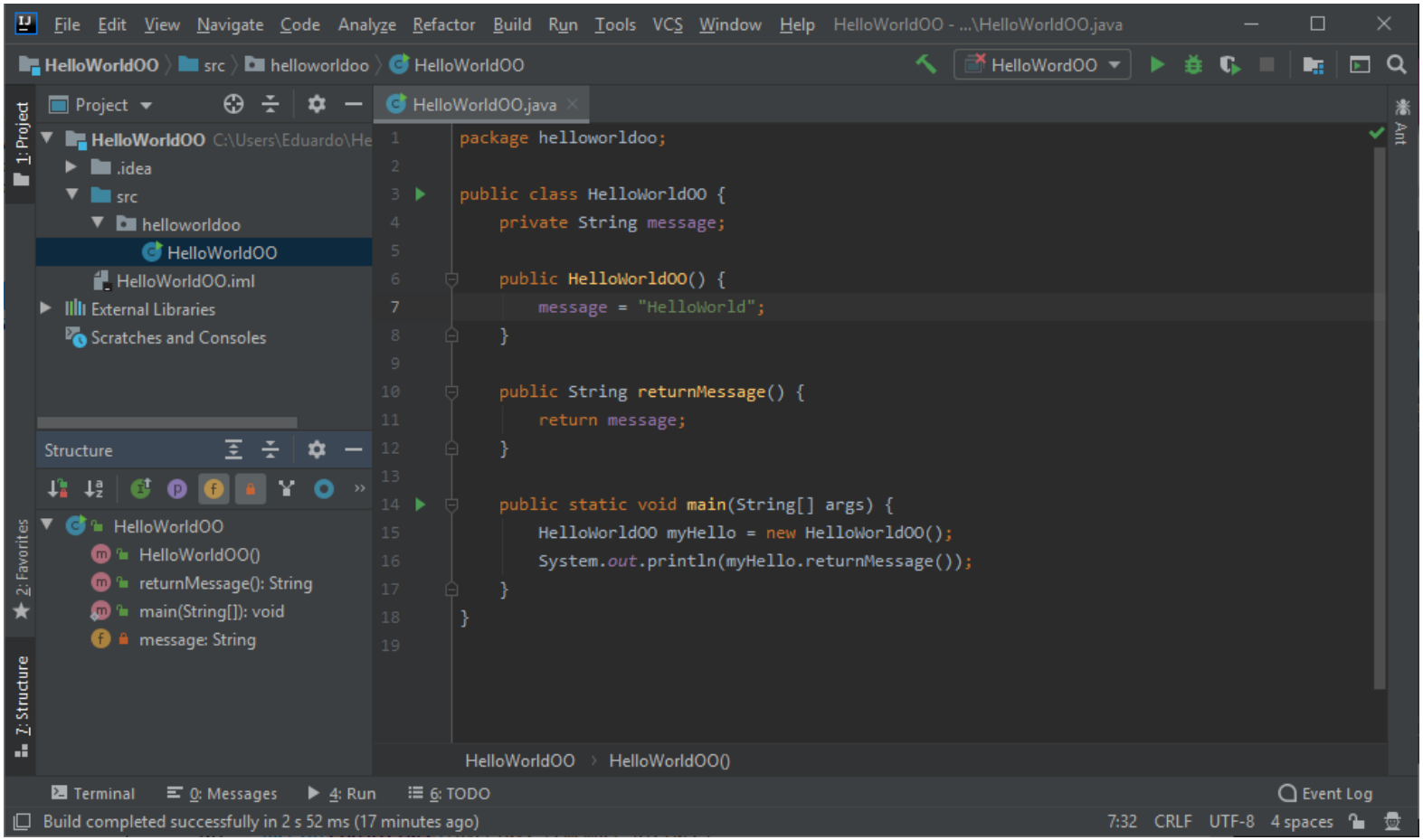
"Hello World" on IntelliJ IDEA

- The editor highlights in red the compilation errors as you write the code.



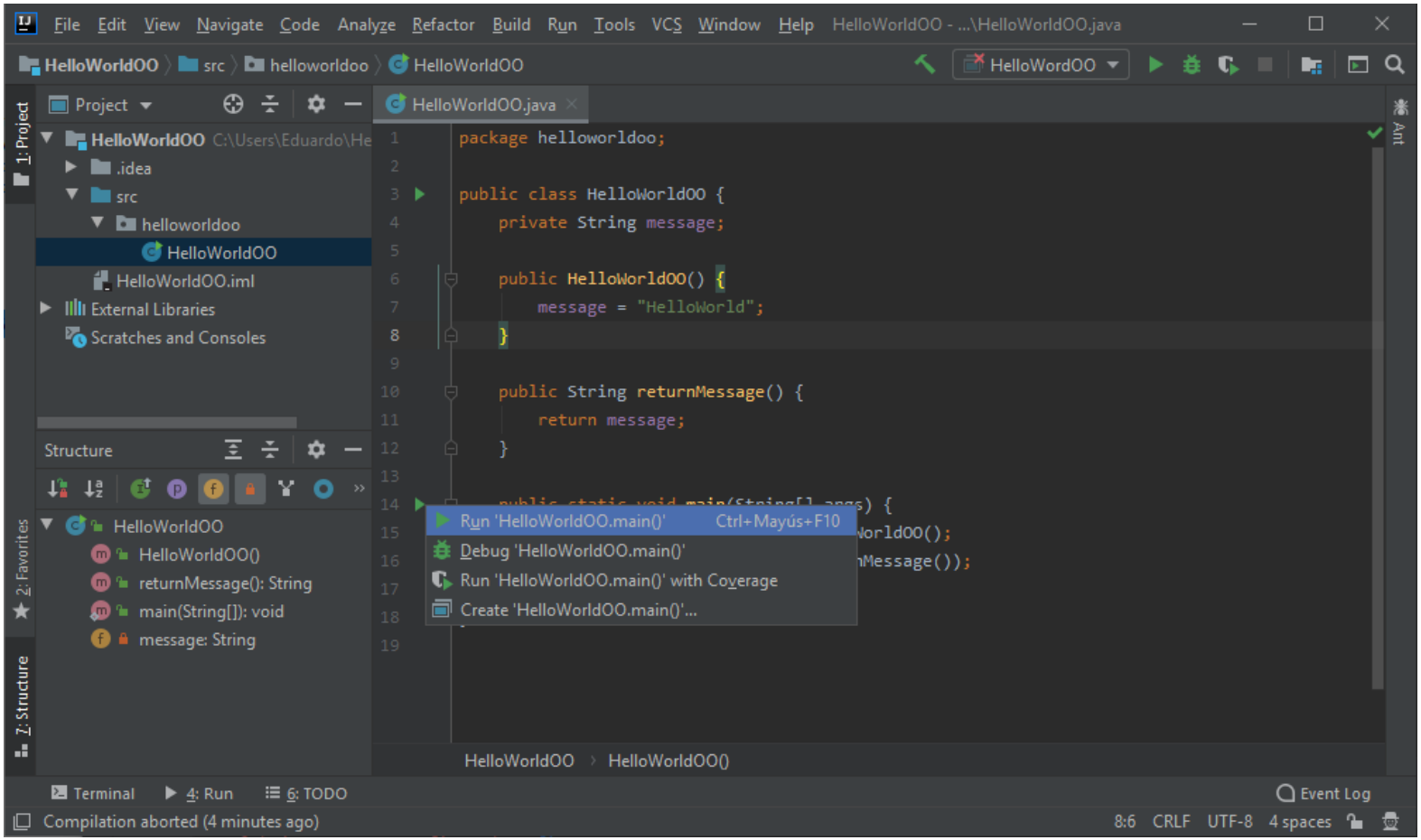
"Hello World" on IntelliJ IDEA

- The *Structure* window offers quick access to the contents of a class.



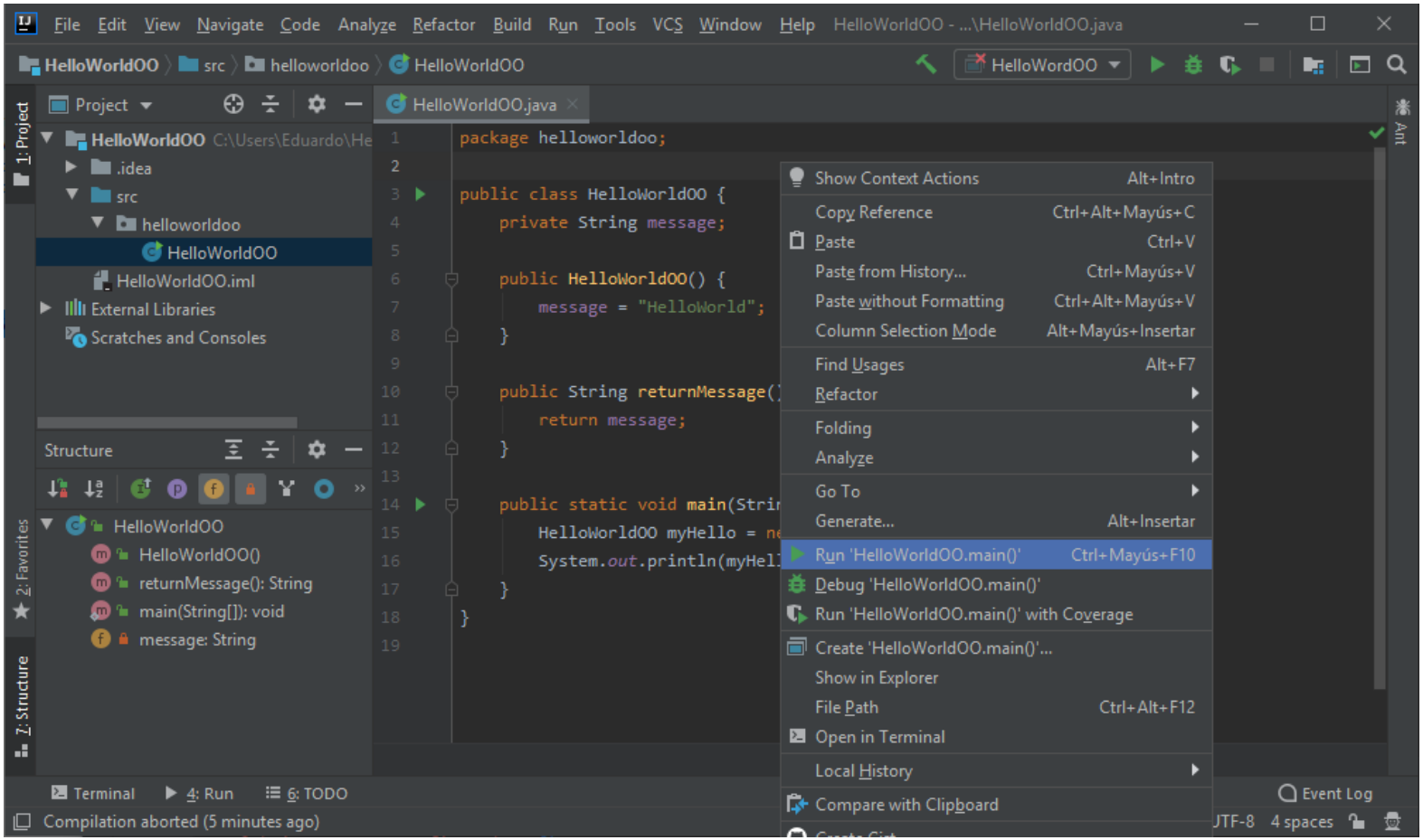
Compiling and running

- The code is being pre-compiled as we write it.
- To run a class with a `main` method, we can use the green triangle next to the `main`...



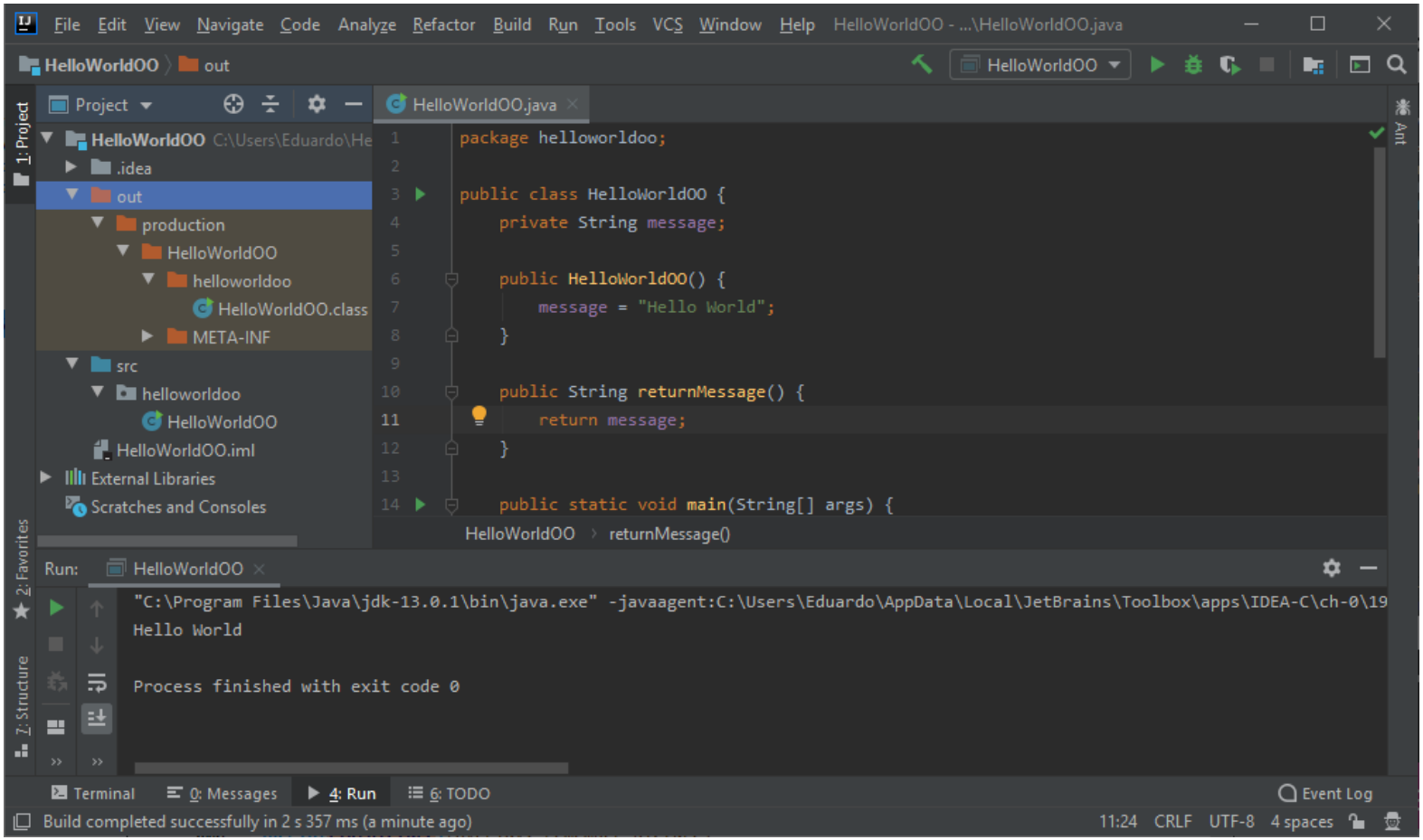
Compiling and running

- ... use the contextual menu when you right-click, or use the `Ctrl+Shift+F10` keyboard shortcut.



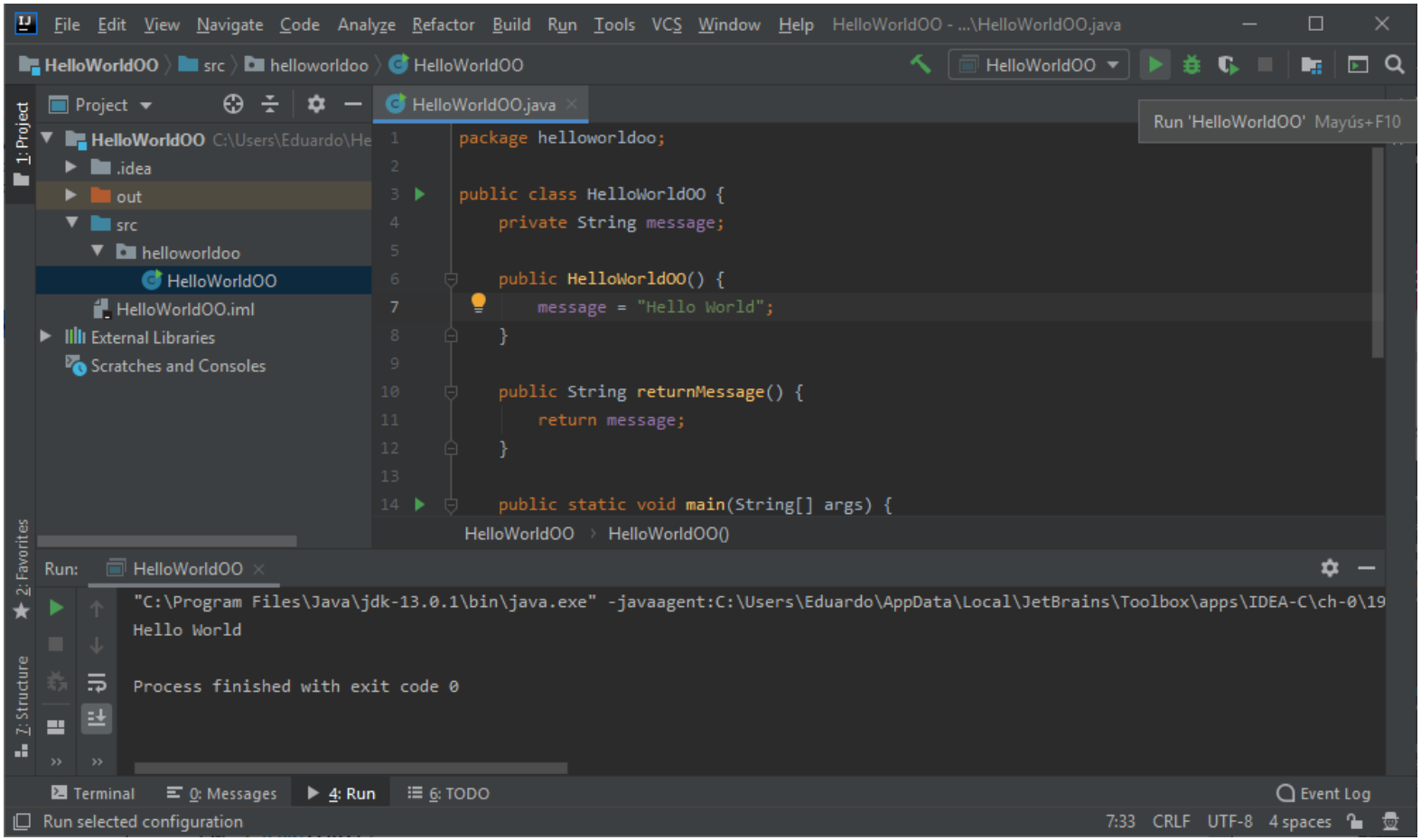
Compiling and running

- Running a project creates an `out` folder with the compiled `.class` files.
- The *Run* window is shown with the result of the execution.



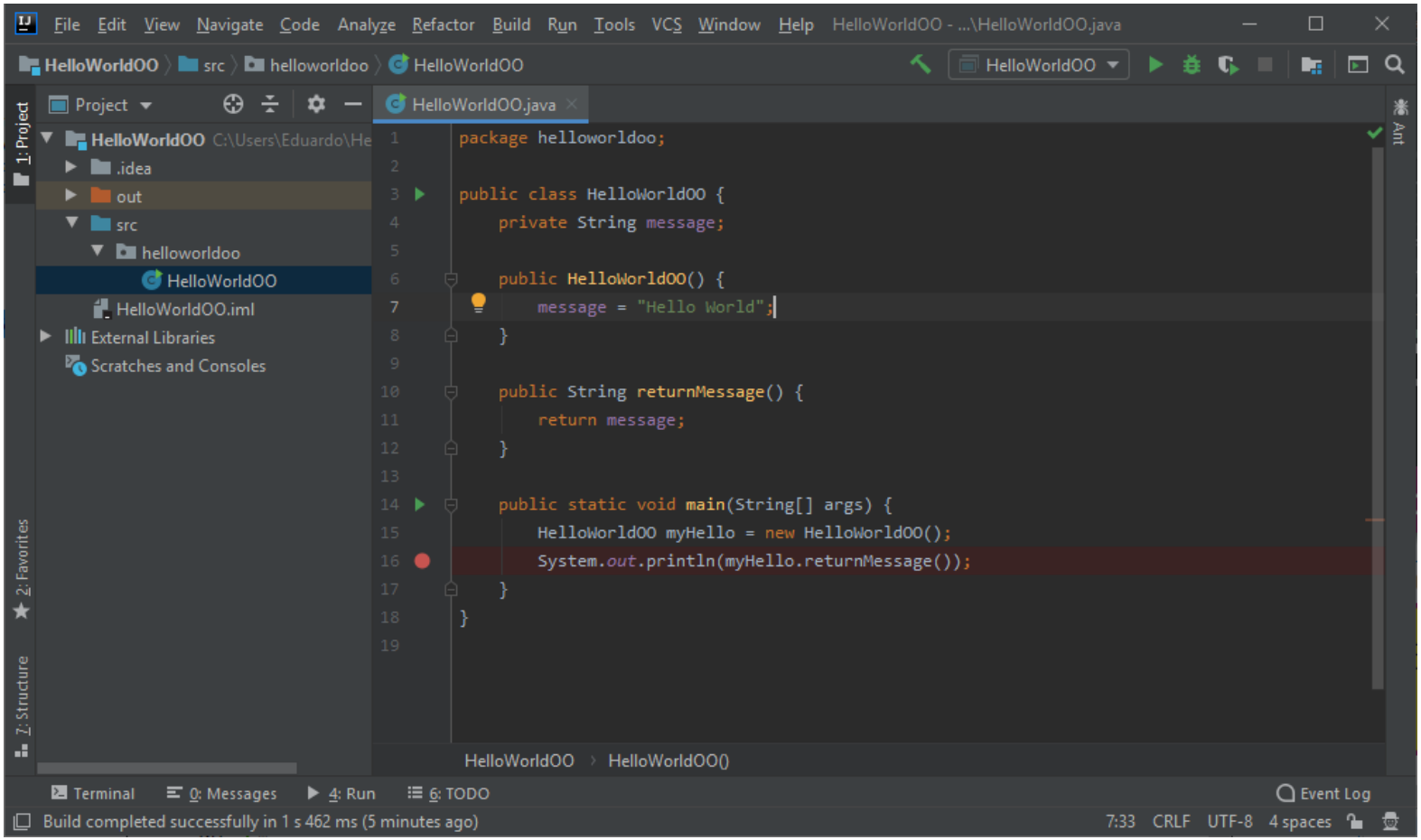
Compiling and running

- The first execution also creates a "*configuration*" that we can further customize or run again with `Mayús+F10` or the green triangle on the upper right corner.



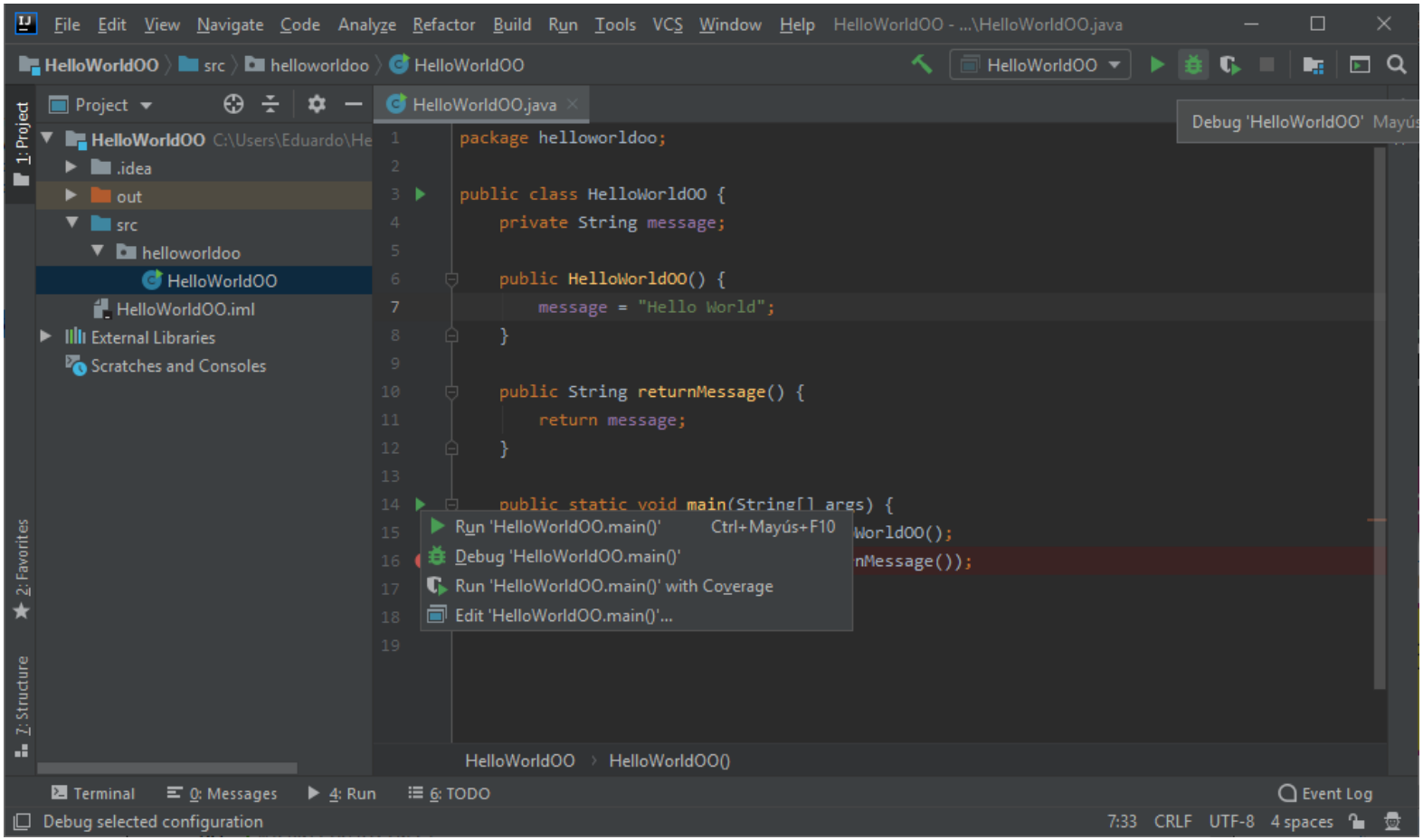
Debugging

- In order to (*debug*) code or execute it step by step, we must set a (*breakpoint*) by clicking next to the line number.



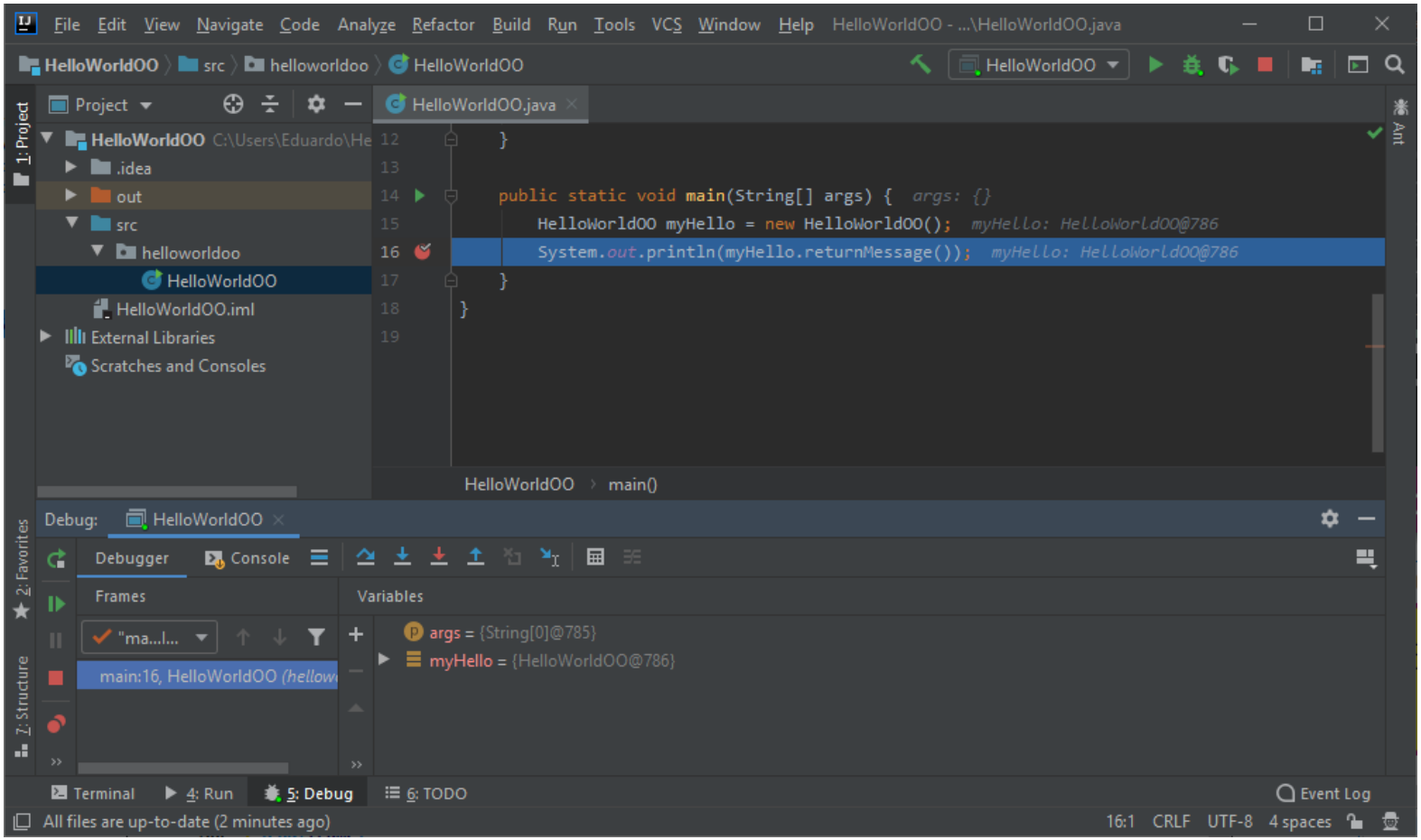
Debugging

- Clicking on the green *bug* icon, we start the debugging session.



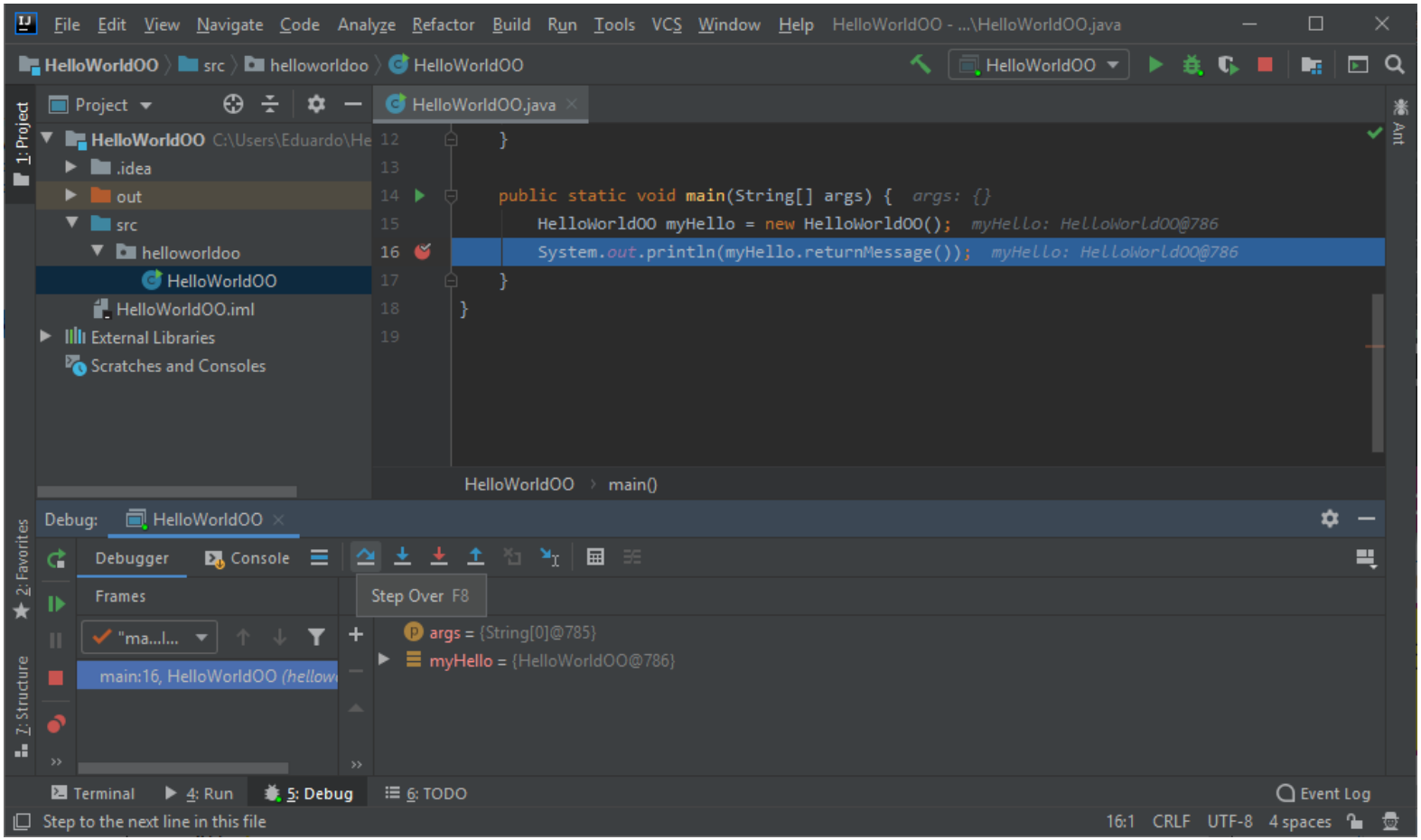
Debugging

- Execution stops at the *breakpoint*.
- A *Debug* window is shown, which lets us see the values of the variables and control the execution step by step.



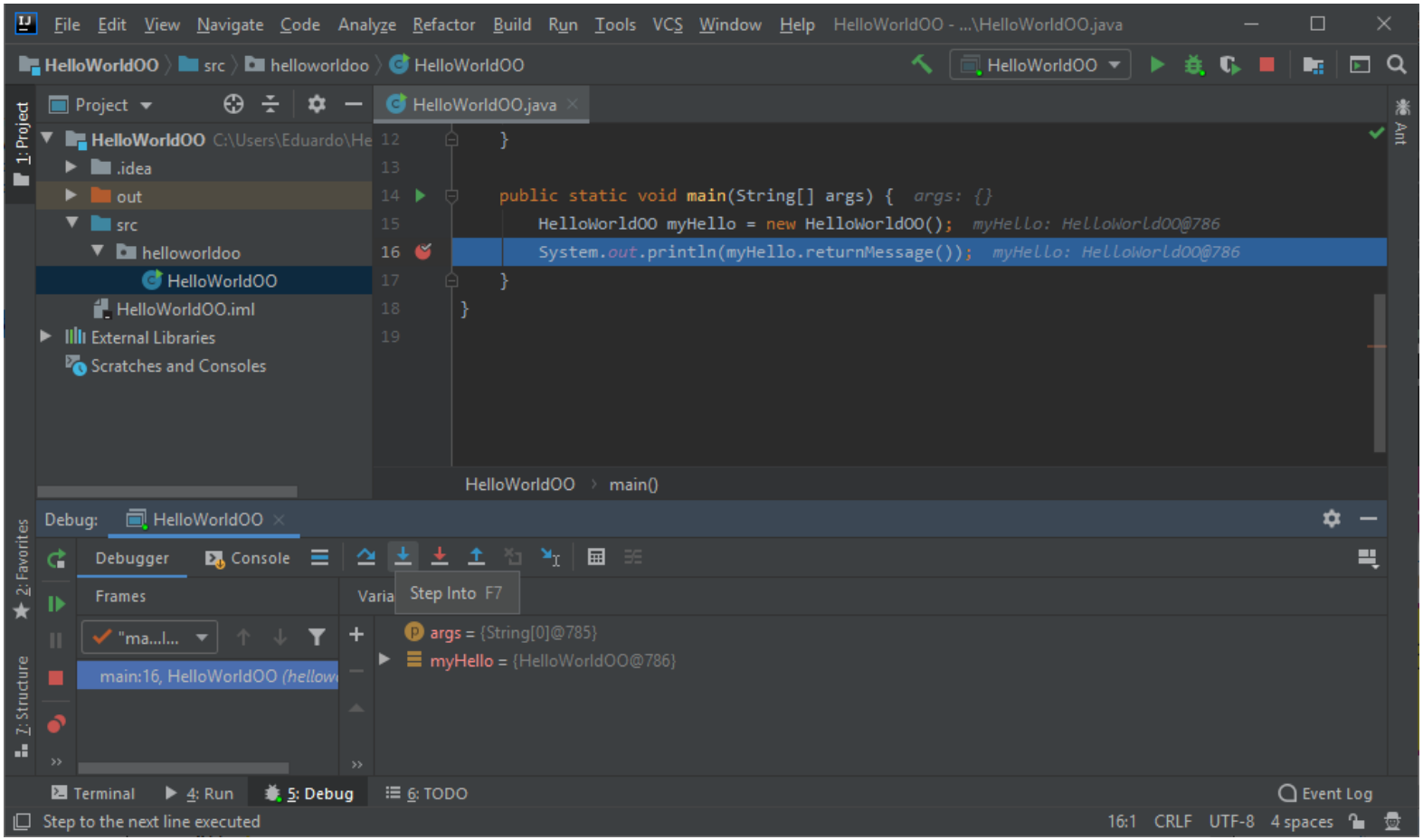
Debugging

- The execution is essentially controlled by the `F8` key or *Step Over*, which runs a method directly (not step by step)...



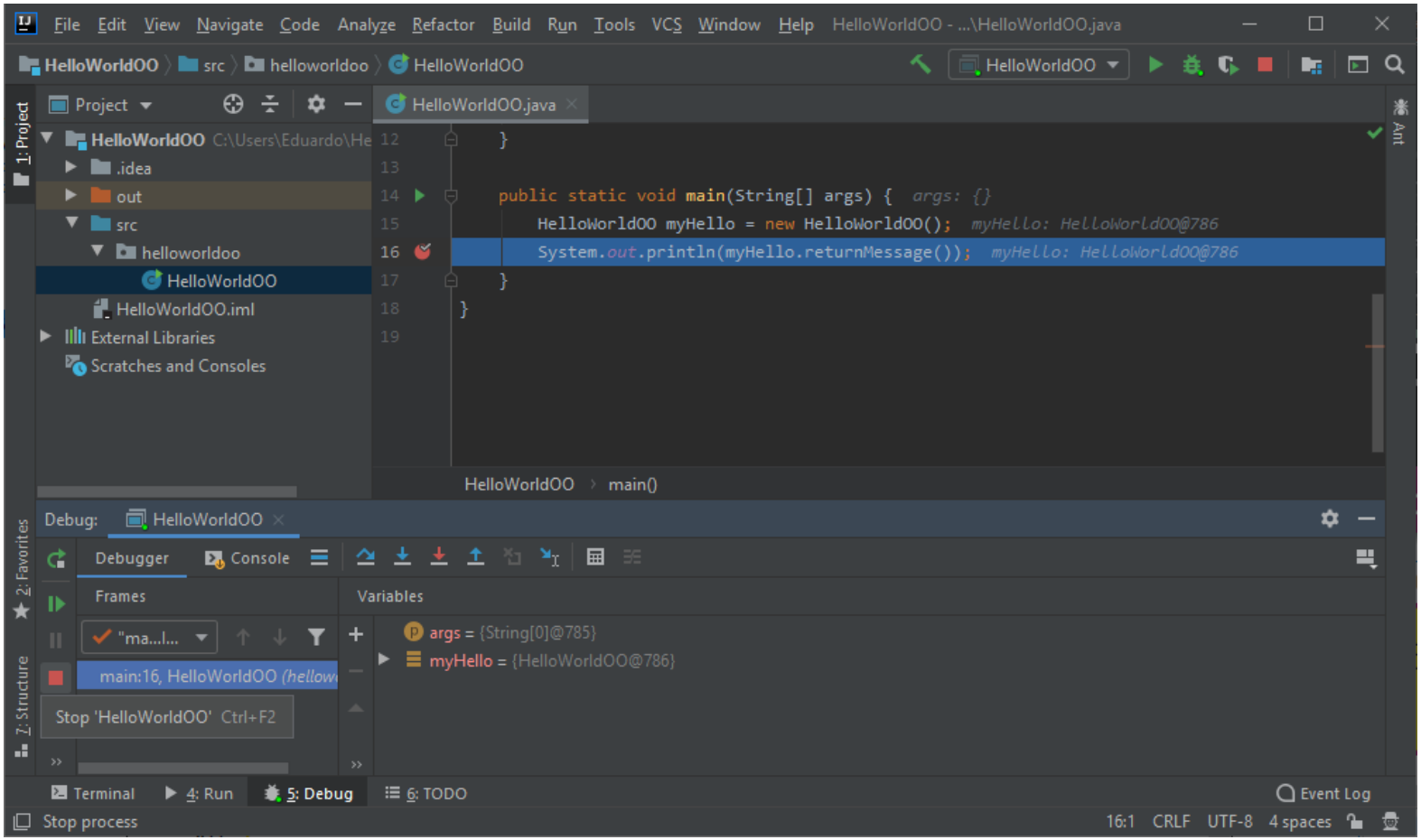
Debugging

- ... and using the `F7` key or *Step Into*, which executes a method step by step.



Debugging

- Debugging ends when the execution ends, or at any point if we click on the *Stop* button (`Ctrl+F2`).



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Naming conventions

- Java is case-sensitive.
- Identifiers typically use the **CamelCase** notation (i.e., no spaces between letters, mixes uppercase and lowercase).
- **Following these conventions is important (failing to do this may be penalized in your grade.)**.
- First letter is in uppercase for classes (e.g., `GeometricFigure`), and in lowercase for variables (e.g., `localVariable`).

Naming conventions

Indentifier	**Rule**	**Example**
Classes and interfaces	Nouns; CamelCase starting with a capital letter	`class ImageSprite`
Methods	Verbs; CamelCase starting with a lowercase letter	`runFast();` `getBackground();`
Variables	Nouns; CamelCase starting with a lowercase letter	`int widthFigure;` `int heightFigure;`
Constants	All caps (no CamelCase); underscores for spacing	`int MIN_WIDTH=1;` `int MAX_WIDTH=99`
Packages	Lowercase (no CamelCase); short names	`java.awt.datatransfer,` `java.util`

Primitive data types

Type	Size	Range	Format	Example
byte	8 bits	-128..127	Two's complement	`88`
short	16 bits	-32.768..32767	Two's complement	`-1578`
int	32 bits	$-2^{31}..2^{31}-1$	Two's complement	`423424`
long	64 bits	$-2^{63}..2^{63}-1$	Two's complement	`123456L`
float	32 bits	..[2]	IEEE 754	`126.5f`
double	64 bits	..	IEEE 754	`126.5d`
char	16 bits	0..65.535	Unicode	`'a'`
boolean	1 bit[3]	[true/false]	Binario	`false`

[2] Consult `https://docs.oracle.com/javase/specs/jls/se14/html/jls-4.html#jls-4.2.3`

[3] Real size not stated

Arrays

- Arrays are similar to those of C, but with significant differences.
- It is possible to declare an array and assign values immediately (as in C).
- But it is also possible to declare an array of unspecified size and specifying it later using the `new` operator.

Arrays

```
int[] numbers1 = {1, 4, 5, 2, 7}; // as in C

int[] numbers2; // not size declared
numbers2 = {8, 7, 2 ,9, 4}; // ERROR: array literals only in declaration
numbers2 = new int[5]; // allocating 5 positions with "0" values
System.out.println(numbers2[2]); // Prints 0
```

Arrays

- Arrays are pointers, so we can dinamically change the address they point to.
- We can use it to make them "grow" copying their data to bigger arrays (costly but useful).
- Accessing an index outside of the dimensions of the *array* causes a runtime error.

Arrays that *grow*

```
int[] numbers1 = {4, 9, 3, 6, 2}; // five positions
int[] numbers2 = new int[10];
for (int i=0; i<numbers1.length; i++) {
    numbers2[i] = numbers1[i]; // copy items
}
numbers1 = numbers2; // numbers1 points to numbers2
System.out.println(numbers1[0]); // 4
System.out.println(numbers1.length); // numbers1 has 10 positions

numbers1[15] = 42; // Throws ArrayIndexOutOfBoundsException
```

Matrices

- A matrix is actually an array of arrays.

Matrices

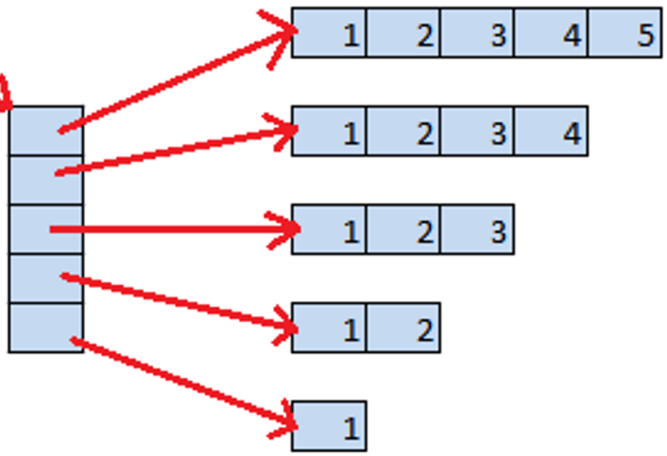
```
int[][] matrix = {{1, 2, 3},
                  {4, 5, 6},
                  {7, 8, 9}};
System.out.println(matrix[1][2]); // 6
```

	Column 0	Column 1	Column 2
Row 0	matrix[0][0] **1**	matrix[0][1] **2**	matrix[0][2] **3**
Row 1	matrix[1][0] **4**	matrix[1][1] **5**	matrix[1][2] **6**
Row 2	matrix[2][0] **7**	matrix[2][1] **8**	matrix[2][2] **9**

Matrices

- Unlike C, the rows do not necessarily have the same length.
- This results in *ragged arrays*.

```
int[][] triangleArray = {
        {1, 2, 3, 4, 5},
        {2, 3, 4, 5},
        {3, 4, 5},
        {4, 5},
        {5},
};
```



Strings

- Represents a sequence of characters.
- Can be easily instantiated using *literals*:
  `String s = "Hello World";`
- Immutable (once created, they cannot be modified).
- There are functions for obtaining a new String that is a modified version of another String. e.g. `toUpperCase()`.
- The mutable (modifiable) version of a String is represented by the class `StringBuilder`.

`String` and `StringBuilder`

```
String s1 = "Hello World"; // String literals
String s2 = s1.toUpperCase(); // s1 is immutable
System.out.println("s1 = " + s1); // s1 = Hello World
System.out.println("s2 = " + s2); // s2 = HELLO WORLD

StringBuilder sb = new StringBuilder("Hello");
sb.append(" World"); // StringBuilder is mutable
System.out.println("sb = " + sb); // "sb = HelloWorld";
```

Strings

- Special characters are added to `Strings` using *escape sequences*: tabulation (`\t`), new line (`\n`), double quotes (`\"`), single quotes (`\'`), backslash (`\\`), etc.
- These escape sequences can be avoided by using *text blocks* (Java 15) defined with triple quotation marks (whitespace to the left is ignored).

Escape sequences and text blocks

```
String query1 =
        "SELECT name, age\n" +
        "FROM EMP\n" +
        "WHERE name = \'John\'\n" +
        "\tAND age > 20";

String query2 = """
                SELECT name, age
                FROM EMP
                WHERE name = 'John'
                    AND age > 20
                """;
```

Operators

Type	**Operator**	**Description**
Binary arithmetic	+, -, *, /, %	
Unary arithmetic	++, - -	Increment, Decrement
Equality	==, !=	Equal, Not equal
Relational	>, >=, <, <=	
Conditional	&&, ||	Logical AND, Logical OR
Type comparison	instanceof	Whether an object is an instance of the class
Bitwise operation	&, |, ^, ~	AND, OR, XOR, NOT
Bit shifting	>>, <<, >>>	Right, Left, Unsigned right
Assignment	=, (operator)=	Basic, Cumulative

Control Structures

- The syntax for control structures is basically identical to that of C, with some later additions.
- If the block has only one instructions, curly brackets are not necessary (but they're recommended to avoid ambiguity and errors).

Conditional structures `if..(then)..else`

```
// if..(then)
if (isMoving) {
    currentSpeed++;
}

// if..(then)..else
if (isMoving) {
    currentSpeed++;
} else {
    currentSpeed = 0;
}
```

Control Structures

- The switch statement is similar in C and Java, but it's too error-prone (it's easy to forget the `break`) .

Traditional `switch` statement

```
switch (day) {
    case MONDAY:
    case FRIDAY:
    case SUNDAY:
        numLetters = 6;
        break;
    case TUESDAY:
        numLetters = 7;
        break;
    case THURSDAY:
    case SATURDAY:
        numLetters = 8;
        break;
    case WEDNESDAY:
        numLetters = 9;
        break;
    default:
        throw new IllegalStateException("Wat: " + day);
}
```

Control Structures

- Since Java 14, you can use `switch` statements that let you assign the result of a `switch` to a variable.
- They avoid the controversial `break`.
- They check at compile time if all possibilities are covered, making the `default` clause unnecessary.

Conditional structure with `switch` expressions

```
numLetters = switch (day) {
    case MONDAY, FRIDAY, SUNDAY -> 6;
    case TUESDAY                -> 7;
    case THURSDAY, SATURDAY     -> 8;
    case WEDNESDAY              -> 9;
};
```

Control Structures

- `While` loops are also similar to those of C.

`While` loops

```
// while loop
int count = 0;
while (count < 10) {
    count++;
}
System.out.println("count = " + count);

// do..while loop
count = 0;
do {
    count++;
} while (count < 10) ;
System.out.println("count = " + count);
```

Control Structures

- Java has two types of `for` statements. One is analogous to the C `for`.
- The other is called the `for-each` loop and is used to iterate through collections of objects ⇒ **Unit 3**.

`For` loops

```
// Classic for
for(int i = 0; i<10; i++) {
    System.out.println(i);
}

// For-each loop
int[] data = {0, 1, 2, 3, 4, 5};
for(int i : data) {
    System.out.println(i); // 0 1 2 3 4 5
}
```

Control Structures

- `break` and `continue` are also like in C.

For loops

```
System.out.println("break and continue");
for(int i = 0; i<10; i++) {
    if (i == 5)
        continue;
    if (i == 8)
        break;
    System.out.println(i); // 0 1 2 3 4 6 7
}
```

Control Structures

- Java also lets you use `break` and `continue` to jump to labeled locations.
- They're a controlled *goto* that jumps to a specified, non-arbitrary place when using nested loops.

For loops

```
int[][] arrayOfInts = {{ 32, 87, 3}, {12, 1076, 2000}, { 622, 127, 77}};
int i = -1;
int j = -1;
int searchFor = 12;
SEARCH: // LABEL
for (i = 0; i < arrayOfInts.length; i++) {
    for (j = 0; j < arrayOfInts[i].length; j++) {
        if (arrayOfInts[i][j] == searchFor) {
            break SEARCH; // Break the two loops
        }
    }
}
System.out.println("Found " + searchFor + " at [" + i + ", " + j + "]");
```

Comments

Comments

```
public class Class {
    /* Variables */
    private int x;
    private int y;
    /*
     * Methods
     * (reading and writing)
     */
    public int getX() { return x; }

    /**
     * Assigns the value i to the attribu
     * (if greater than zero)
     * @param i The value that will be assigned to x
     */
    public void setX(int i) {
        if (i < 0) {
            x = 0; // Negative values are not allowed
        } else {
            x = i; // i is assigned to x
        }
    }
}
```

Block comment, one line

Block comment, multiple lines

Javadoc comment

Line comment

Javadoc comments

- Javadoc comments start with `/**`
- Placed above the corresponding class or method.
- May include standardized tags (e.g., `@param`, `@return`, `@author`, etc.)
- The `javadoc` tool reads these comments and tags and generates HTML-formatted documentation (e.g., the Java API Specification at `https://docs.oracle.com/en/java/javase/11/docs/api/index.html`).
- Integrated Development Environments (IDEs) simplify the task of writing Javadoc comments.
- **Javadoc comments are not mandatory in this course, but we expect regular comments in the code, especially to explain complicated fragments..**

Practice 1: Introduction to Java

Software Design (614G01015)

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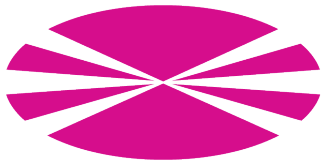

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