The LifeCycle of a Java Program

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SOURCE CODE

1

```
public class MyClass {
public void display() {

}
}
```

Create a Java scource code file & write code with the help of class, methods etc. Save the file with .java extension

COMPILE

2

By using javac command, the source code will be compiled and validated for any syntax errors. With the help of JDK we can run javac command

BYTE CODE

3

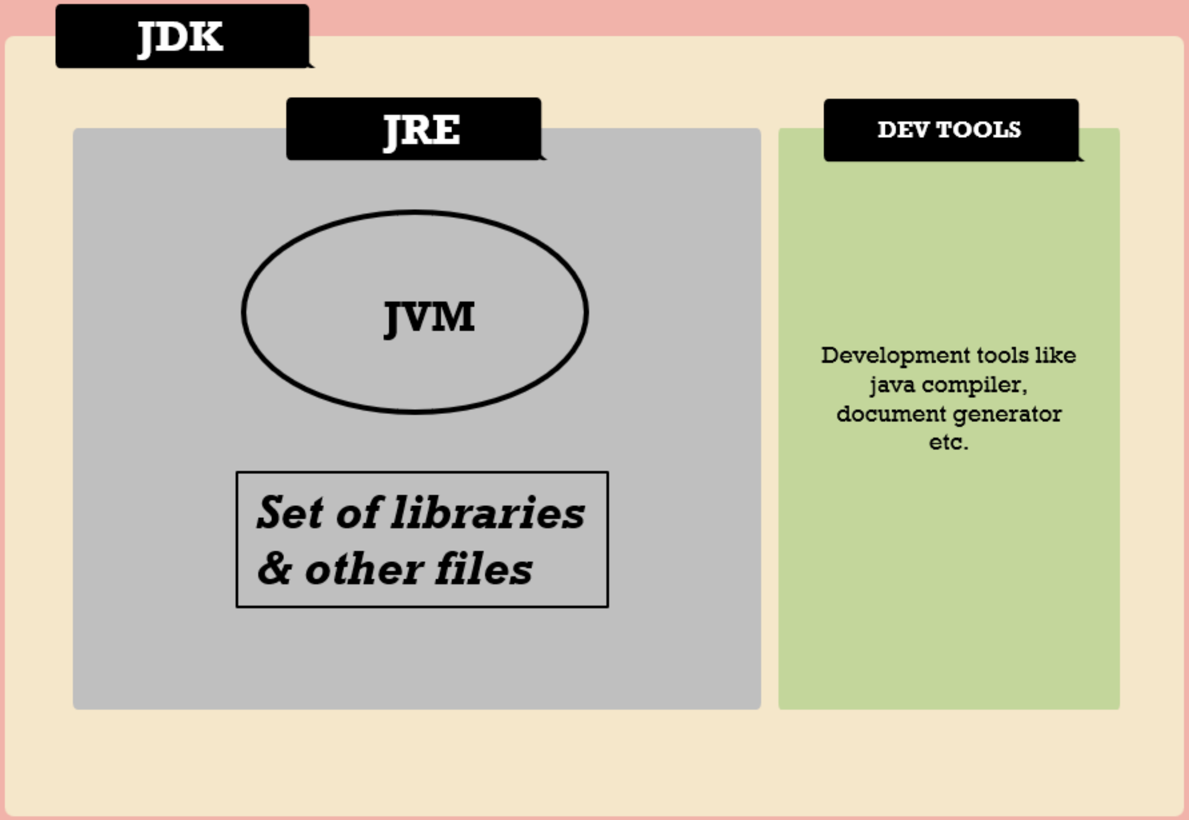
If the compilation successful, a new file with .class extension will be generated. It contains bytecode. The format of bytecode is always the same, regardless of what type of machine it was created on.

OUTPUT CODE

4

JVM inside a machine will read the byte code and translate the same into OS specific machine or executable output code. The JVM is an essential part of the Java platform, which includes the JDK, the JRE, and other tools and libraries.

What is JDK, JRE, JVM ?


JDK
JRE
DEV TOOLS
JVM
Set of libraries & other files
Development tools like java compiler, document generator etc.

Java Development Kit (JDK)

A collection of programs (tools and utilities), including the Java Runtime Environment (JRE), an interpreter/loader (Java), a compiler (javac), an archiver (jar), a documentation generator (Javadoc), and other tools needed in Java development.

Java Compiler

A program that can read a text written in the Java programming language and translate it into bytecode that can be interpreted by the Java Virtual Machine (JVM) into binary code that is executable by a computer

Java Runtime Environment (JRE)

The Java Runtime Environment provides the minimum requirements for executing a Java application; it consists of the Java Virtual Machine (JVM), core classes, and supporting files. Usually developers only need JDK & all other people install JRE alone

Java Virtual Machine (JVM)

A program that reads bytecode of the compiled Java program and interprets it into OS specific binary code that is executable by a computer.

⚠

JDK = JRE (JVM + LIBRARIES) + DEV TOOLS

JRE = JVM + LIBRARIES

From Java 9, the JRE is no longer offered. Only the JDK is offered. This is to reduce the java installation size by removing duplicate files.

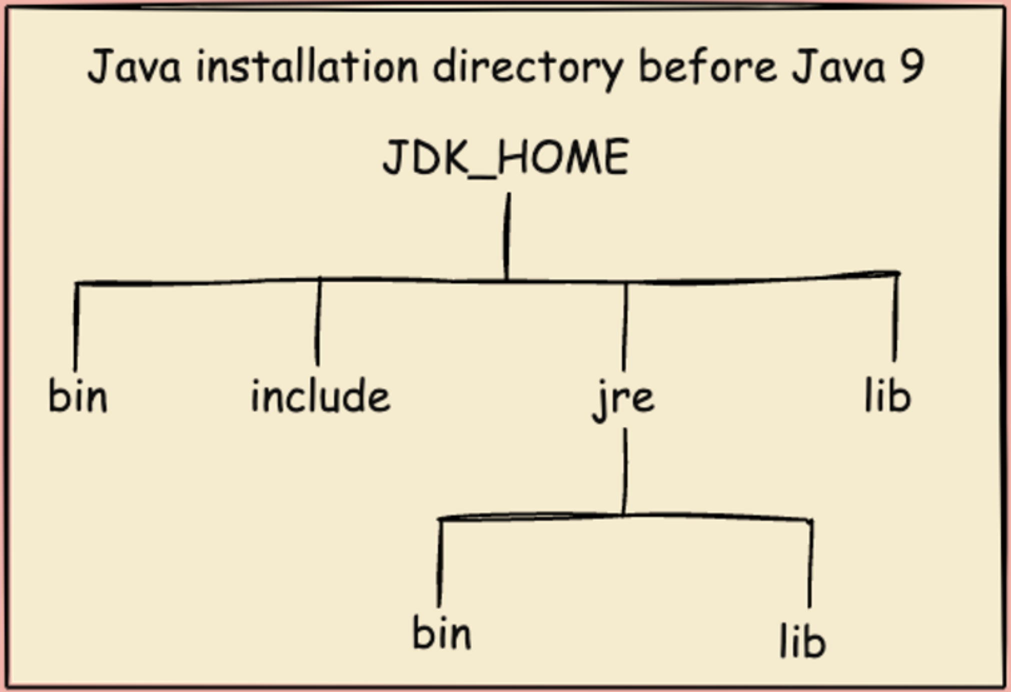
What is JDK, JRE, JVM ?

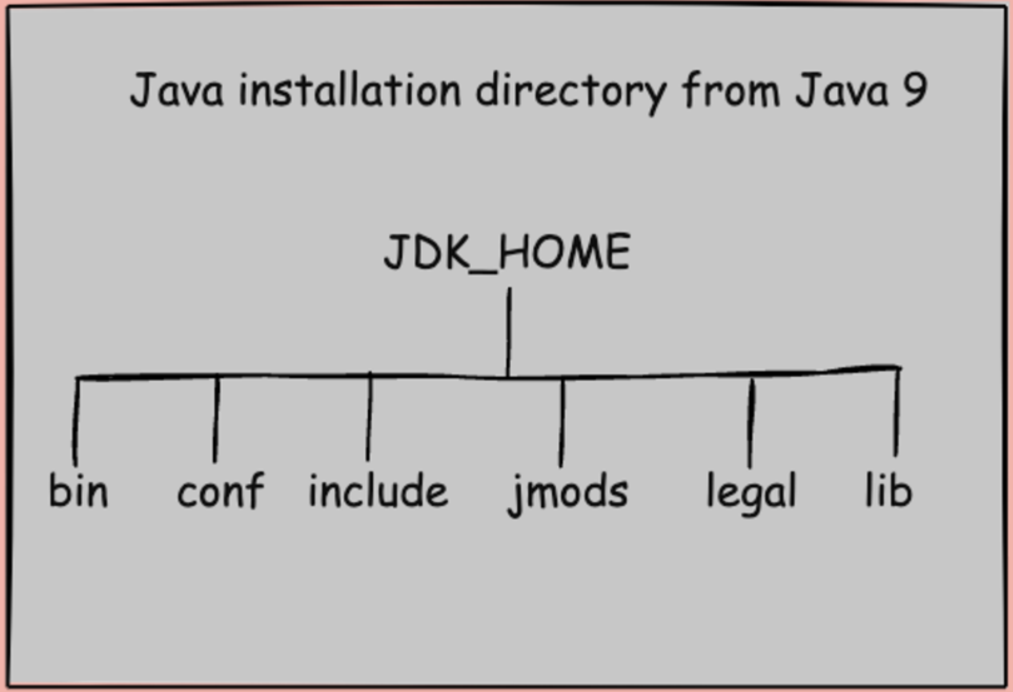
Before JDK 9, the Java Development Kit (JDK) build system generated two distinct types of runtime images: a Java Runtime Environment (JRE) and a Java Development Kit (JDK). The JRE constituted a comprehensive implementation of the Java SE platform, while the JDK included both an embedded JRE and additional development tools and libraries. Users were given the flexibility to install either the standalone JRE or the JDK, which inherently included an embedded JRE.

With the advent of Java 9, a substantial reorganization took place in the directory structure of the JDK. Notably, the traditional dichotomy between a JDK and a JRE was eliminated. This restructuring led to a flattened directory hierarchy for the JDK, thereby streamlining the organization of its components. The distinctions between a JDK with an embedded JRE and a standalone JRE were removed, simplifying the deployment and usage of Java runtime environments.

If needed, Organizations or Developers can build their own custom JRE using jlink option introduced in Java 9.

Below are the JDK folder structure differences from before Java 9 and after Java 9,





The LifeCycle of a Java Program

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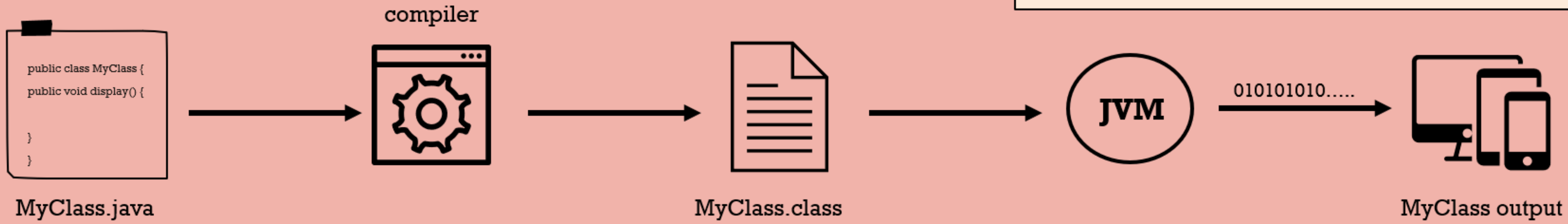
What makes Java is a platform independent is JVM. Every computer will install JDK based on their OS & in the same process they get a OS specific JVM & it takes care of converting the byte code to specific OS executable code



Java is a platform independent language & it follows the principle " Write Once, Run Anywhere (WORA) ". It means the same compiled Java code developed by developer can be executed in different machines of various OS like windows, Linux, Mac etc.

Usually the developers responsibility is to write a valid source code, compile & test the program. So the java source code & compiled .class file will be same in all the machines.

The LifeCycle of a Java Program

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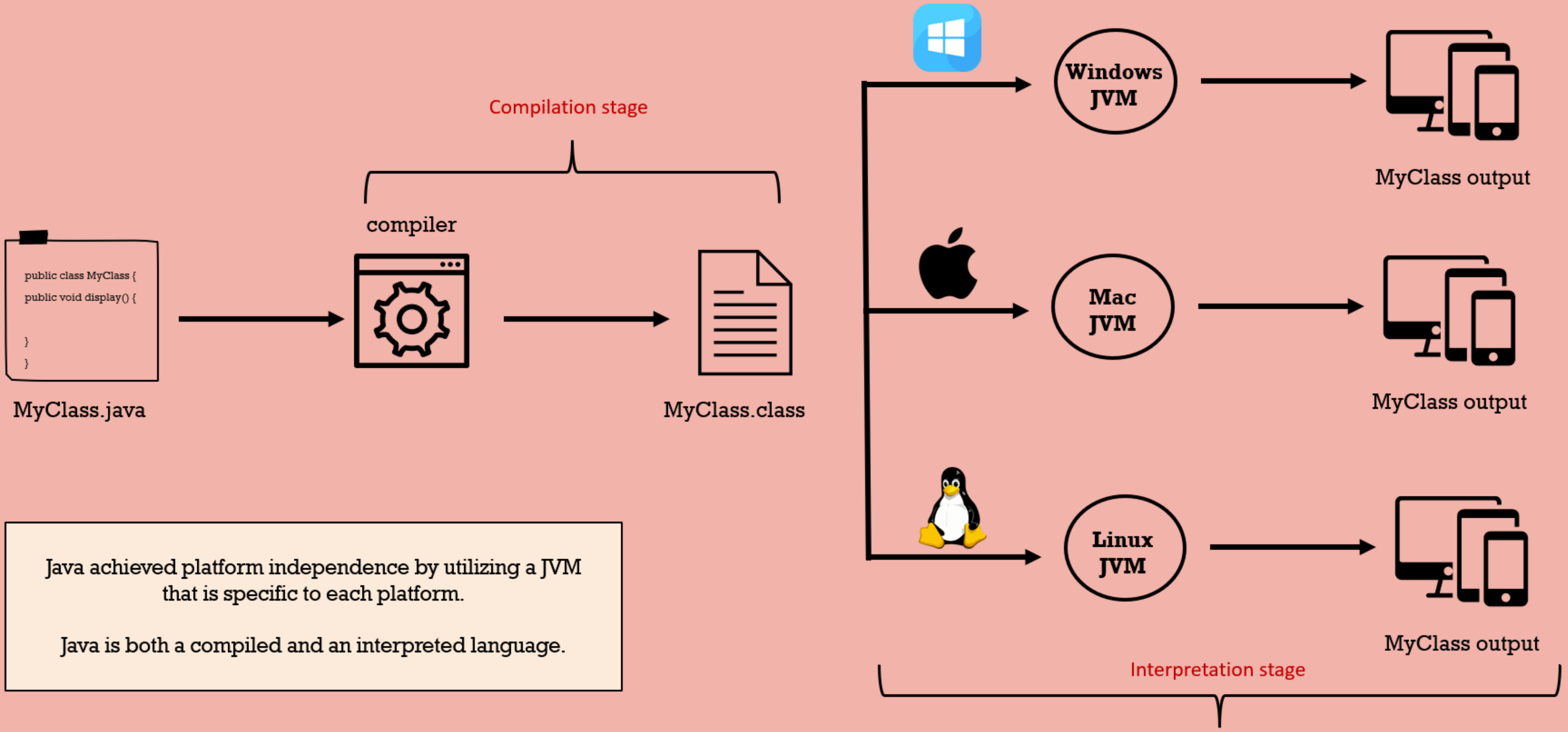

Java achieved platform independence by utilizing a JVM that is specific to each platform.

Java is both a compiled and an interpreted language.

The LifeCycle of a Java Program

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What happens in compilation stage ?

Java source code undergoes a transformation into basic binary instructions. Nevertheless, while C or C++ source code is translated into native instructions tailored for a specific processor model, Java source code is compiled into a standardized format—comprising instructions intended for the virtual machine, commonly referred to as bytecode.

What happens in interpretation stage ?

When you run a Java program, the JVM reads the bytecode instructions line by line and interprets them. The JVM's interpreter component translates each bytecode instruction into machine-specific code or actions, which are executed by the underlying hardware. This allows Java programs to be executed on different computer architectures without modification, as long as there is a JVM available for that platform.

Dynamic or JIT Compilation

Java goes a step further to optimize performance. It incorporates a feature known as "dynamic" or "just-in-time" (JIT) compilation. With JIT compilation, the JVM can translate bytecode into native machine code on-the-fly as the program runs. JIT compilation is a significant performance enhancement. Instead of interpreting bytecode line by line, the JVM translates frequently executed portions of bytecode into native machine code. This native code can run much faster than interpreted bytecode because it's specific to the host system's architecture. This dynamic compilation happens at runtime, so only the parts of the code that are actively used get compiled to native code, reducing overhead.

JIT compilation analogy

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Imagine you have a big book of instructions, but you can't read it directly. Instead, you have to interpret it line by line, telling yourself what to do next. This is what the Java Virtual Machine (JVM) does when it runs a Java program.

However, if you read the book many times, you can start to remember what to do without having to interpret the instructions every time. This is what the JIT compiler does. It compiles the Java bytecode into machine code that the CPU can understand directly.

The JIT compiler doesn't compile all of the bytecode at once. Instead, it compiles the methods that are used most often. This means that the first time you run a Java program, it may start slowly. But as you use the program more and more, the JIT compiler will compile more of the bytecode, and the program will run faster.

Here is a simple analogy that may help you understand JIT compilation:

Imagine you are a child, and your mother gives you a list of chores to do. You could read the list and do each chore one at a time. But if you are smart, you will start to group the chores together so that you can do them more efficiently. For example, you might group together all of the chores that require you to go to the kitchen, like setting the table and putting away the dishes.

The JIT compiler does something similar. It groups together the Java bytecode that is used most often and compiles it into machine code. This means that the CPU can execute the code more efficiently.

JIT compilation is one of the reasons why Java programs can run so fast, even though they are not compiled into machine code before they are executed.

Q & A

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Is Java language platform dependent or independent ?

Java is a platform-independent language, meaning that code written in Java on a Windows operating system can be executed on a Mac or Linux operating system, and the resulting output will be the same.

Is Java software platform dependent or independent ?

Java software is platform dependent due to the platform-dependent nature of the JVM, which is separately available for each operating system.

Is JVM installed automatically with OS ?

No, JVM is not installed automatically with the operating system. It needs to be separately installed on the system in order to run Java programs.

What are important components of Java installation ?

JDK (Java Development Kit) - It is a software development kit that provides all the tools necessary to develop, compile, and run Java programs. It includes the Java compiler, Java runtime environment (JRE), and other development tools such as debuggers and documentation.

JVM (Java Virtual Machine) - It is an abstract machine that provides a runtime environment in which Java programs can run. JVM interprets the compiled Java bytecode and provides a layer of abstraction between the code and the underlying operating system. JVM is platform-dependent and must be installed separately on each operating system.

JRE (Java Runtime Environment) - It is a subset of the JDK that includes only the JVM and other components required to run Java applications. By default, JRE is no more available as a separate option from JDK 9.

Java program code structure

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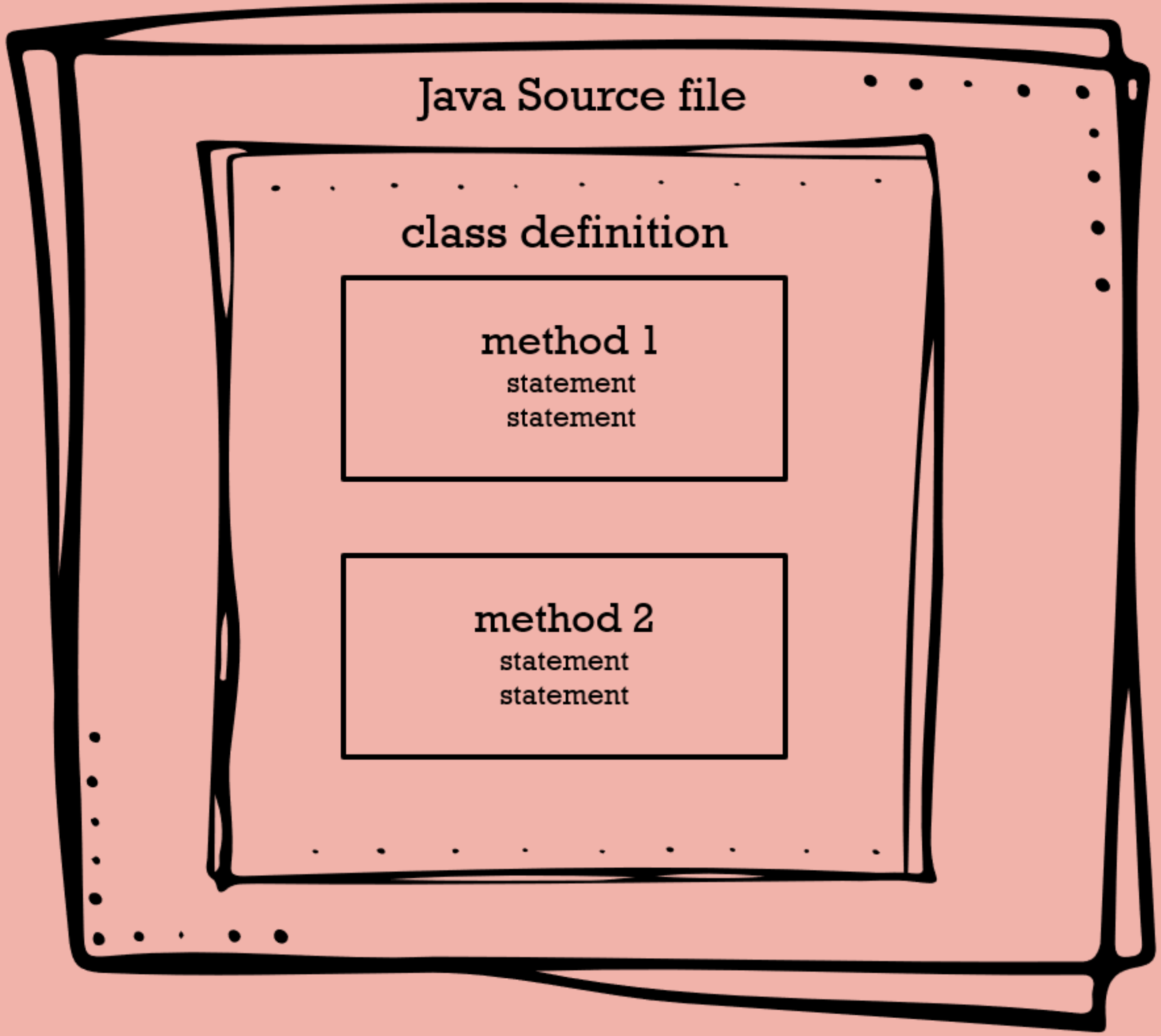

- In a java source file, define a class.
- Inside a class, define methods.
- Inside a method, write java statements.

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Java program code structure

What goes in a source file?

A source code file (with the .java extension) typically holds one class definition. The class represents a piece of your program. The class must go within a pair of curly braces.

```
public class Vehicle
{


}
```

Vehicle.java class

What goes in a class?

A class has one or more methods. In the Vehicle class, the move method will hold instructions on how the Vehicle should move. Your methods must be declared inside a class & should also have pair of curly braces.

```
public class Vehicle
{
      void move() {

      }

}
```

move method inside a class

What goes in a method?

Within the curly braces of a method, we can write instructions on how that method should be performed. Method code is basically a set of java statements

```
public class Vehicle
{
      void move() {
          statement1;
          statement2;

      }
}
```

statements

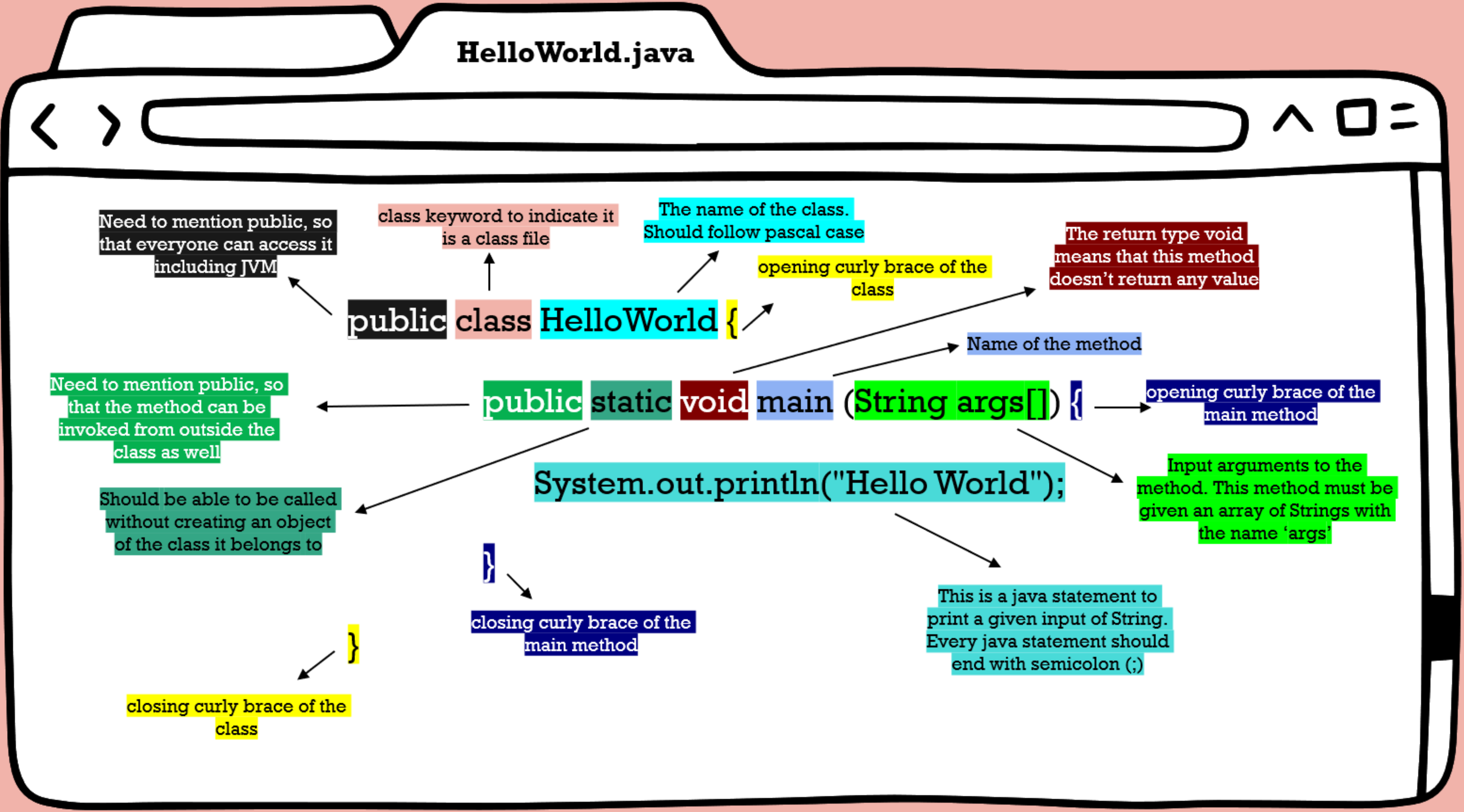
How JVM knows where to start ?

Upon startup, the JVM scans for the class specified in the command line. Following this, it seeks a particular method that is written in a prescribed manner, as shown below. The code enclosed within the curly braces { } of the main method is then executed by the JVM. It is necessary for every Java application to contain at least one class with a main method (not one main per class; just one main per application)

```
public static void main (String[] args)
{

    // your code
}
```

Let's write first Java class



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

Need to mention public, so that everyone can access it including JVM

class keyword to indicate it is a class file

The name of the class. Should follow pascal case

opening curly brace of the class

The return type void means that this method doesn't return any value

Name of the method

Need to mention public, so that the method can be invoked from outside the class as well

opening curly brace of the main method

Input arguments to the method. This method must be given an array of Strings with the name 'args'

Should be able to be called without creating an object of the class it belongs to

This is a java statement to print a given input of String. Every java statement should end with semicolon (;)

closing curly brace of the main method

closing curly brace of the class

Commands to compile & run Java program

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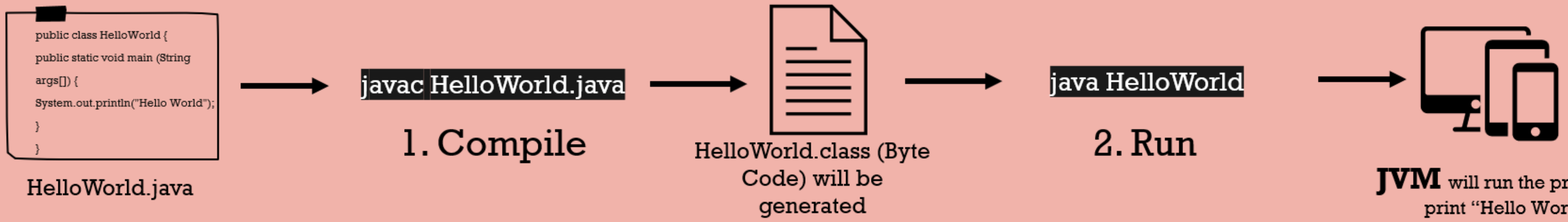
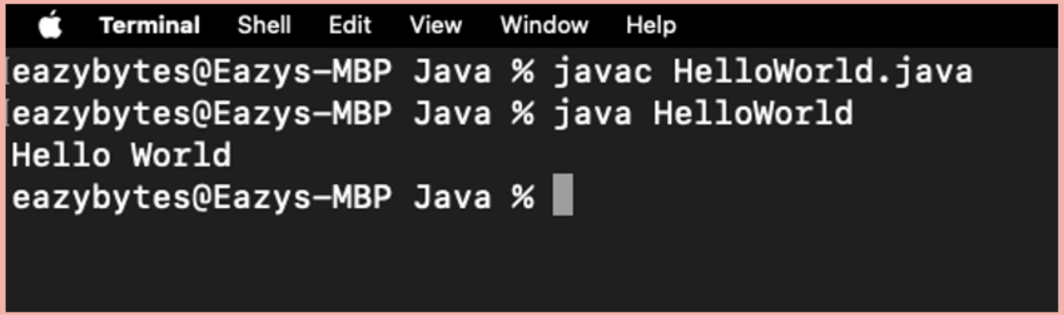
Compiling & running a java program means telling the Java Virtual Machine (JVM) to "Load the class, then start executing its main() method. Keep running 'til all the code in main is finished." For the same we need to run few commands with the help of a window/mas/linux OS terminal. Offcourse they are more automatic/advance ways using the products like IDE which we are going to learn in coming sections. For now let's try to learn the basics.



public class HelloWorld {
public static void main (String args[]) {
System.out.println("Hello World");
}
}
HelloWorld.java
javac HelloWorld.java
1. Compile
HelloWorld.class (Byte Code) will be generated
java HelloWorld
2. Run
JVM will run the program & print "Hello World"

javac: This reads a .java file, compiles it, and creates .class file post validating the java syntaxes



```
eazybytes@Eazys-MBP Java % javac HelloWorld.java
eazybytes@Eazys-MBP Java % java HelloWorld
Hello World
eazybytes@Eazys-MBP Java %
```

java: This executes a .class file with the help of JVM

From Java 11

Launch Single-File Source-Code Programs (Java 11)
Launch Multi-File Source-Code Programs (Java 22)

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Starting from Java 11, it's possible to run Java programs directly from a single file without the need for compilation. This feature is referred to as "single-file source-code programs" or simply "single-file programs" in Java.

The same feature is extended in the form of "multi-file source-code programs" which will allow developers to run a Java program that has logic spread across multiple source code files.

Before Java 11

Hello

```
public class  Hello {

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

}
```

Compilation -> javac Hello.java
Execution -> java Hello

From Java 11

Hello

```
public class  Hello {

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

}
```

Compilation & Execution -> java Hello.java

But this feature works only if you have all your code with in a single source file

From Java 22

Hello

```
public class  Hello {

  public static void main(String[] args)
{
     Greetings.sayHello();
  }

}
```

Greetings

```
public class  Greetings {

  public static String sayHello() {
     System.out.println("Hello World...");
  }

}
```

Compilation & Execution -> java Hello.java

Though Hello has dependency on Greetings, from Java 22, we can execute the code as it supports multi-file source-code programs

From Java 25

Compact Source Files and Instance Main Methods

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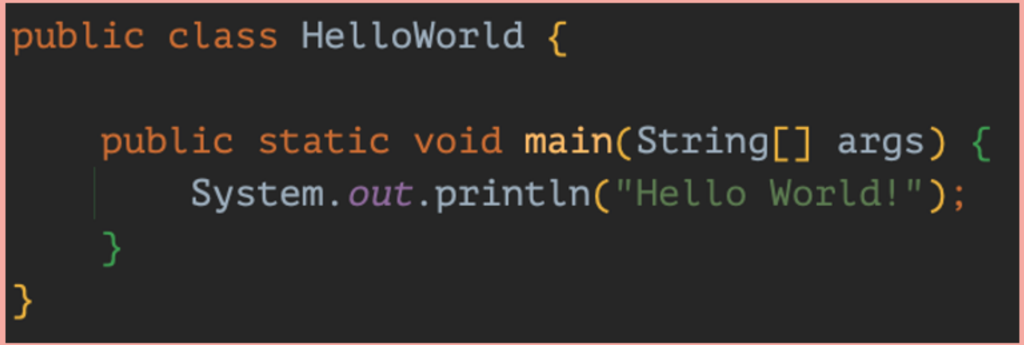
The Java team is making the language more beginner-friendly with features like Compact Source Files and Instance Main Methods.

Beginners can now start coding without first learning advanced Java concepts, while experienced programmers can quickly prototype ideas with less boilerplate. The code can then grow and evolve as skills and applications expand.



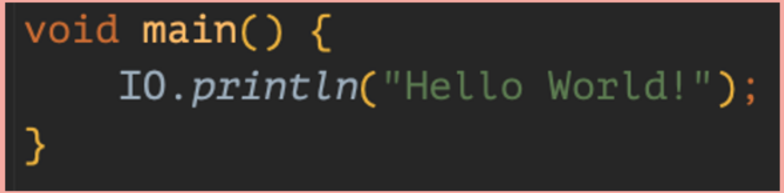
```java
public class HelloWorld {

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

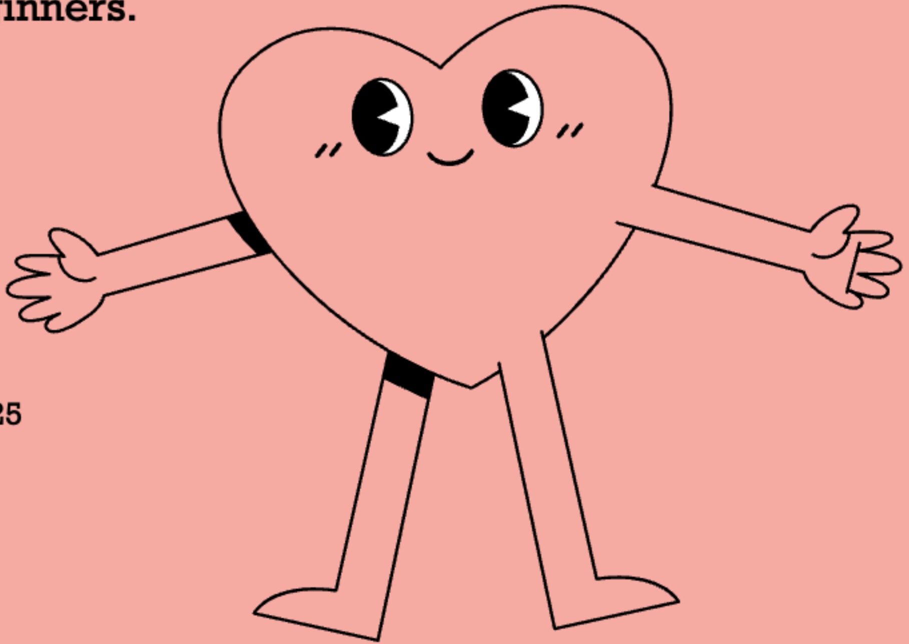
Classic HelloWorld Program before Java 25

A key advantage of the minimal main() method without an explicit class is that the code stays concise and focused, introducing fewer concepts or keywords that might otherwise overwhelm beginners.

Equivalent Compact code from Java 25



```java
void main() {
    IO.println("Hello World!");
}
```



From Java 25

Compact Source Files and Instance Main Methods

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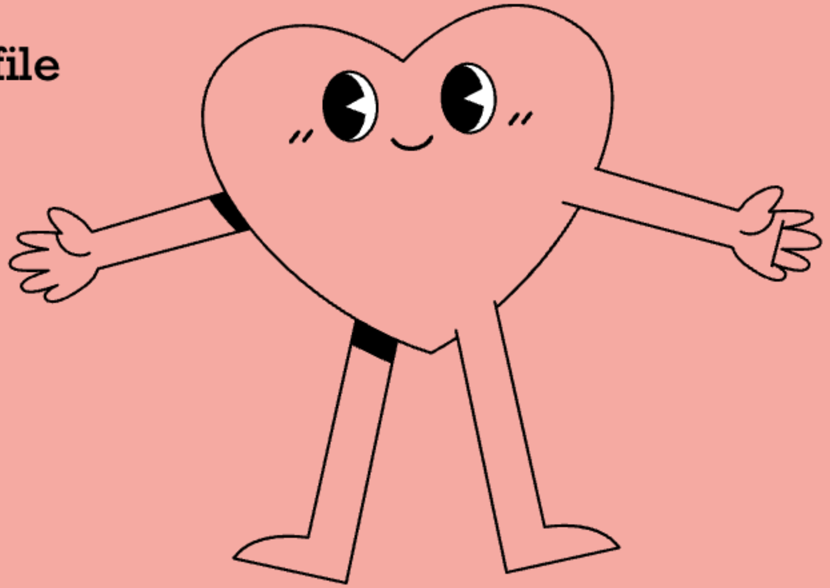
The term instance main() method refers to a main method declared without the static keyword. Traditionally, main was defined as static so it could run without creating an object of its class. In this new approach, main is treated as an instance method, meaning it no longer requires the static modifier.

Different Variations of the main method allowed in the Compact Source file

```
void main() {}
public void main() {}
static void main() {}
public static void main() {}
public void main(String args[]) {}
public static void main(String args[]) {}
```



When a class has both a main(String[] args) method and a no-argument main() method, the JVM launcher gives preference to the main(String[] args) method as the program's entry point.

Bye Bye jShell & Hi to **IDE**(Integrated Development Environments)

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IDEs (Integrated Development Environments) are software applications that provide developers with a comprehensive set of tools to write, test, and debug code in one place. Here are some reasons why IDEs like IntelliJ are essential for developers:

Increased productivity
IDEs offer developers a range of features such as code completion, refactoring, debugging, and testing, which save a lot of time and effort. With an IDE, developers can write, test, and debug their code much faster, leading to increased productivity.

Integration with tools and frameworks
IDEs provide integration with popular tools and frameworks, such as Git, Maven, and Spring, making it easier for developers to work with these technologies.

Better code quality
IDEs provide developers with features like syntax highlighting, code formatting, and error highlighting, which help identify and fix errors and inconsistencies in the code. This results in code that is easier to read and maintain, leading to better overall code quality.

Collaboration
IDEs provide collaboration features that allow multiple developers to work on the same codebase simultaneously, making it easier to manage code changes and track progress.

Various famous IDEs available for Developers

IntelliJ IDEA

Eclipse

Visual Studio code

NetBeans

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Why IntelliJ IDEA ?

1 Undoubtedly, IntelliJ IDEA is the preferred IDE for software developers. Its design prioritizes efficiency and intelligence, providing a seamless workflow experience for designing, implementing, building, deploying, testing, debugging & refactoring. With a vast array of features and a wide selection of plugins that can be integrated into the editor, IntelliJ IDEA offers developers a comprehensive & powerful toolset.

2 One of the things that stands out to me about IntelliJ IDEA is its ability to provide helpful and intelligent suggestions. These suggestions go beyond just technology integrations and productivity shortcuts, as they offer guidance on best practices for naming conventions and instructions on migrating to new Java features. I often highlight this feature in conversations with students because of its simplicity and usefulness.

3 There are two versions of IntelliJ IDEA available: a **paid version** and a **free community edition**. While the paid version is widely regarded as the top Java IDE, the community edition is also highly capable, and that is the version we will be using in this course. To use an analogy, the community edition is akin to a Netflix HD subscription, whereas the paid version would be more like a Netflix 4K subscription.

4 To install IntelliJ IDEA, visit the following URL and download the appropriate installer for your operating system. Once downloaded, run the installer and accept the default settings.

https://www.jetbrains.com/idea/