

Java

Introduction

History of Java

- Java was originally developed by Sun Microsystems starting in 1991
 - James Gosling
 - Patrick Naughton
 - Chris Warth
 - Ed Frank
 - Mike Sheridan
- This language was initially called ***Oak***
- Renamed ***Java*** in 1995

What is Java

- A simple, object-oriented, distributed, interpreted, robust, secure, architecture neutral, portable, high-performance, multithreaded, and dynamic language -- **Sun Microsystems**
- **Object-Oriented**
 - No free functions
 - All code belong to some class
 - Classes are in turn arranged in a hierarchy or package structure

What is Java

- **Distributed**

- Fully supports IPv4, with structures to support IPv6
- Includes support for Applets: small programs embedded in HTML documents

- **Interpreted**

- The program are compiled into Java Virtual Machine (JVM) code called bytecode
- Each bytecode instruction is translated into machine code at the time of execution

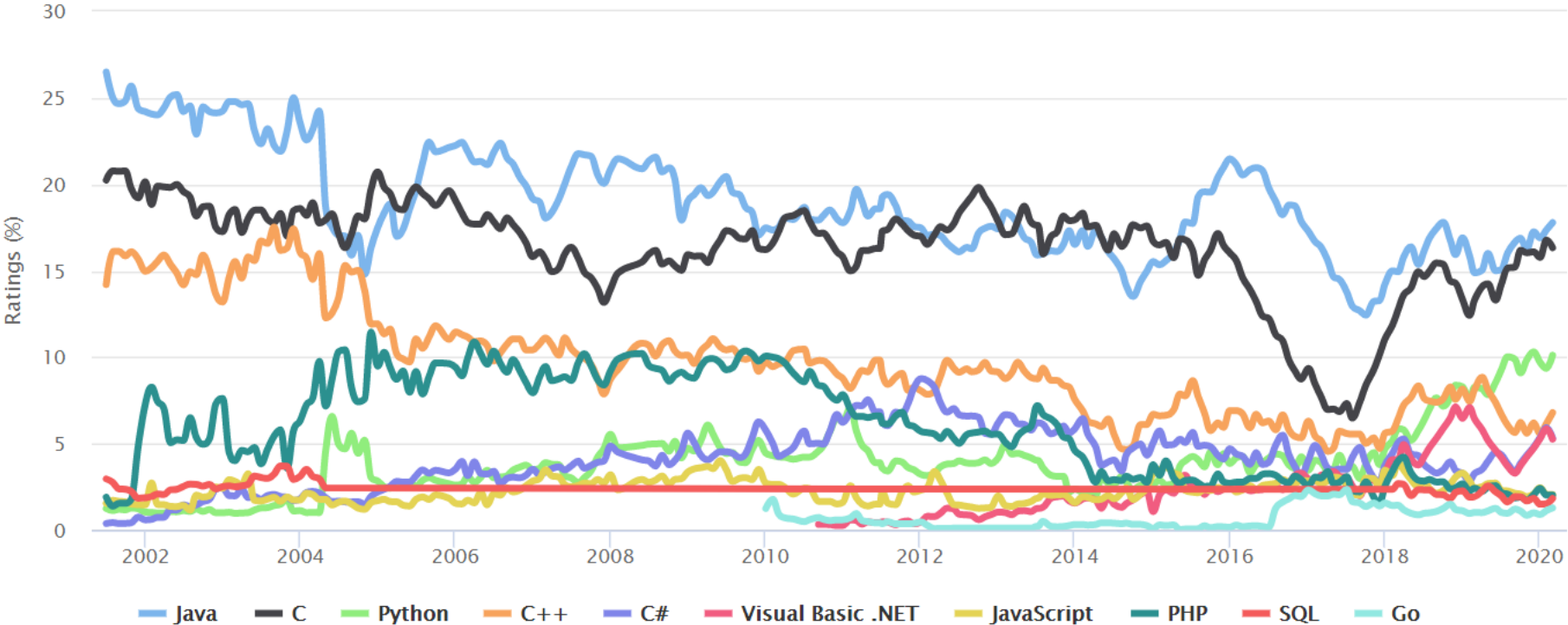
What is Java

- **Robust**
 - Java is simple – no pointers/stack concerns
 - Exception handling – try/catch/finally series allows for simplified error recovery
 - Strongly typed language – many errors caught during compilation

Java – The Most Popular (2020)

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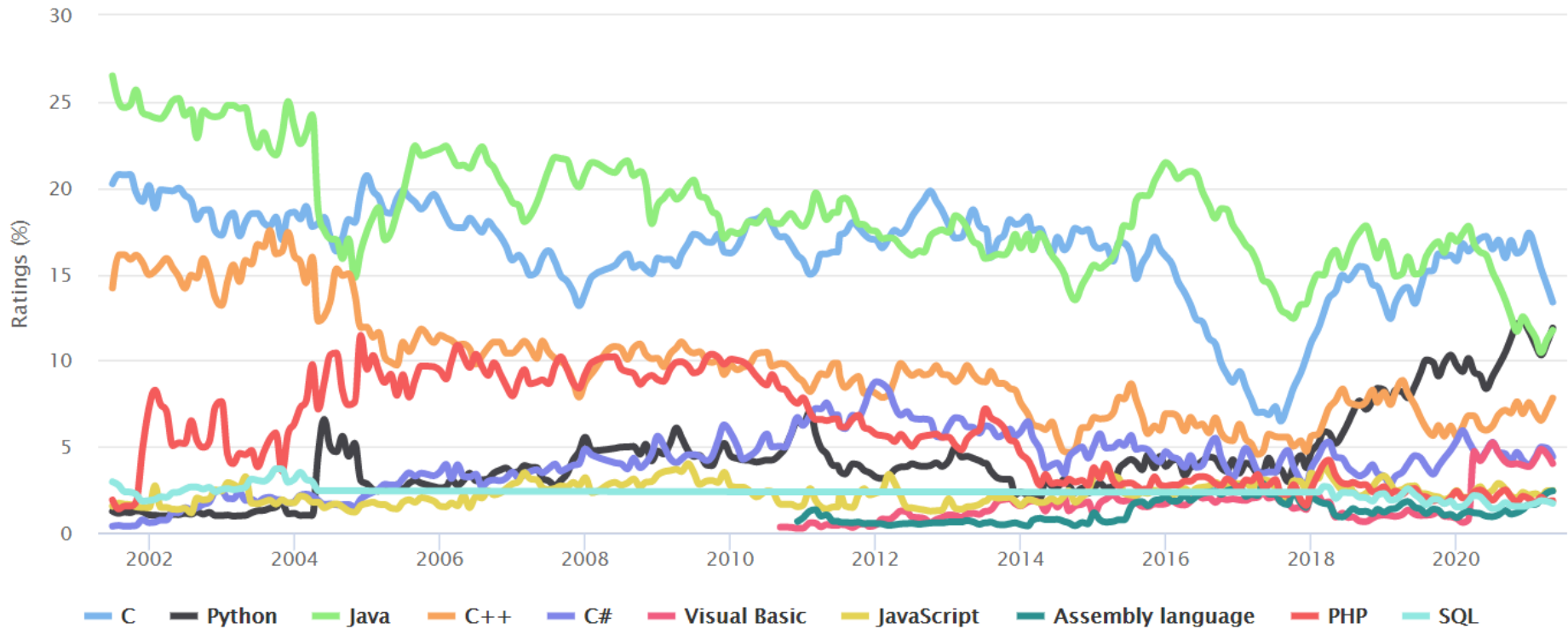
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Java – Top Three (2021)

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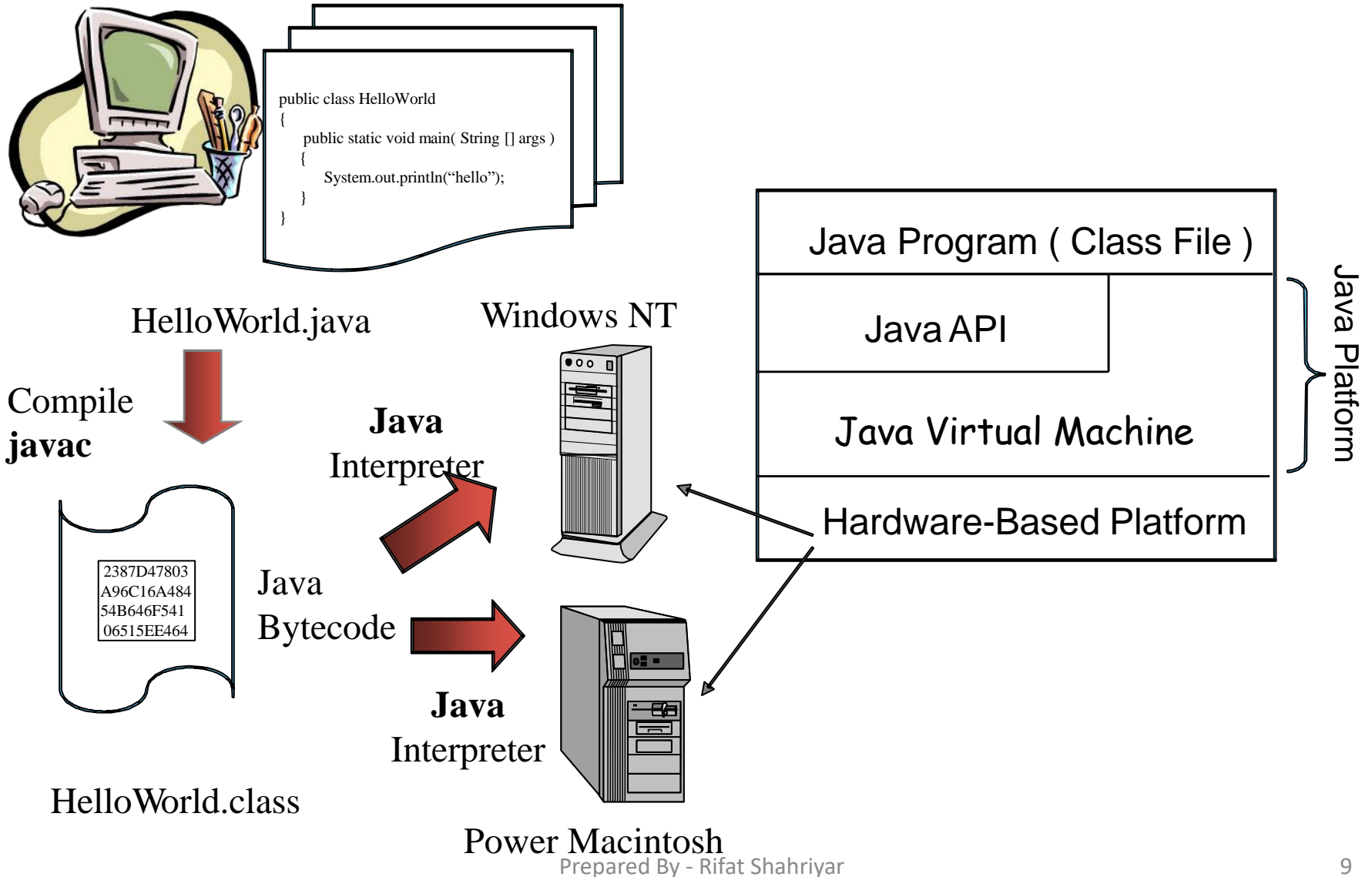
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Java Editions

- Java 2 Platform, Standard Edition (J2SE)
 - Used for developing Desktop based application and networking applications
- Java 2 Platform, Enterprise Edition (J2EE)
 - Used for developing large-scale, distributed networking applications and Web-based applications
- Java 2 Platform, Micro Edition (J2ME)
 - Used for developing applications for small memory-constrained devices, such as cell phones, pagers and PDAs

Java platform



Java Development Environment

- Edit
 - Create/edit the source code
- Compile
 - Compile the source code
- Load
 - Load the compiled code
- Verify
 - Check against security restrictions
- Execute
 - Execute the compiled

Phase 1: Creating a Program

- Any text editor or Java IDE (Integrated Development Environment) can be used to develop Java programs
- Java source-code file names must end with the **.java** extension
- Some popular Java IDEs are
 - NetBeans
 - Eclipse
 - IntelliJ

Phase 2: Compiling a Java Program

- ***javac Welcome.java***
 - Searches the file in the current directory
 - Compiles the source file
 - Transforms the Java source code into bytecodes
 - Places the bytecodes in a file named **Welcome.class**

Bytecodes *

- They are not machine language binary code
- They are independent of any particular microprocessor or hardware platform
- They are platform-independent instructions
- Another entity (interpreter) is required to convert the bytecodes into machine codes that the underlying microprocessor understands
- This is the job of the **JVM** (Java Virtual Machine)

JVM (Java Virtual Machine) *

- It is a part of the JDK and the foundation of the Java platform
- It can be installed separately or with JDK
- A virtual machine (VM) is a software application that simulates a computer, but hides the underlying operating system and hardware from the programs that interact with the VM
- It is the JVM that makes Java a portable language

JVM (Java Virtual Machine) *

- The same bytecodes can be executed on any platform containing a compatible JVM
- The JVM is invoked by the java command
 - *java Welcome*
- It searches the class Welcome in the current directory and executes the main method of class Welcome
- It issues an error if it cannot find the class Welcome or if class Welcome does not contain a method called main with proper signature

Phase 3: Loading a Program *

- One of the components of the JVM is the class loader
- The class loader takes the .class files containing the programs bytecodes and transfers them to RAM
- The class loader also loads any of the .class files provided by Java that our program uses

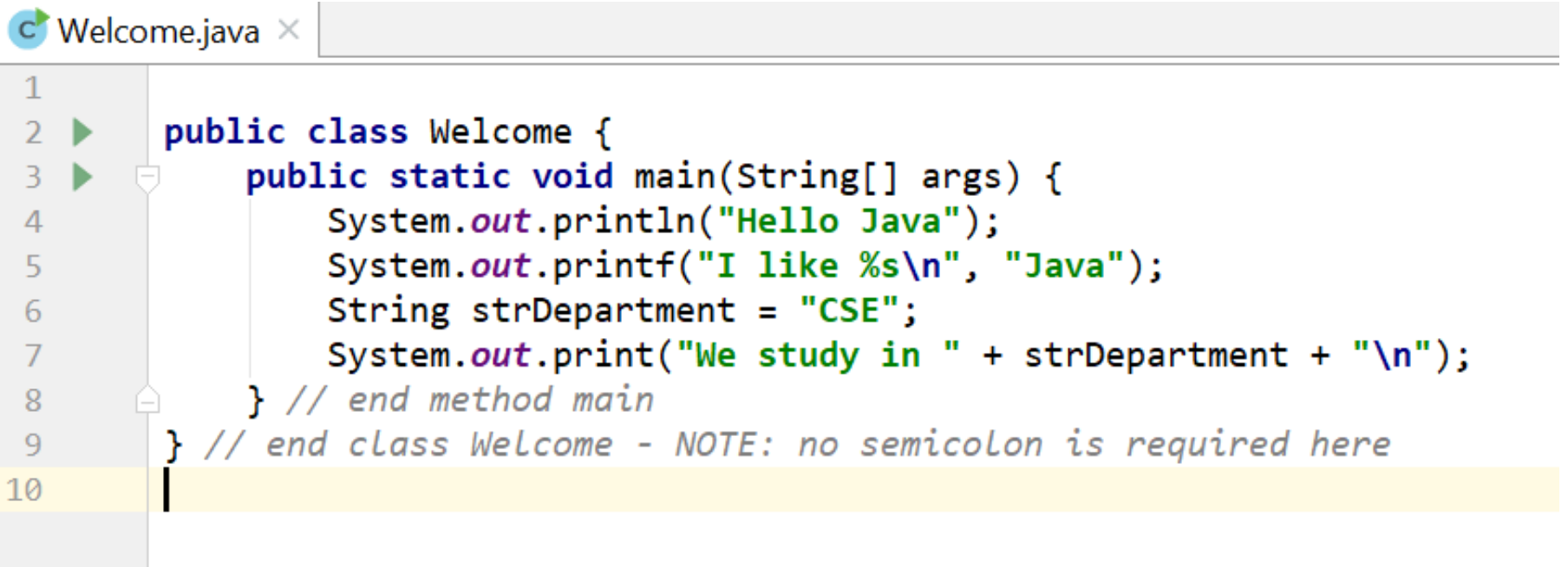
Phase 4: Bytecode Verification *

- Another component of the JVM is the bytecode verifier
- Its job is to ensure that bytecodes are valid and do not violate Java's security restrictions
- This feature helps to prevent Java programs arriving over the network from damaging our system

Phase 5: Execution

- Now the actual execution of the program begins
- Bytecodes are converted to machine language suitable for the underlying OS and hardware
- Java programs actually go through two compilation phases
 - Source code -> Bytecodes
 - Bytecodes -> Machine language

Editing a Java Program



```
1  
2 ▶ public class Welcome {  
3 ▶   public static void main(String[] args) {  
4     System.out.println("Hello Java");  
5     System.out.printf("I like %s\n", "Java");  
6     String strDepartment = "CSE";  
7     System.out.print("We study in " + strDepartment + "\n");  
8   } // end method main  
9 } // end class Welcome - NOTE: no semicolon is required here  
10
```

Examining Welcome.java

- A Java source file can contain multiple classes, but only one class can be a public class
- Typically Java classes are grouped into packages (similar to namespaces in C++)
- A public class is accessible across packages
- The source file name must match the name of the public class defined in the file with the .java extension

Examining Welcome.java

- In Java, there is no provision to declare a class, and then define the member functions outside the class
- Body of every member function of a class (called method in Java) must be written when the method is declared
- Java methods can be written in any order in the source file
- A method defined earlier in the source file can call a method defined later

Examining Welcome.java

- ***public static void main(String[] args)***
 - **main** is the starting point of every Java application
 - **public** is used to make the method accessible by all
 - **static** is used to make main a static method of class Welcome. Static methods can be called without using any object; just using the class name. JVM call main using the **ClassName.methodName** (*Welcome.main*) notation
 - **void** means main does not return anything
 - **String args[]** represents an array of String objects that holds the command line arguments passed to the application. *Where is the length of args array?*

Examining Welcome.java

- Think of JVM as a outside Java entity who tries to access the main method of class Welcome
 - main must be declared as a public member of class Welcome
- JVM wants to access main without creating an object of class Welcome
 - main must be declared as static
- JVM wants to pass an array of String objects containing the command line arguments
 - main must take an array of String as parameter

Examining Welcome.java

- ***System.out.println()***
 - Used to print a line of text followed by a new line
 - **System** is a class inside the Java API
 - **out** is a public static member of class System
 - **out** is an object of another class of the Java API
 - **out** represents the standard output (similar to stdout or cout)
 - **println** is a public method of the class of which out is an object

Examining Welcome.java

- **System.out.print()** is similar to **System.out.println()**, but does not print a new line automatically
- **System.out.printf()** is used to print formatted output like printf() in C
- In Java, characters enclosed by double quotes ("") represents a String object, where String is a class of the Java API
- We can use the plus operator (+) to concatenate multiple String objects and create a new String object

Compiling a Java Program

- Place the .java file in the bin directory of your Java installation
 - ***C:\Program Files\Java\jdk-11.0.11\bin***
- Open a command prompt window and go to the bin directory
- Execute the following command
 - ***javac Welcome.java***
- If the source code is ok, then javac (the Java compiler) will produce a file called Welcome.class in the current directory

Compiling a Java Program

- If the source file contains multiple classes then javac will produce separate .class files for each class
- Every compiled class in Java will have their own .class file
- .class files contain the bytecodes of each class
- So, a .class file in Java contains the bytecodes of a single class only

Executing a Java Program

- After successful compilation execute the following command
 - *java Welcome*
 - *Note that we have omitted the .class extension here*
- The JVM will look for the class file *Welcome.class* and search for a *public static void main(String args[])* method inside the class
- If the JVM finds the above two, it will execute the body of the main method, otherwise it will generate an error and will exit immediately

Another Java Program

```
A.java x
1 ▶ public class A {
2     private int a;
3
4     public A()
5     {
6         this.a = 0;
7     }
8
9     public void setA(int a)
10    {
11        this.a = a;
12    }
13
14    public int getA()
15    {
16        return this.a;
17    }
18
19 ▶ public static void main(String args[])
20    {
21        A ob;
22        ob=new A();
23        ob.setA(10);
24        System.out.println(ob.getA());
25    }
26 }
27 }
```

Examining A.java

- The variable of a class type is called a reference
 - *ob* is a reference to A object
- Declaring a class reference is not enough, we have to use `new` to create an object
- Every Java object has to be instantiated using keyword **new**
- We access a public member of a class using the dot operator (`.`)
 - Dot (`.`) is the only member access operator in Java
 - Java does not have `->`, `&` and `*`



Primitive (built-in) Data types

- Integers
 - **byte** **8-bit integer (new)**
 - short 16-bit integer
 - int 32-bit signed integer
 - long 64-bit signed integer
- Real Numbers
 - float 32-bit floating-point number
 - double 64-bit floating-point number
- Other types
 - **char** **16-bit, Unicode 2.1 character**
 - boolean true or false, *false is not 0 in Java*

Boolean Type

```
Boolean.java x
1  ▶ public class Boolean {
2  ▶  ▶ public static void main(String[] args) {
3      int a = 10;
4      if (a > 0) // if (a) will give compilation error
5      {
6          System.out.println("Inside If");
7      }
8      boolean b = false;
9      if (b)
10     {
11         System.out.println("Inside If");
12     }
13     else
14     {
15         System.out.println("Inside Else");
16     }
17 }
18 }
19
```


Non-primitive Data types

- The non-primitive data types in java are
 - Objects
 - Array
- Non-primitive types are also called reference types

```
public class Box {
    int L, W, H;

    Box(int l, int w, int h)
    {
        L = l;
        W = w;
        H = h;
    }

    public static void main(String[] args)
    {
        Box p; // p is a reference pointing to null
        p = new Box(1, 2, 3); // now the actual object is created
    }
}
```

Primitive vs. Non-primitive type

- Primitive types are handled by value – the actual primitive values are stored in variable and passed to methods

```
int x = 10;
```

```
public MyPrimitive(int x) { }
```

- Non-primitive data types (objects and arrays) are handled by reference – the reference is stored in variable and passed to methods

```
Box b = new Box(1,2,3);
```

```
public MyNonPrimitive(Box x) { }
```

Primitive vs. Non-primitive type

- Primitive types are handled by value
 - There is no easy way to swap two primitive integers in Java
 - No method like **void swap(int *x, int *y)**
 - Can only be done using object or array
- But do we actually need a method to swap?
 - **x += (y - (y = x))** does the same in a single statement

Java References

- Java references are used to point to Java objects created by new
- Java objects are **always** passed **by reference** to other functions, ***never by value***
- Java references act as pointers but does not allow pointer arithmetic
- We cannot read the value of a reference and hence cannot find the address of a Java object
- We cannot take the address of a Java reference

Java References

- We can make a Java reference point to a new object
 - By copying one reference to another
ClassName ref2 = ref1; // Here ref1 is declared earlier
 - By creating a new object and assign it to the reference
ClassName ref1 = new ClassName();
- We cannot place arbitrary values to a reference except the special value **null** which means that the reference is pointing to nothing
 - ClassName ref1 = 100; // compiler error*
 - ClassName ref2 = null; // no problem*

Java References

```
Box.java x
1 public class Box {
2     int L, W, H;
3
4     Box(int l, int w, int h)
5     {
6         L = l;
7         W = w;
8         H = h;
9     }
10
11    public static void main(String[] args)
12    {
13        Box b1; // b1 refers to null
14        Box b2; // b2 refers to null
15        b1 = new Box( l: 8, w: 5, h: 7); // b1 refers to new object (8, 5, 7)
16        b2 = b1; // b2 refers to b1, so both refers (8, 5, 7)
17        b1 = new Box( l: 3, w: 9, h: 2); // b1 refers to new object (3, 9, 2)
18        b1 = b2; // b1 refers to b2, what happens to object (3, 9, 2)
19    }
20 }
21
```

Java version, IDE, and Textbook

- We will follow Java SE 11 (LTS), latest release - 11.0.11
 - <https://www.oracle.com/java/technologies/javase-jdk11-downloads.html>
- We will use IntelliJ IDEA Community version
 - <https://www.jetbrains.com/idea/download/>
- Books
 - Java: The Complete Reference, 11th Edition by Herbert Schildt
 - Effective Java, 3rd edition by Joshua Bloch (for future)