

# 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

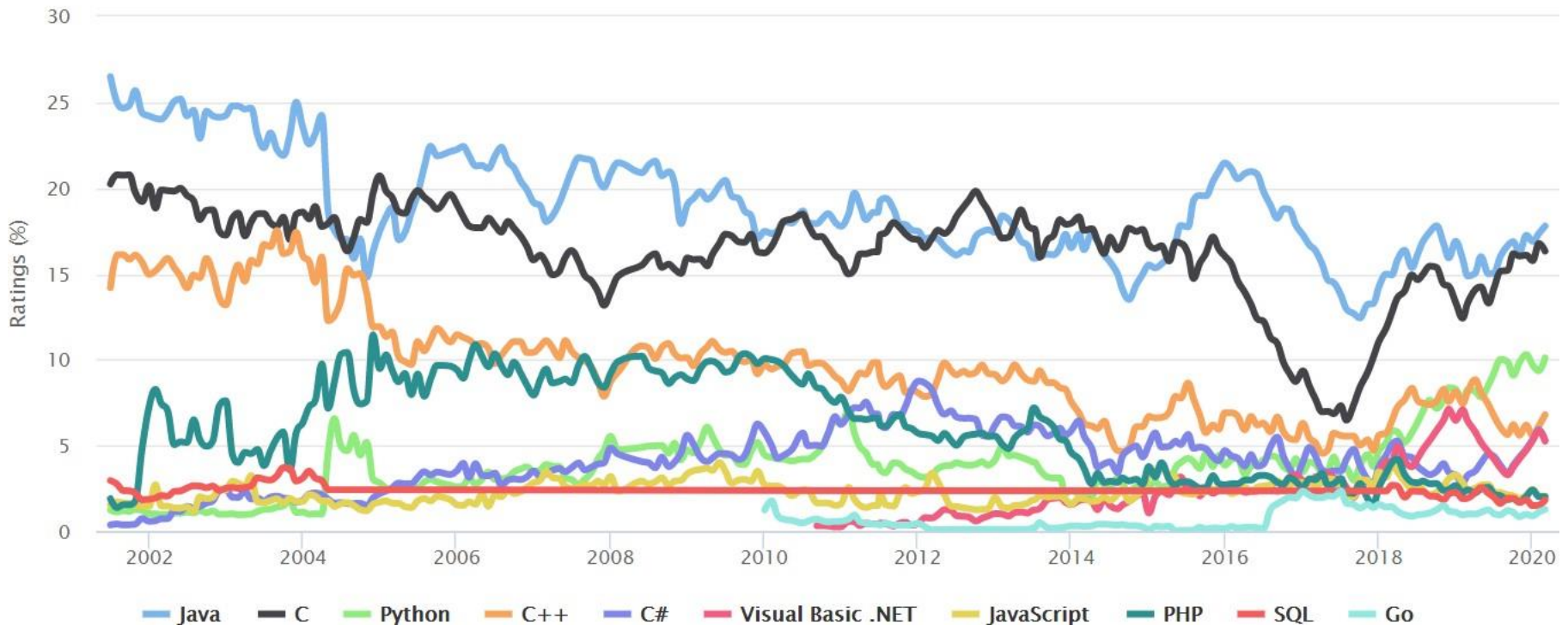
- **Robust**

- 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)

## TIOBE Programming Community Index

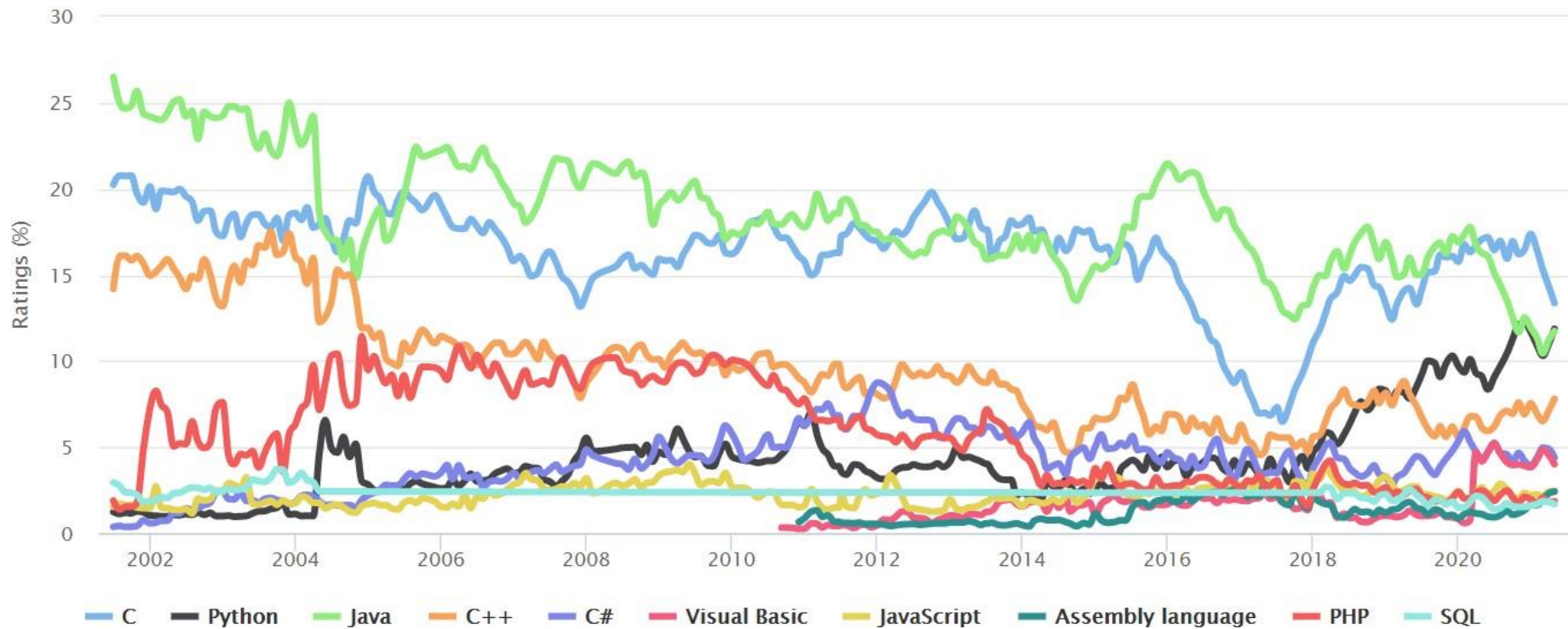
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# Java – Top Three (2021)

## TIOBE Programming Community Index

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## Very Long Term History

To see the bigger picture, please find below the positions of the top 10 programming languages of many years back. Please note that these are *average* positions for a period of 12 months.

Programming Language	2021	2016	2011	2006	2001	1996	1991	1986
C	1	2	2	2	1	1	1	1
Java	2	1	1	1	3	15	-	-
Python	3	5	6	8	25	24	-	-
C++	4	3	3	3	2	2	2	6
C#	5	4	5	7	13	-	-	-
Visual Basic	6	13	-	-	-	-	-	-
JavaScript	7	7	10	9	9	20	-	-
PHP	8	6	4	4	10	-	-	-

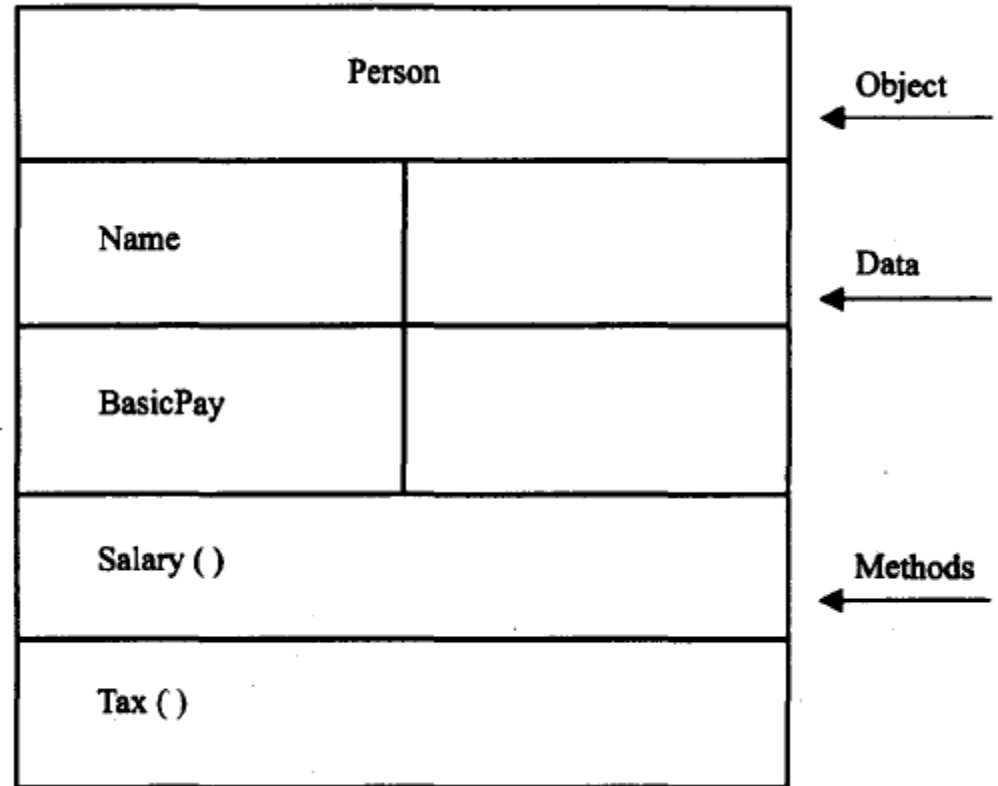


# Java Editions

- 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

# OOP Paradigm

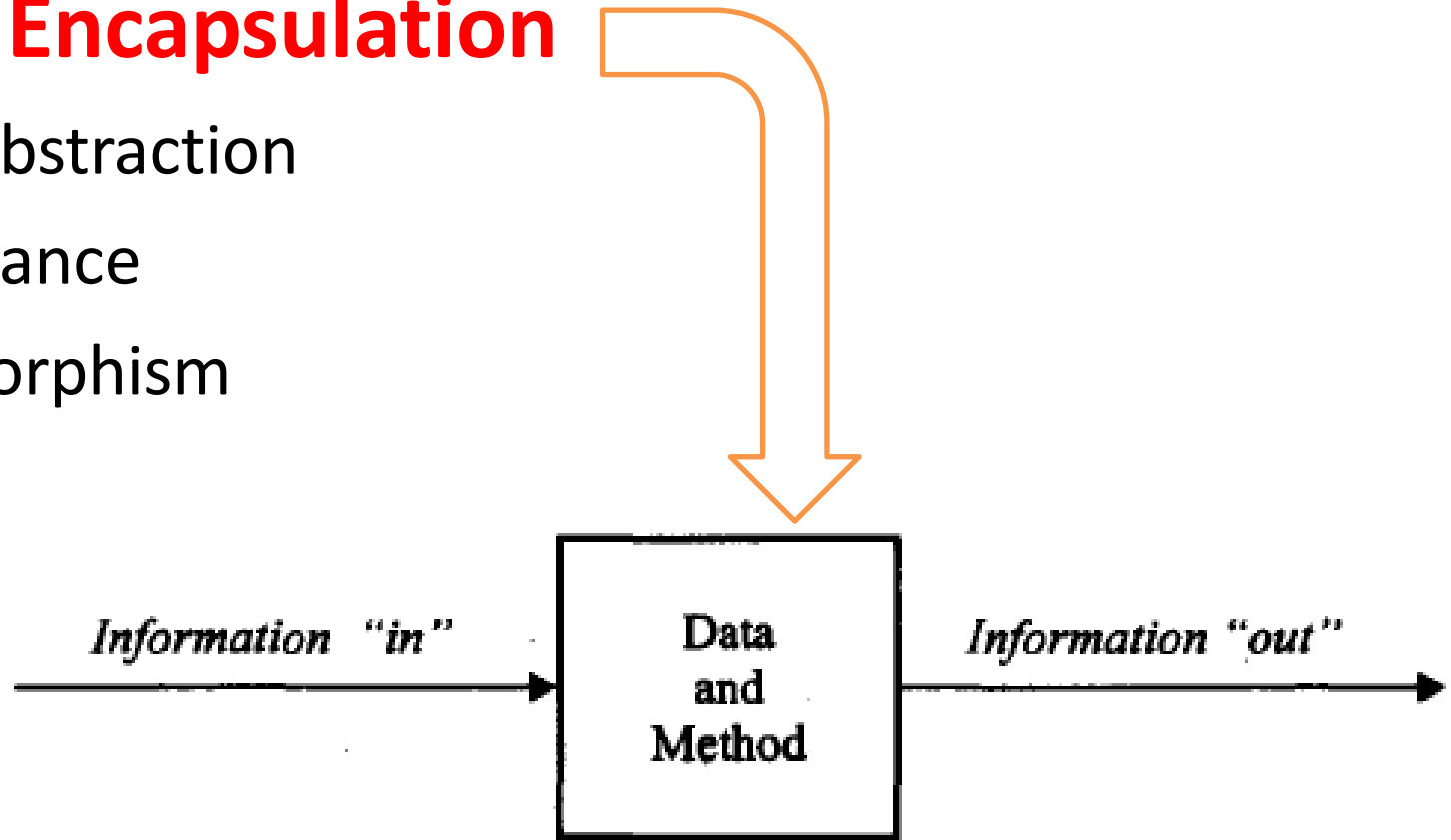
- Class
- Object
- Methods
- Data



# OOP Pillars

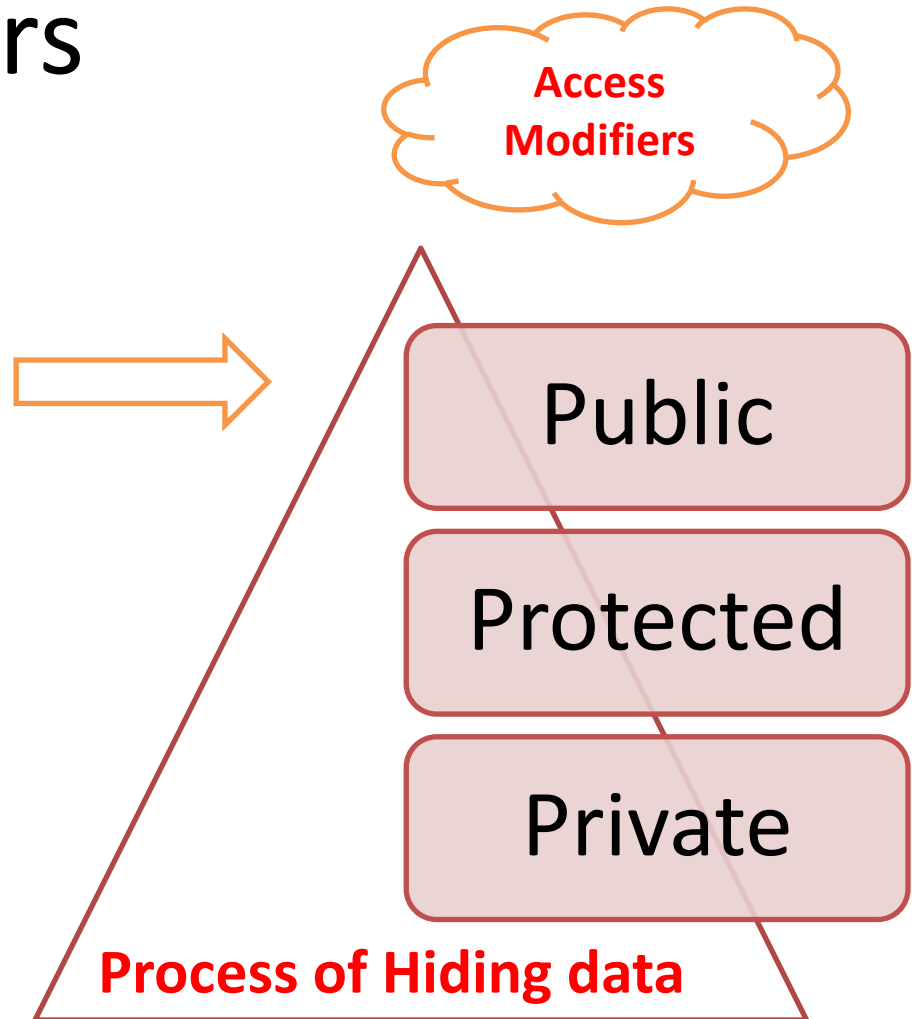
- **Data Encapsulation**

- Data Abstraction
- Inheritance
- Polymorphism



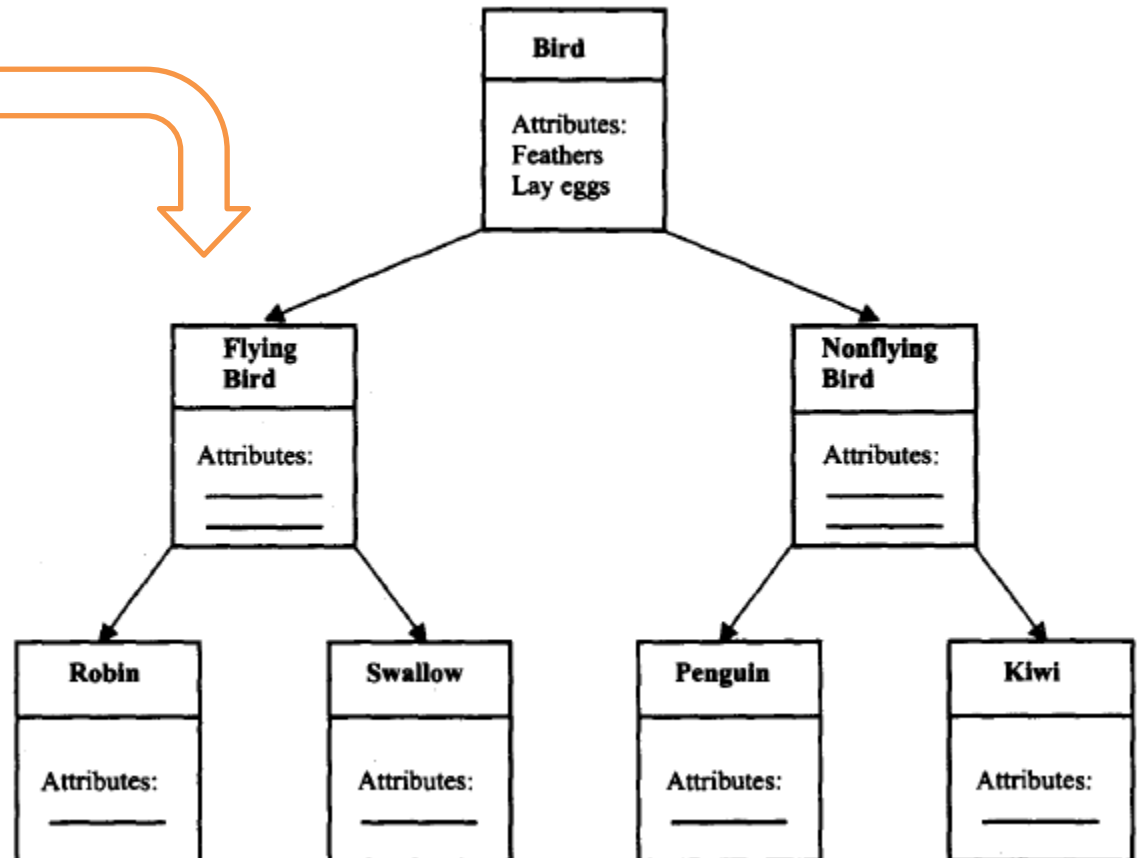
# OOP Pillars

- Data Encapsulation
- **Data Abstraction**
- Inheritance
- Polymorphism



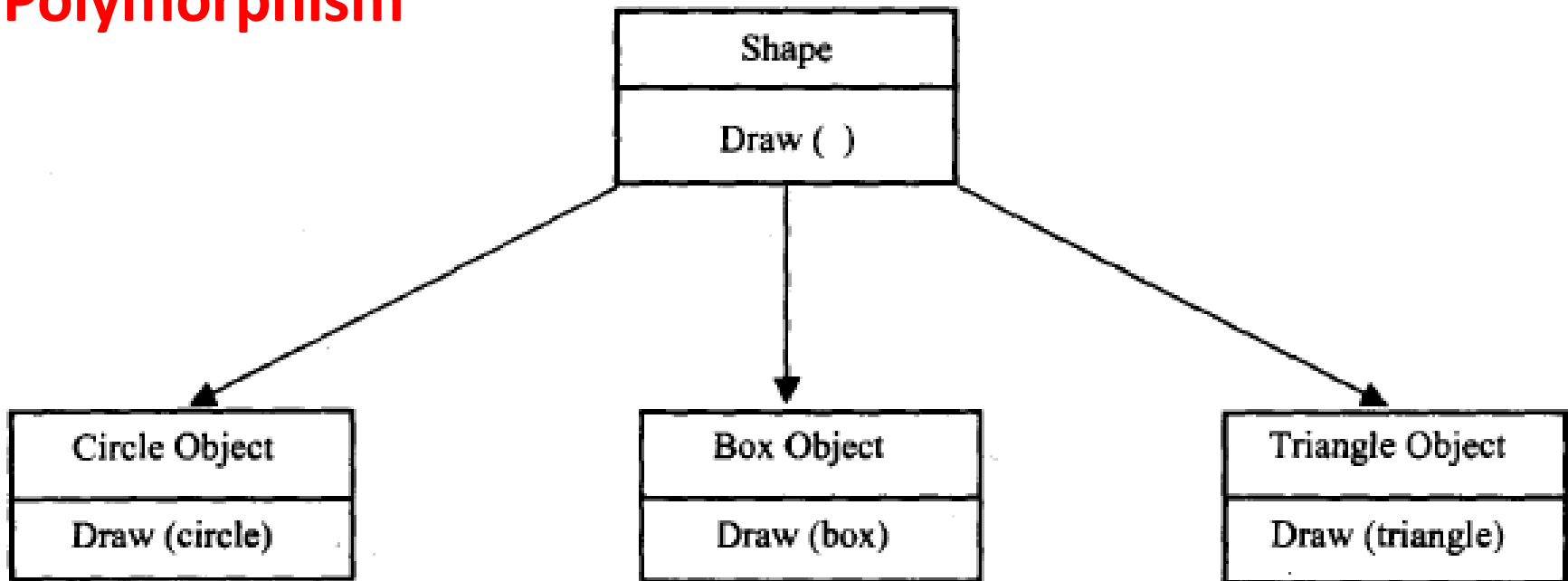
# OOP Pillars

- Data Encapsulation
- Data Abstraction
- **Inheritance**
- Polymorphism



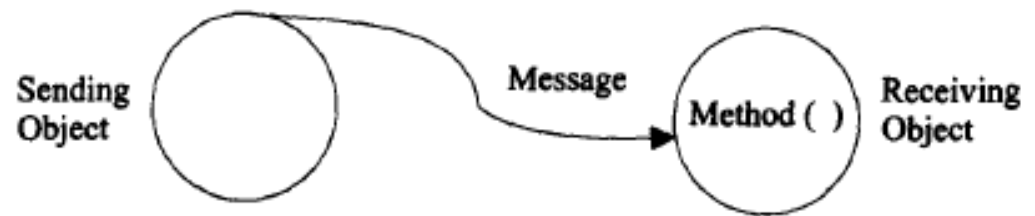
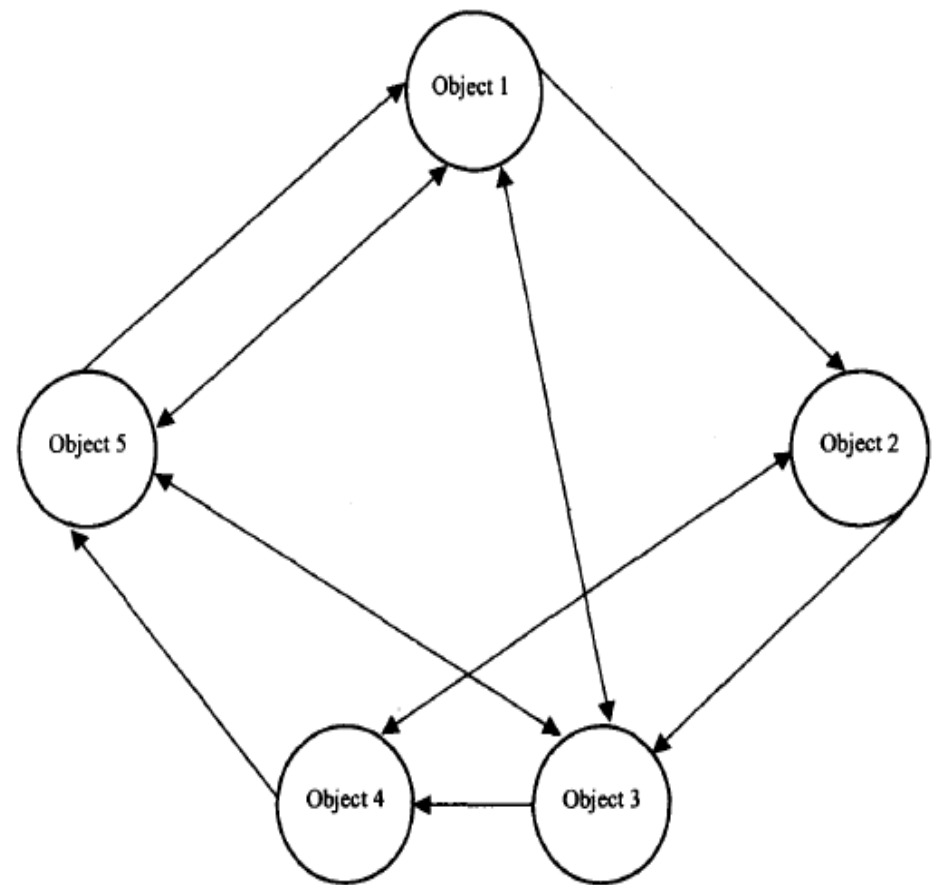
# OOP Pillars

- Data Encapsulation
- Data Abstraction
- Inheritance
- **Polymorphism**

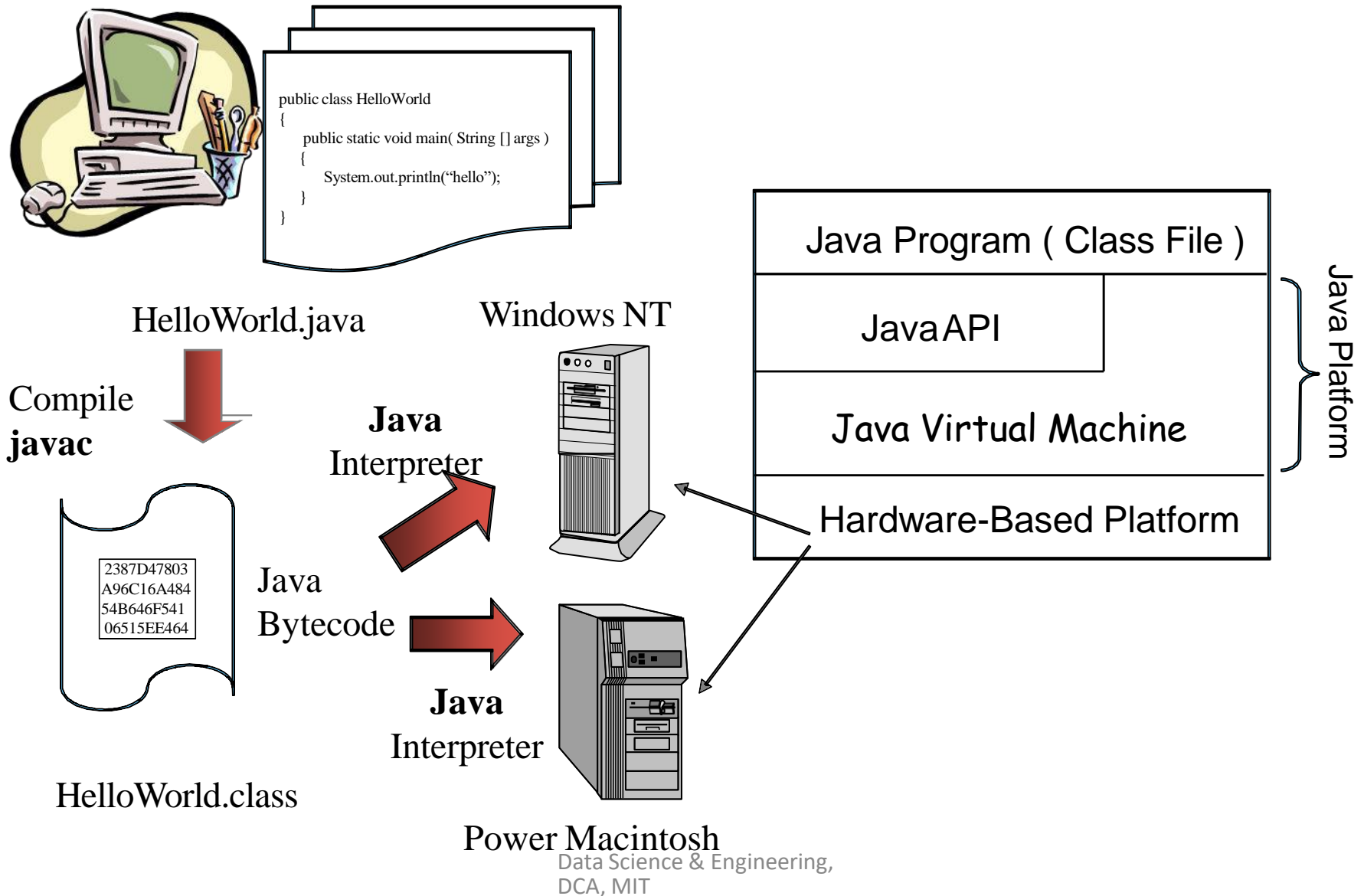


# Message Communication

- An object-oriented program consists of a set of objects that communicate with each other.
- It involves the following basic steps:
  1. Creating classes that define objects and their behavior.
  2. Creating objects from class definitions.
  3. Establishing communication among objects.



# Java Execution Procedure





# HelloWorld.java

Case  
Sensitive

Class name  
same as Source  
file name

Comments /\*  
(enter)

```
/*  
*This is a simple Java program.  
*Call this file "Example.java".  
*/
```

Class starts with  
Caps so does  
Source file name

One main()  
method among  
all class files

```
class HelloWorld  
    // Your program begins with a call to main().  
    public static void main(String args[]) {
```

```
    int numOfPoints = 10;  
    String studentName = "Alice";
```

Variable name  
are Camel Case

```
        System.out.println("This is a simple Java  
program.");  
    }  
}
```

Important:  
Indent, { }, ";"

# 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 HelloWorld.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 ***HelloWorld.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 (contd..)\*

- The same bytecodes can be executed on any platform containing a compatible JVM
- The JVM is invoked by the java command
  - *java HelloWorld.java*
- 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



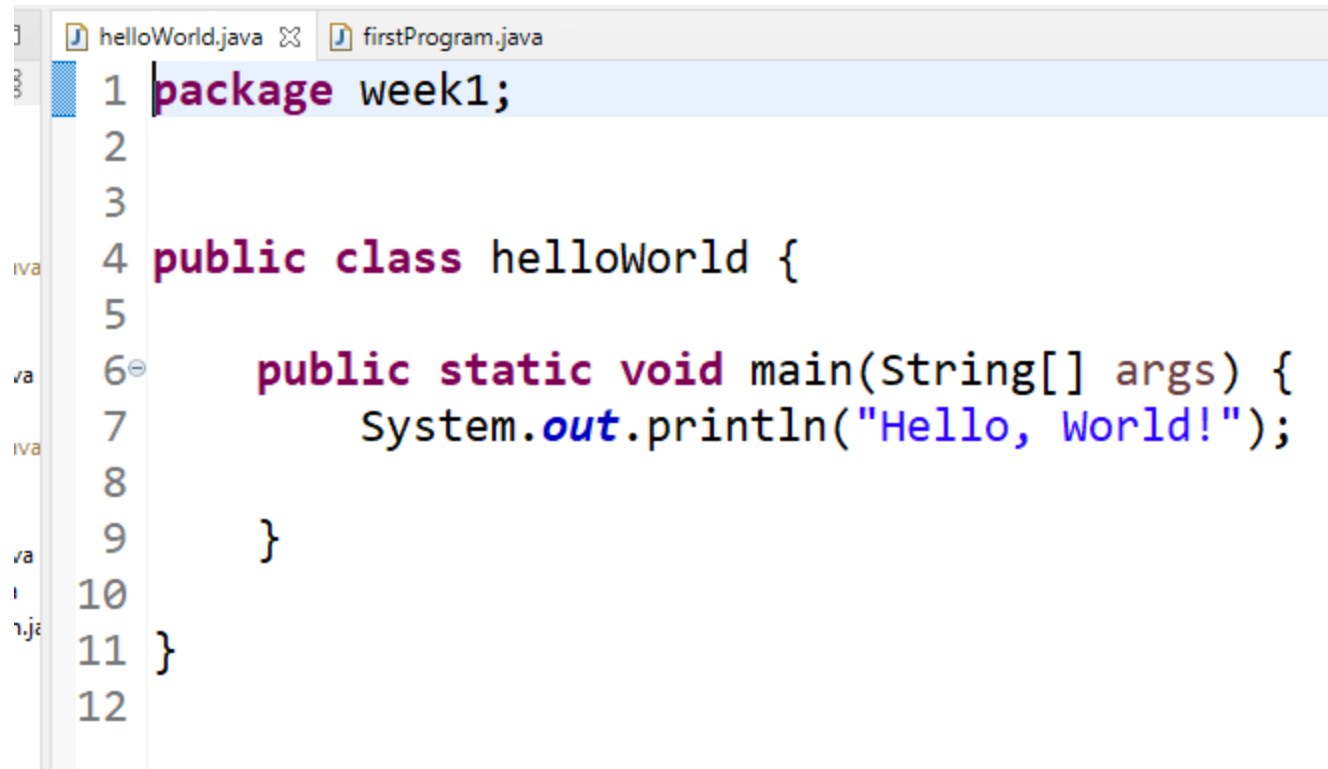
# Phase 4: Bytecode Verification \*

- 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 package week1;
2
3
4 public class helloWorld {
5
6     public static void main(String[] args) {
7         System.out.println("Hello, World!");
8     }
9
10 }
11
12
```

# Examining HelloWorld.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 HelloWorld.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 HelloWorld.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 HelloWorld. Static methods can be called without using any object; just using the class name. JVM call main using the **ClassName.methodName** (Ex. *HelloWorld.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.

# Examining HelloWorld.java

- Think of **JVM as a outside Java** entity who tries to access the main method of class HelloWorld.java
  - main must be declared as a public member of class HelloWorld
- JVM wants to **access main without creating an object** of class HelloWorld
  - 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 HelloWorld.java

- ***System.out.println()***
  - Used to print a line of text followed by a new line(***ln***)
  - **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 HelloWorld.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:\Users\Vidya Rao\eclipse\java-2021-06\eclipse*
- Open a command prompt window and go to the bin directory
- Execute the following command
  - *javac HelloWorld.java*
- If the source code is ok, then javac (the Java compiler) will produce a file called HelloWorld.class in the current directory

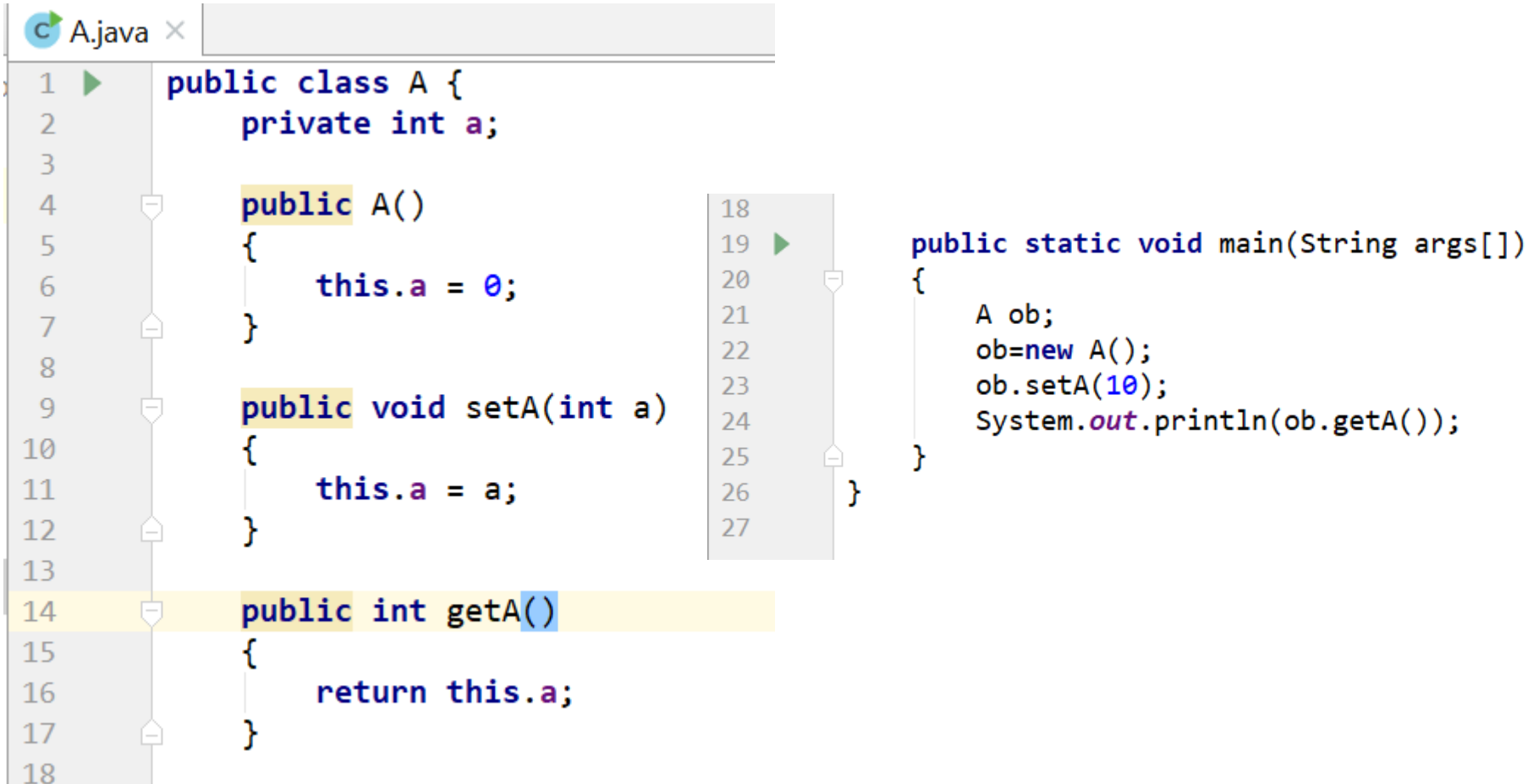
# Compiling a Java Program

- 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 HelloWorld***
  - *Note that we have omitted the .class extension here*
- The JVM will look for the class file **HelloWorld.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



The image shows a screenshot of a Java IDE with a file named 'A.java'. The code defines a public class 'A' with a private integer attribute 'a'. It includes a constructor 'A()' that initializes 'a' to 0, a 'setA(int a)' method to update 'a', and a 'getA()' method to return 'a'. A static 'main' method is also present, which creates an instance of 'A', sets its value to 10, and prints it. The IDE interface includes line numbers, a gutter with fold icons, and a search bar at the top.

```
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    }  
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# 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 `*`



# Control Statements

- a. If loop
- b. For loop
- c. While loop
- d. Block based program

# DIY Program Set 1

- a. Create a class name “GreatestNumber” and define a method that displays the greatest among the three-given number.
- b. Write a Java Program to check if the person is eligible for voting. Consider three test cases.
- c. For a given rectangle find the area. [Hint: (length x breadth) and circumference (2(length + breadth))]



# Variable and Operators

- **Variables**

- White Space
- Identifier
- Comments
- Separators
- Keywords
- Literals

- **Operators**

- Arithmetic Operators
- Relational Operators
- Boolean Operators
- Bitwise Operators
- String Operators
- Assignment Operators

# 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

# DIY Program Set 2

- a. Write a Java program to read an int number, double number and a char from keyboard and perform the following conversions:- int to byte, char to int, double to byte, double to int.
- b. Add two numbers using bitwise operator and check if the output is an even or odd number. [Hint: use left shift and right shift bitwise operators]
- c. By considering a string and a number, perform swap of string to int and int to string. [Hint: a = "hello", b = 123, ==> (swap to) a = 123, b = "hello"]

# 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

- **JDK**: <https://www.oracle.com/java/technologies/downloads/>
- **IDE-Eclipse**: <https://www.eclipse.org/downloads/>
- **Books**
  - Schildt H, Java: The Complete Reference, (10e), Tata McGraw-Hill Education Group, 2017.
  - Balagurusamy E, Programming with Java, (5e), Tata McGraw Hill, 2017.
  - Daniel Liang Y, Introduction to Java Programming, (10e), Pearson Education, 2018.
  - Horstmann CS, Big Java: Early Objects, (5e), Wiley's Interactive Edition, 2015.