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

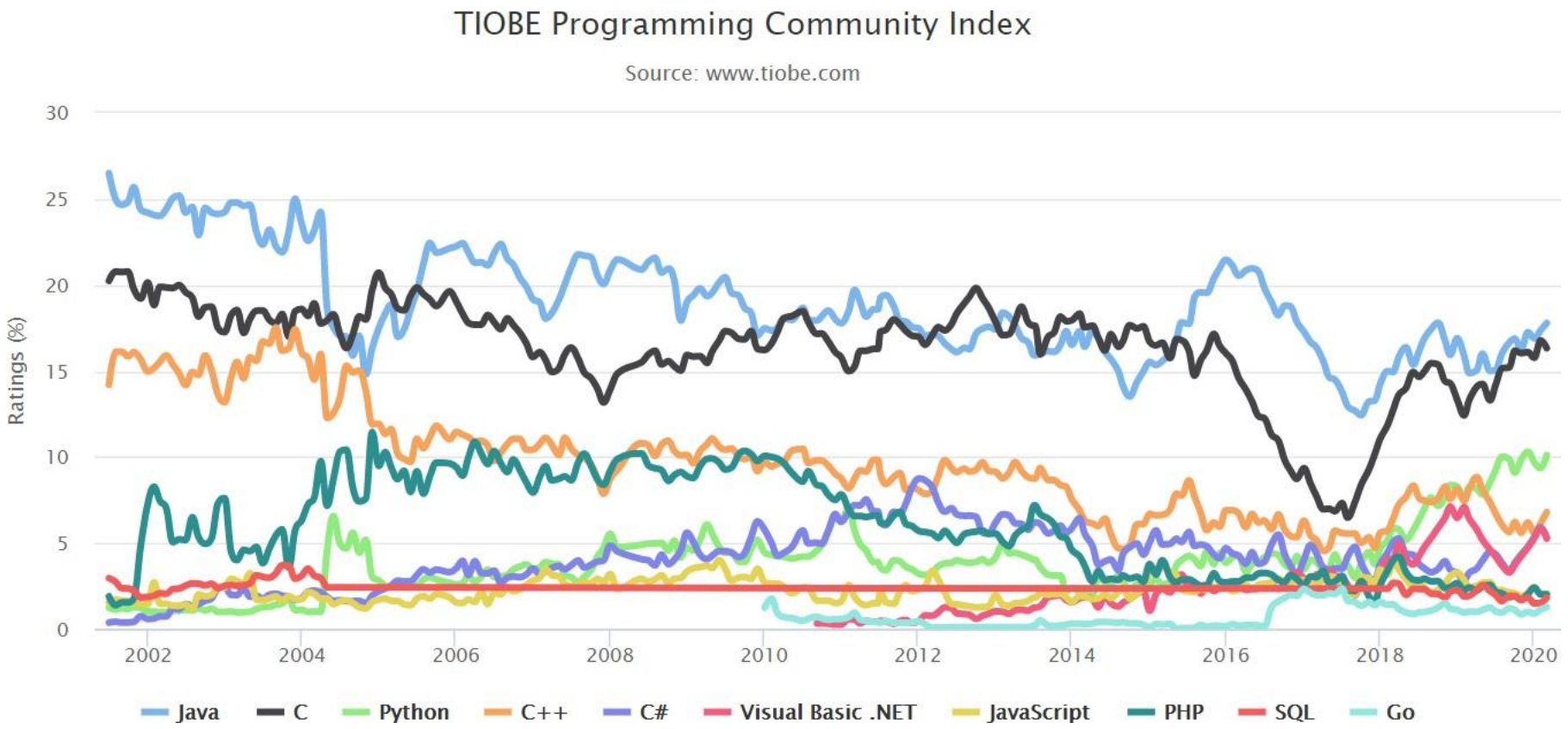
What is Java

- **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

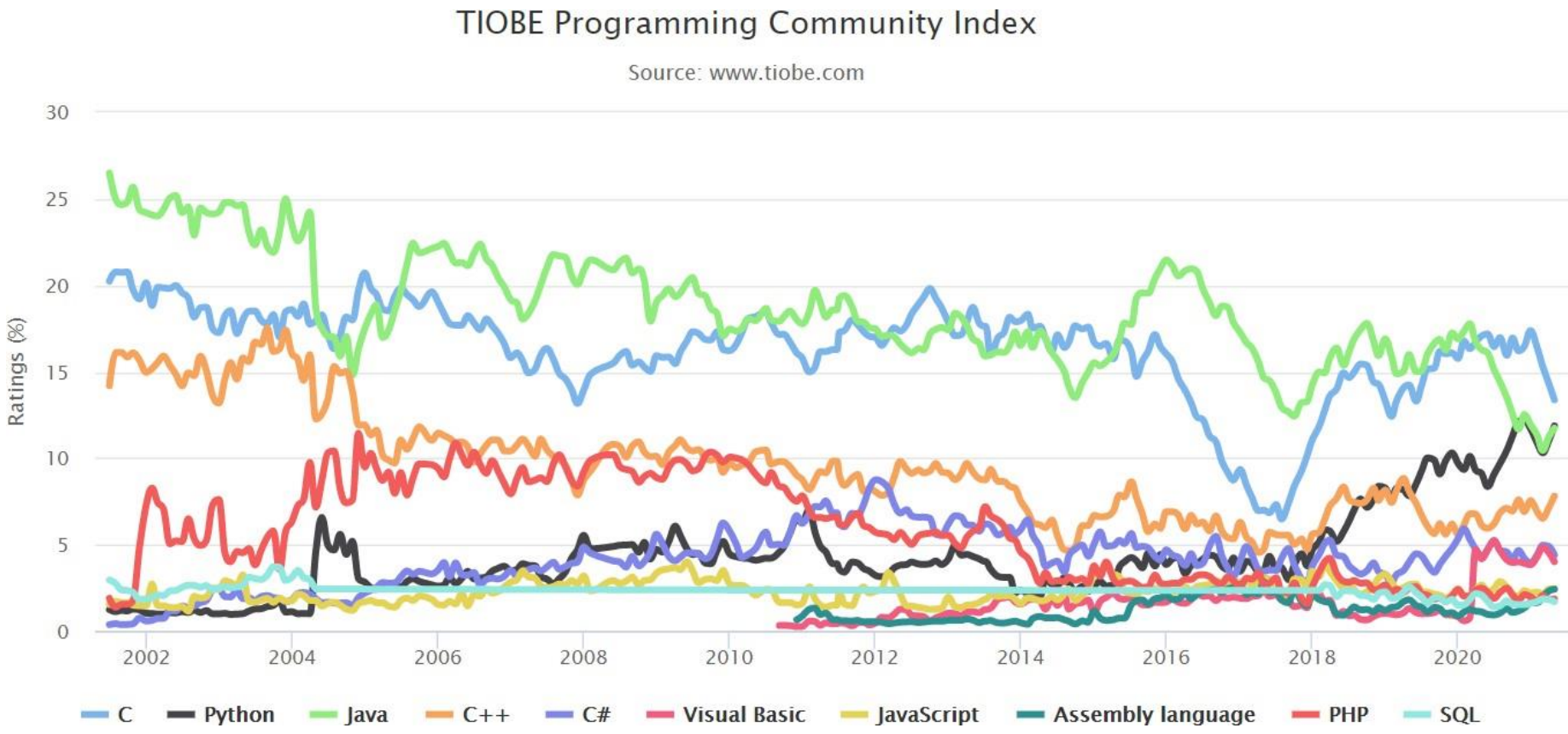
What is Java

- **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)



Java – Top Three (2021)



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.

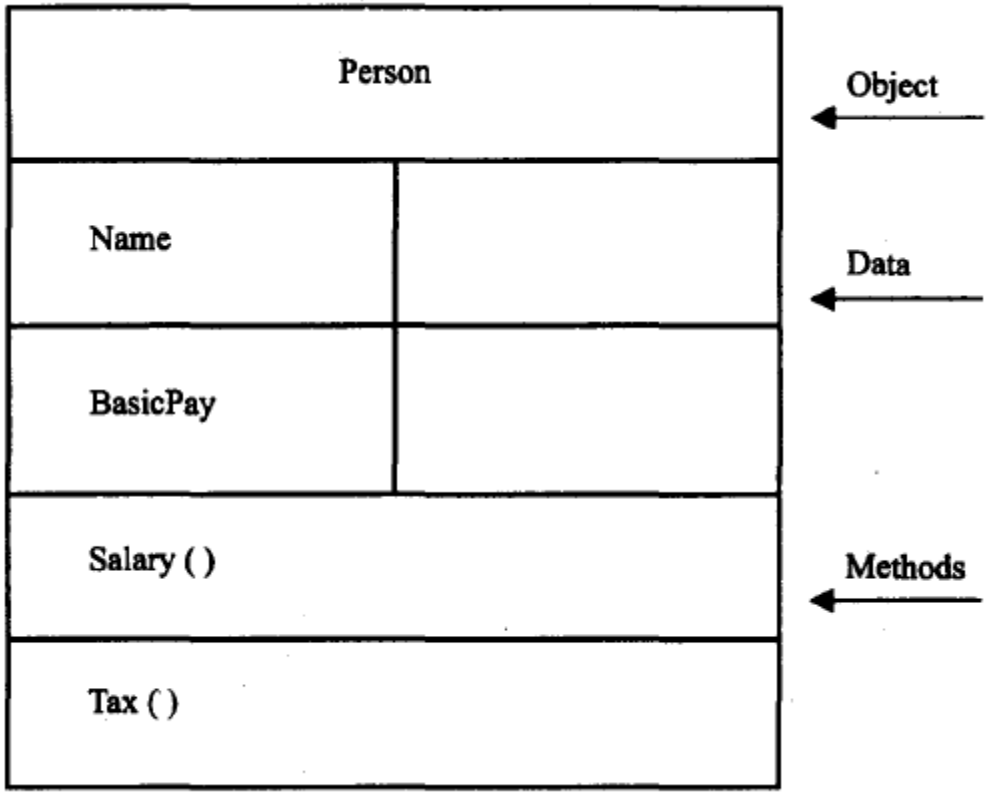
Programming Language	2021	2016	2011	2006	2001	1996	1991	1986
C	1	2	2	2	1	1	1	1
Java	2	1	1	1	3	15	-	-
Python	3	5	6	8	25	24	-	-
C++	4	3	3	3	2	2	2	6
C#	5	4	5	7	13	-	-	-
Visual Basic	6	13	-	-	-	-	-	-
JavaScript	7	7	10	9	9	20	-	-
PHP	8	6	4	4	10	-	-	-

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

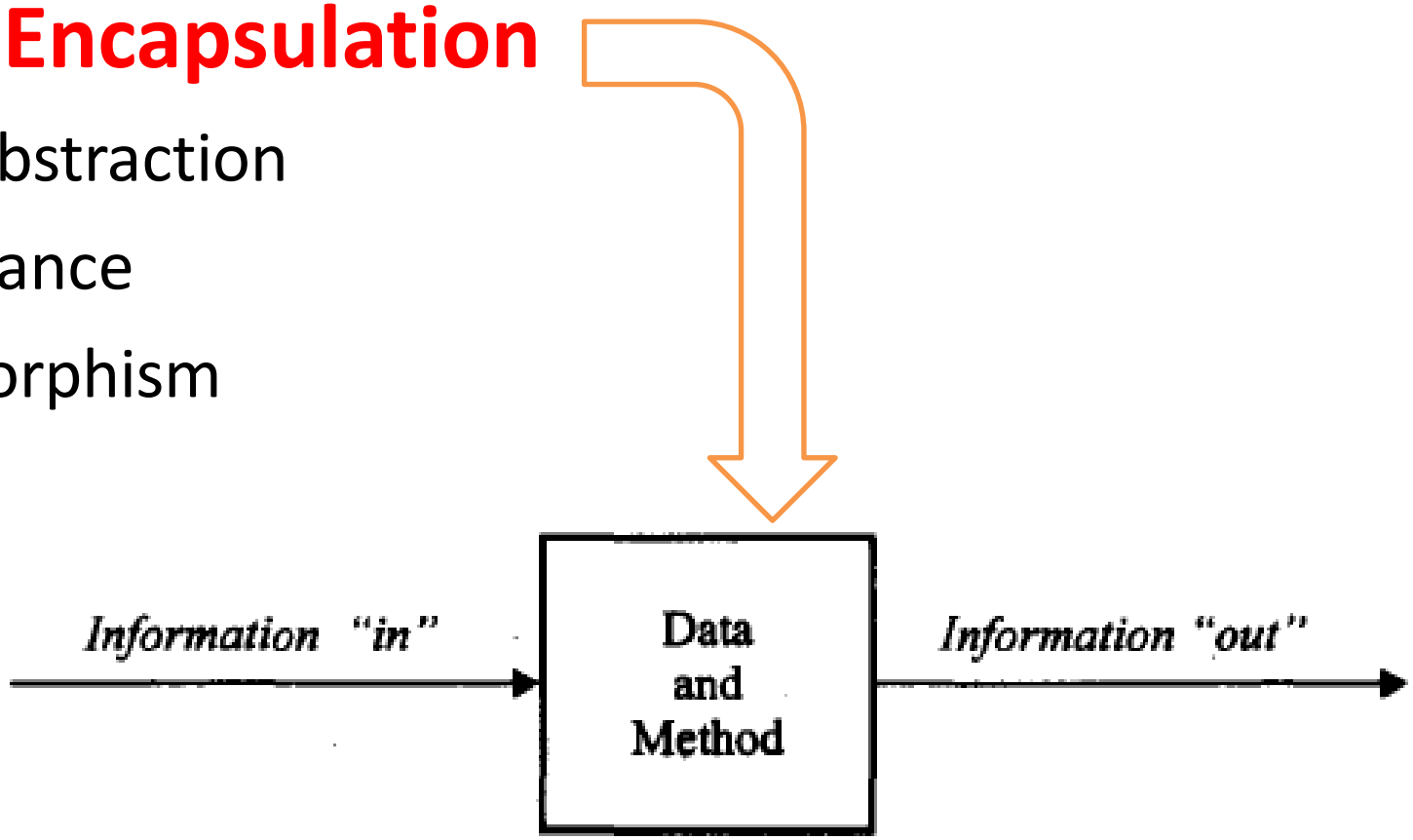
OOP Paradigm

- Class
- Object
- Methods
- Data



OOP Pillars

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



OOP Pillars

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- **Data Abstraction**
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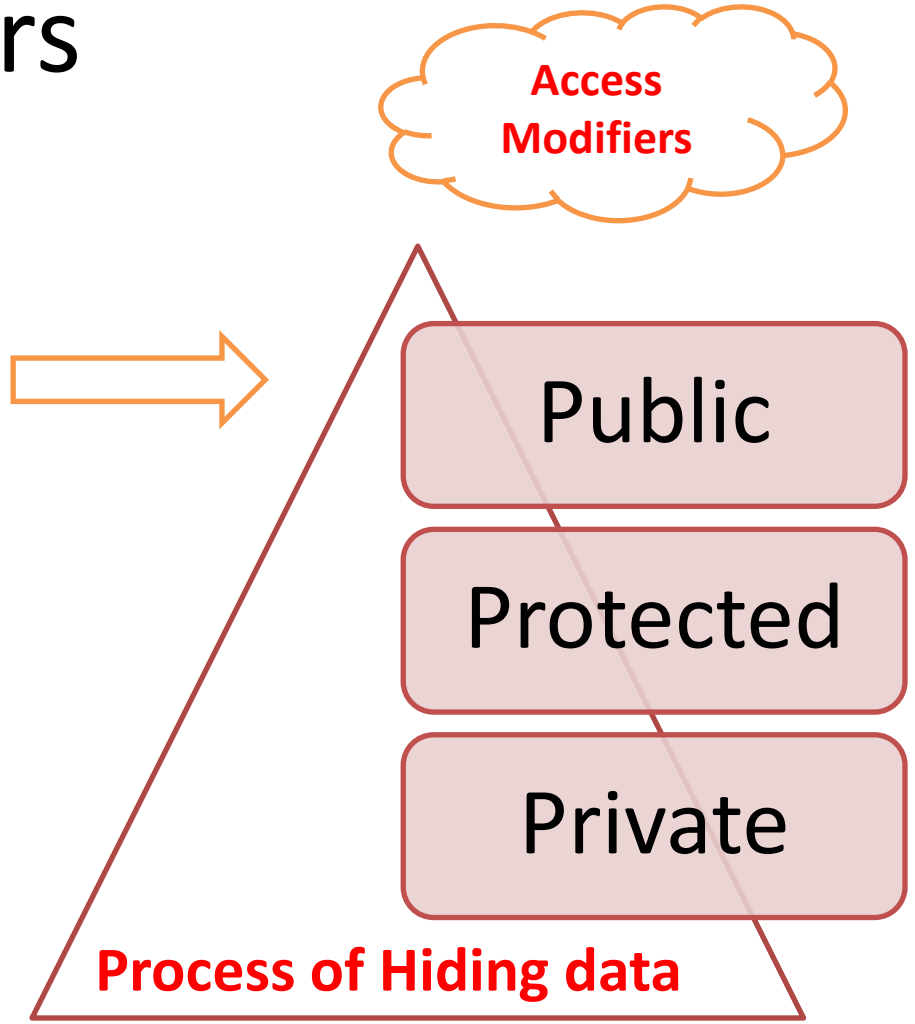

OOP Pillars

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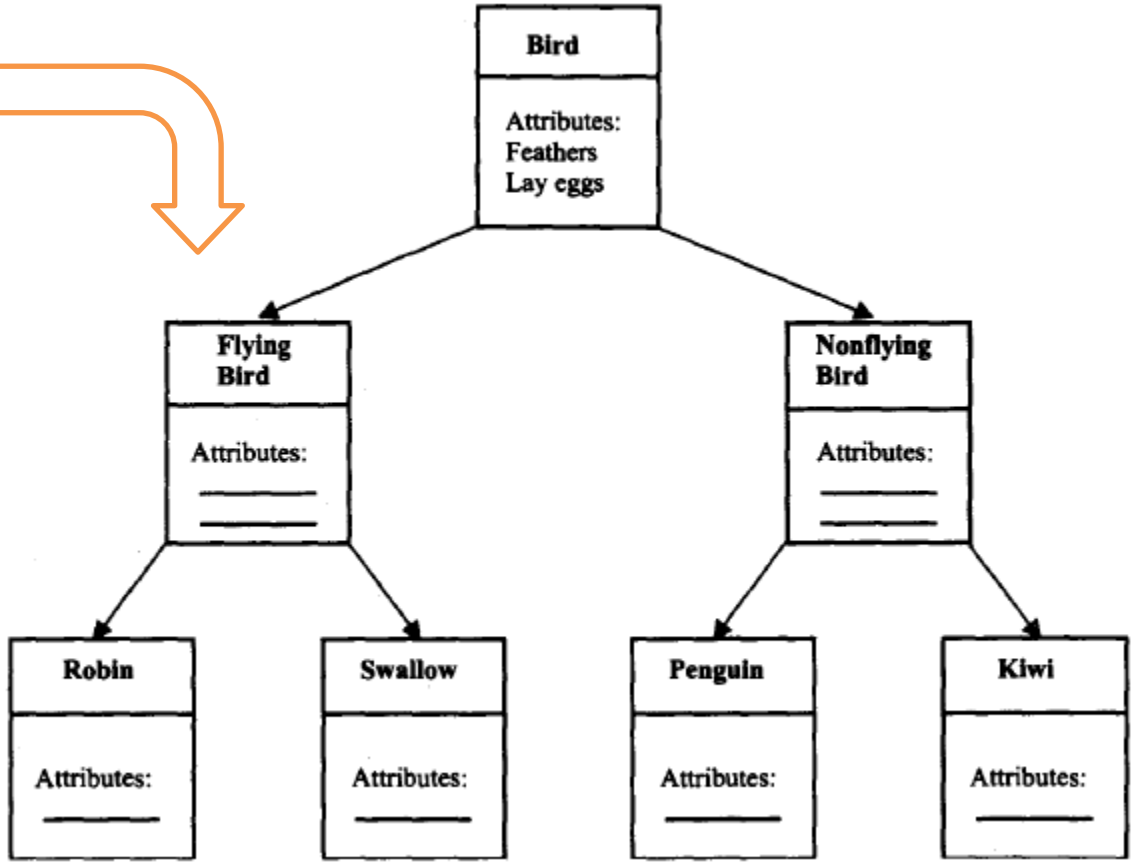
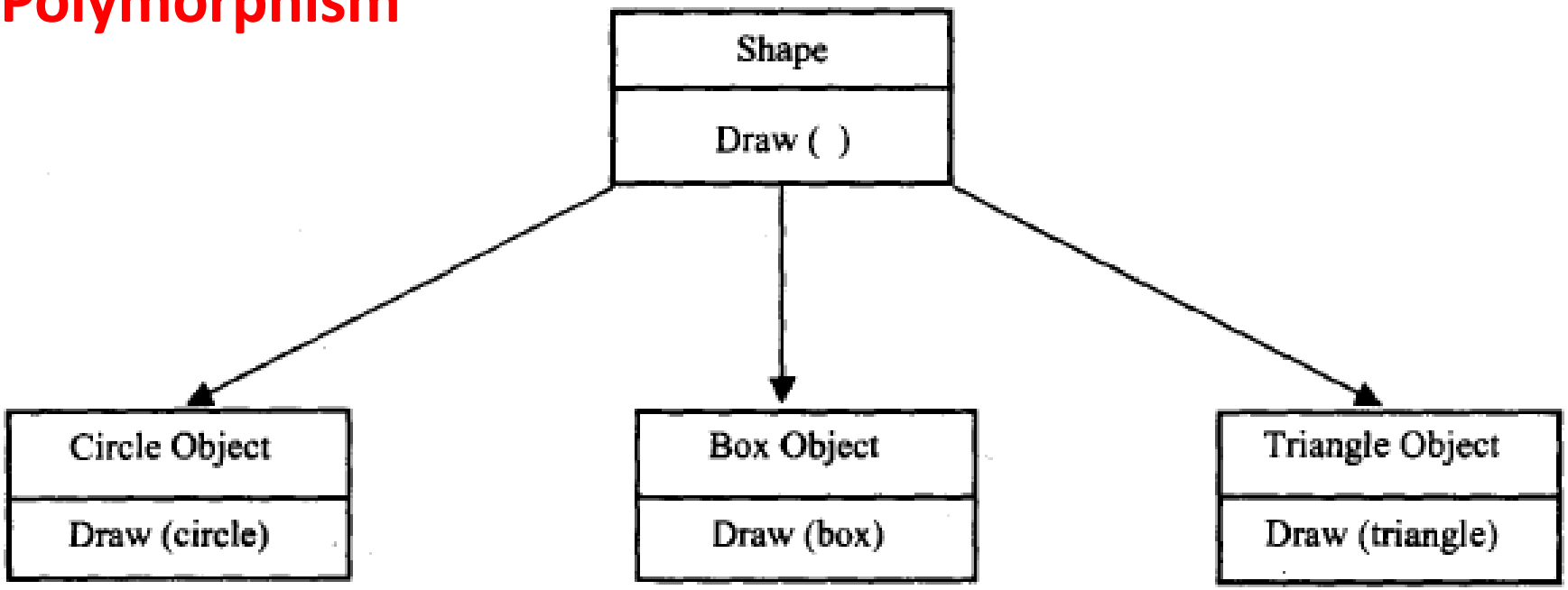
- **Inheritance**
- Polymorphism



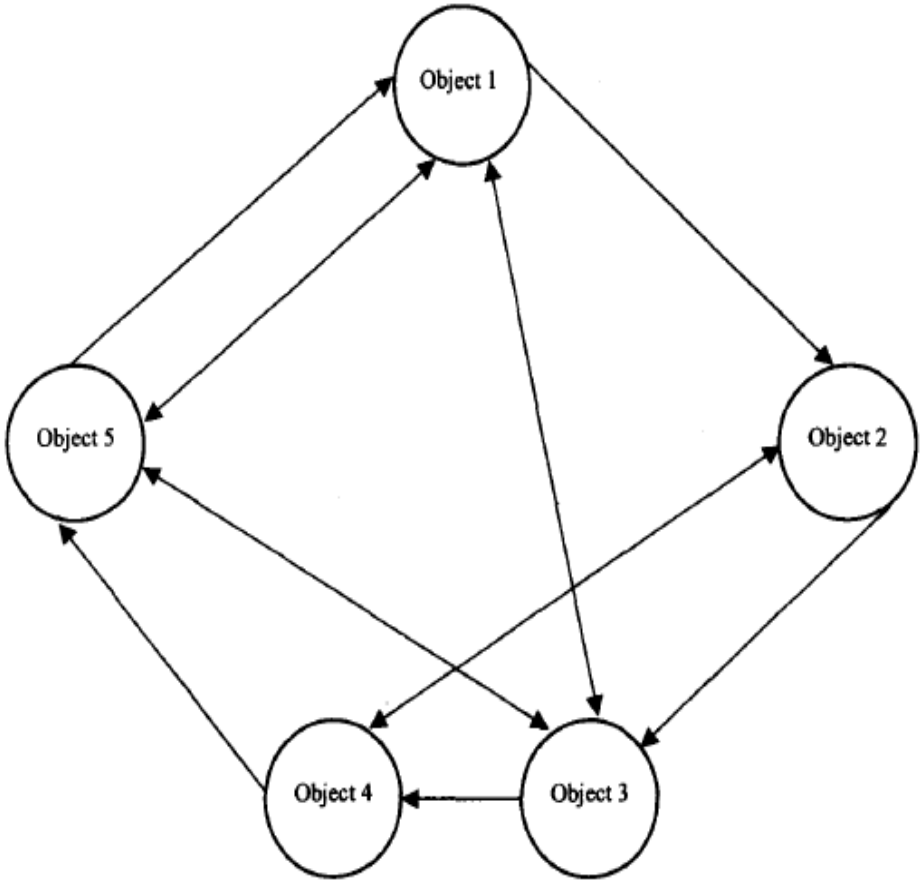
OOP Pillars

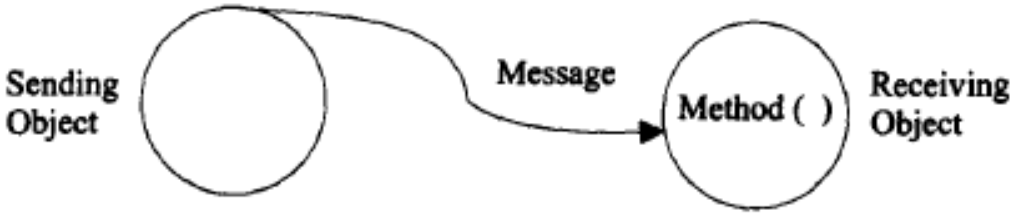
- Data Encapsulation
- Data Abstraction
- Inheritance
- **Polymorphism**



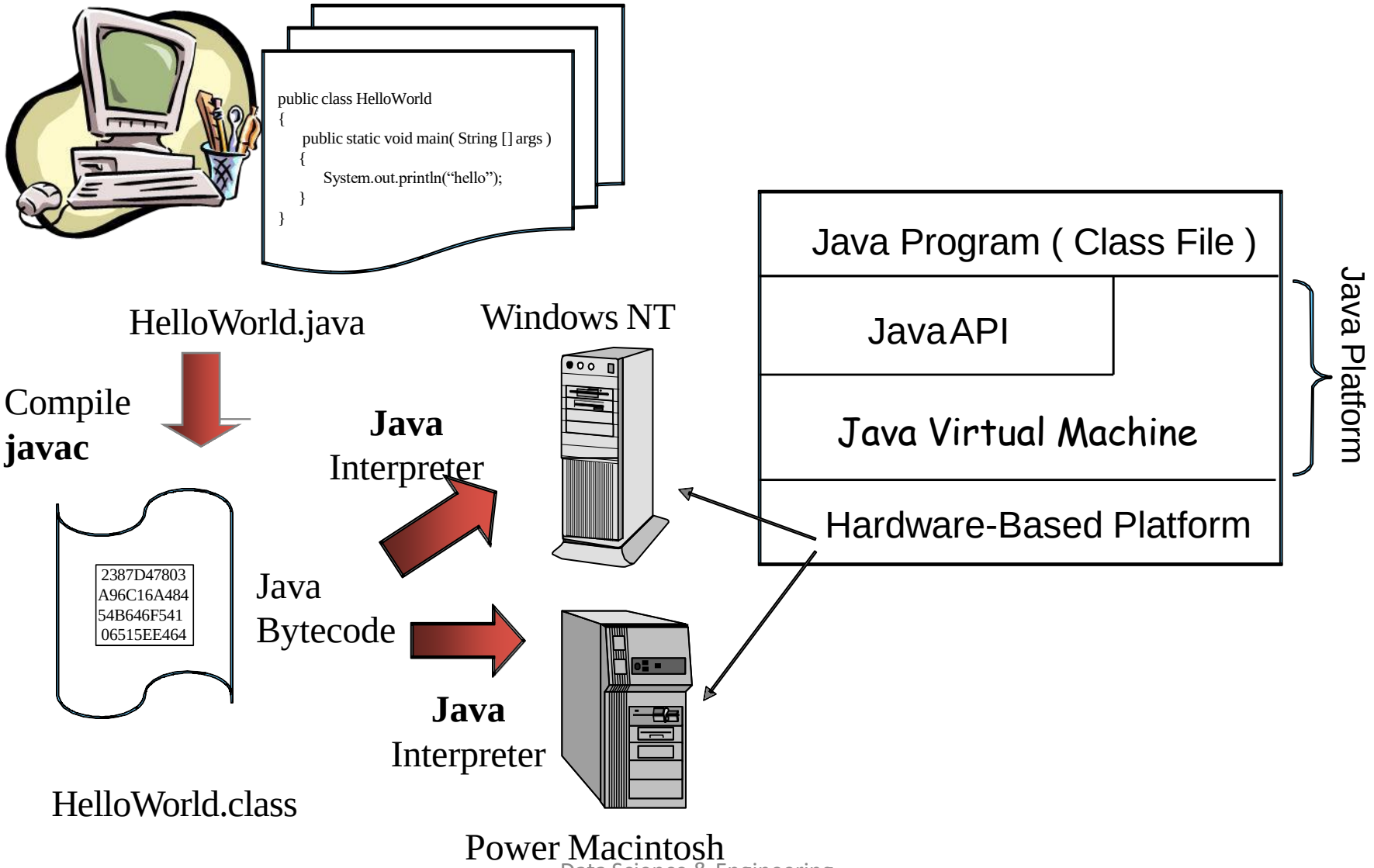
Message Communication

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

    int numOfPoints = 10;
    String studentName = “Alice”;

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

Class starts with Caps so does Source file name

One main() method among all class files

Variable name are Camel Case

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

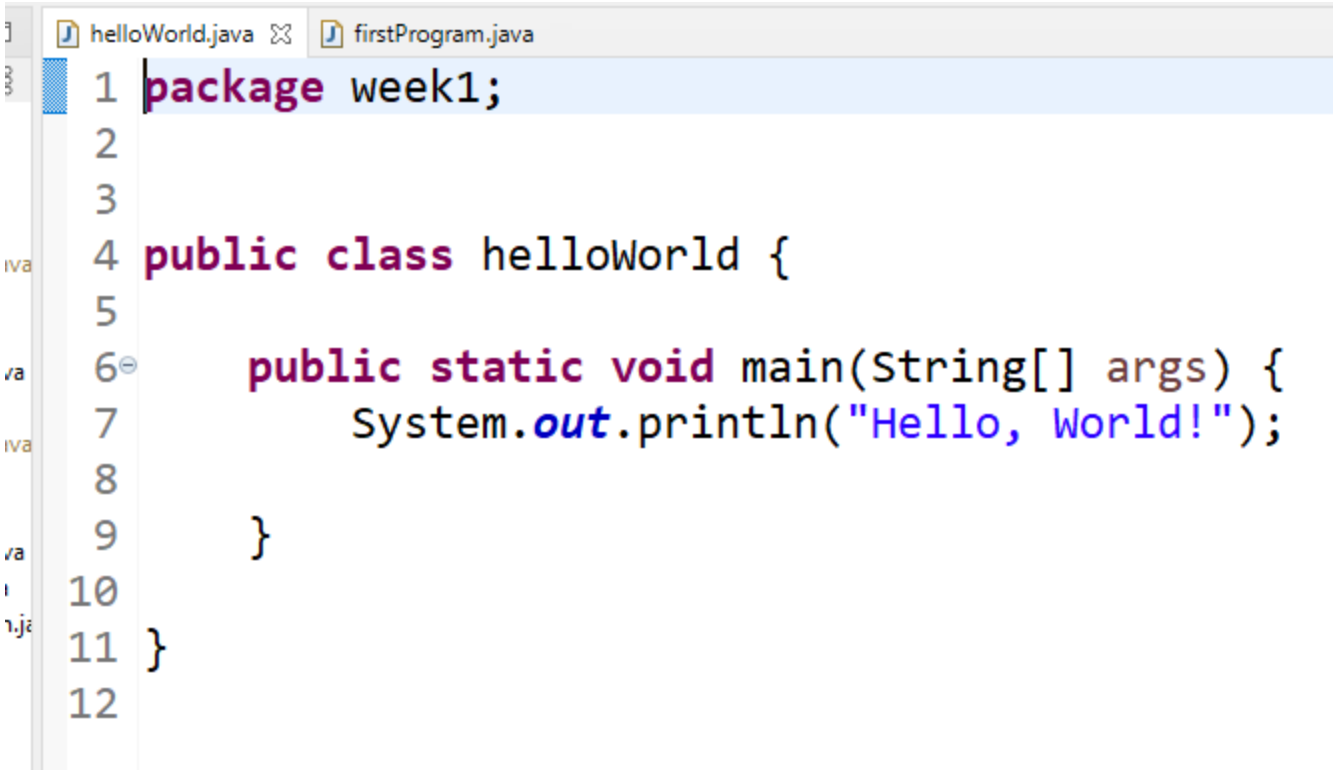
Phase 4: Bytecode Verification *

- 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



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

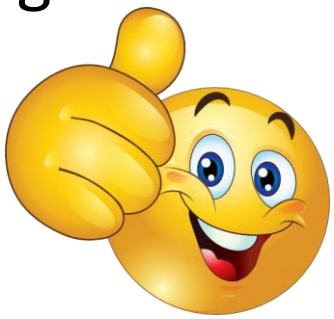
Another Java Program

A.java

```
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 ***



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

```
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( l: 1, w: 2,  h: 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 is the output is a 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

```
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.