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

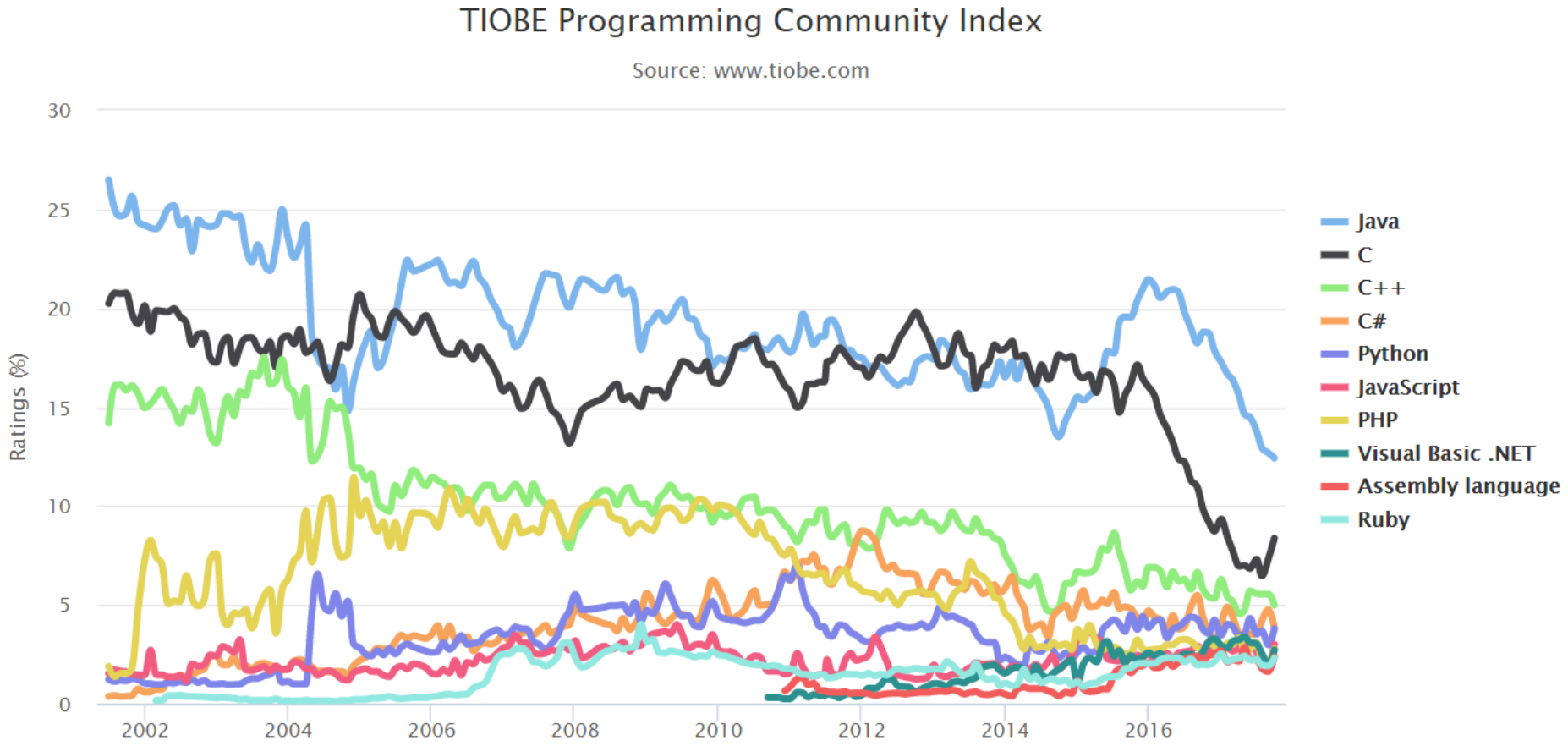
What is Java

- **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

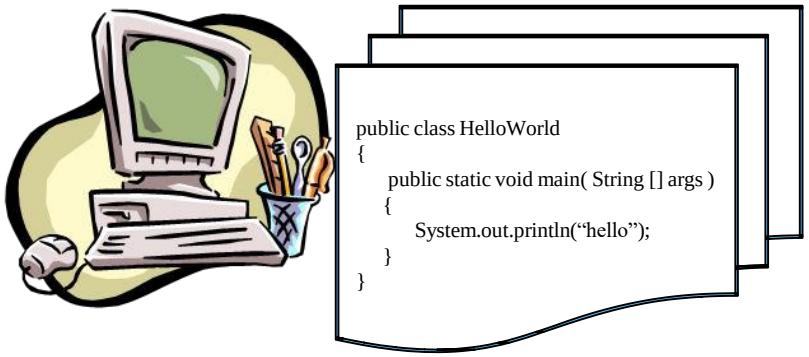
Java – The Most Popular



Java Editions

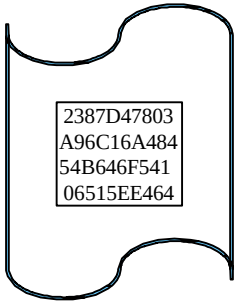
- Java 2 Platform, Standard Edition (J2SE)
  - Used for developing Desktop based application and networking applications
- Java 2 Platform, Enterprise Edition (J2EE)
  - Used for developing large-scale, distributed networking applications and Web-based applications
- Java 2 Platform, Micro Edition (J2ME)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

Java platform



HelloWorld.java

Compile
javac

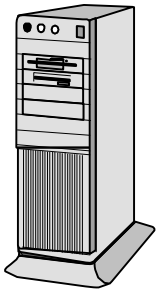


HelloWorld.class

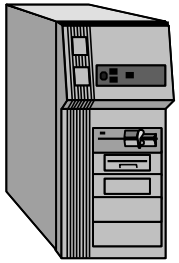
Java
Bytecode

Java
Interpreter

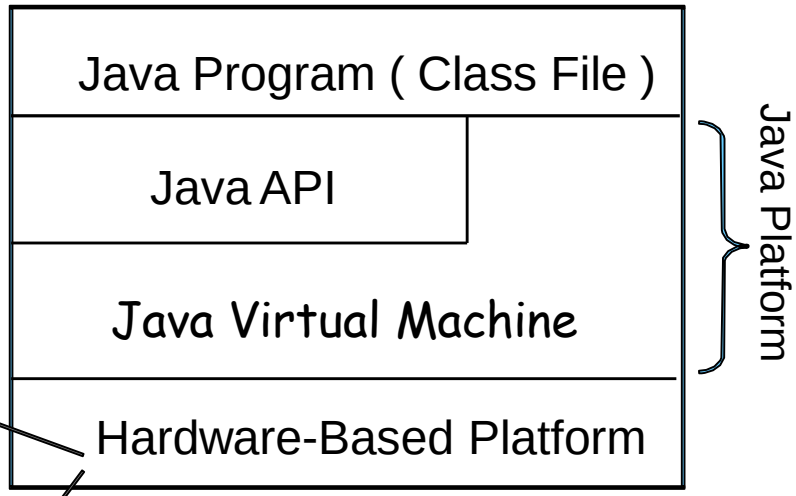
Windows NT



Java
Interpreter



Power Macintosh



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
  - JCreator
  - **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

Welcome.java

```
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\jdk1.8.0_144\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

```
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

```
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

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

```java
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 b1; // b1 refers to null
        Box b2; // b2 refers to null
        b1 = new Box( l: 8,  w: 5,  h: 7); // b1 refers to new object (8, 5, 7)
        b2 = b1; // b2 refers to b1, so both refers (8, 5, 7)
        b1 = new Box( l: 3,  w: 9,  h: 2); // b1 refers to new object (3, 9, 2)
        b1 = b2; // b1 refers to b2, what happens to object (3, 9, 2)
    }
}
```

Textbook

- We will mostly follow Java 8, if time permits will see the new features of Java 9
- Books
  - Java: The Complete Reference, 9th Edition by Herbert Schildt
  - Effective Java, 2nd edition by Joshua Bloch (for future)
- Web
  - http://rifatshahriyar.github.io/CSE107.html