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

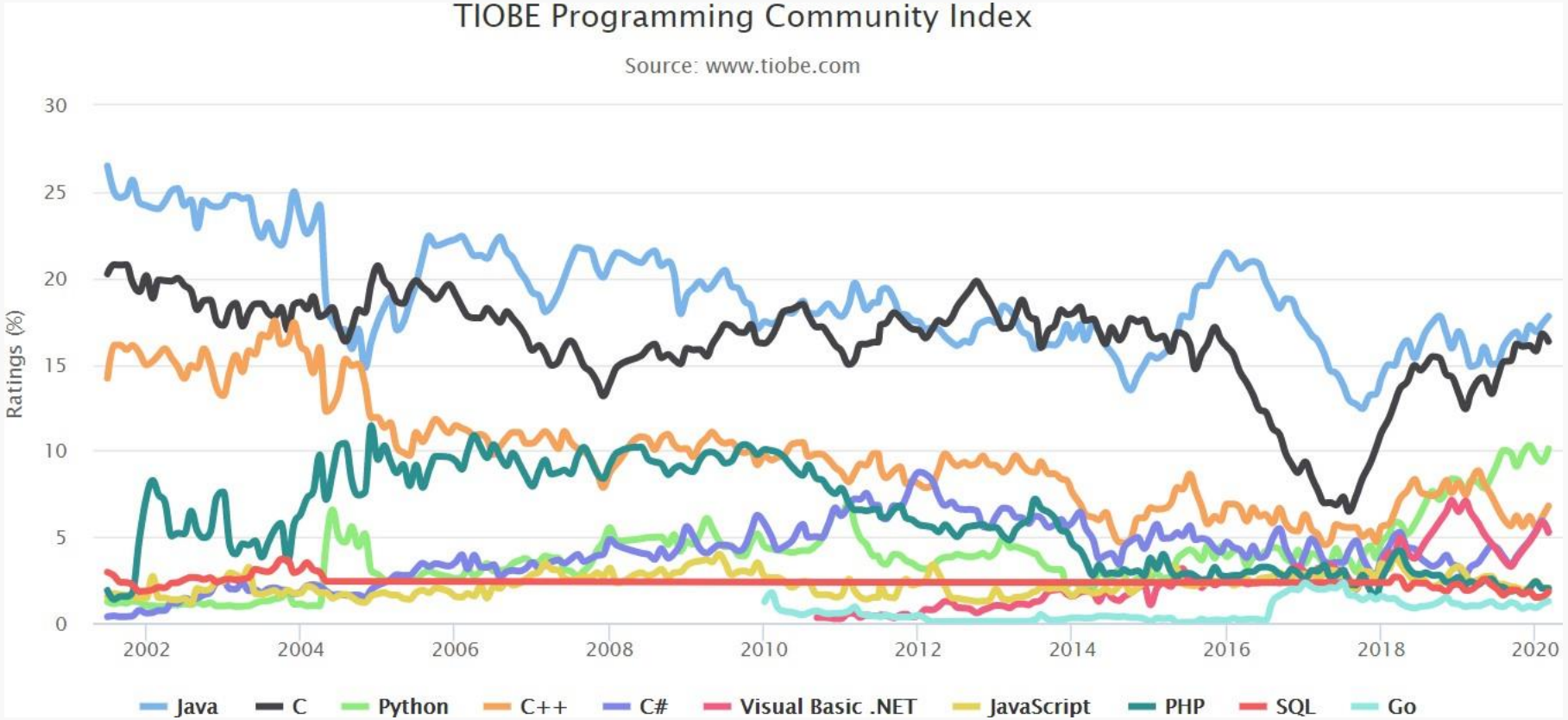
What is Java

- **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

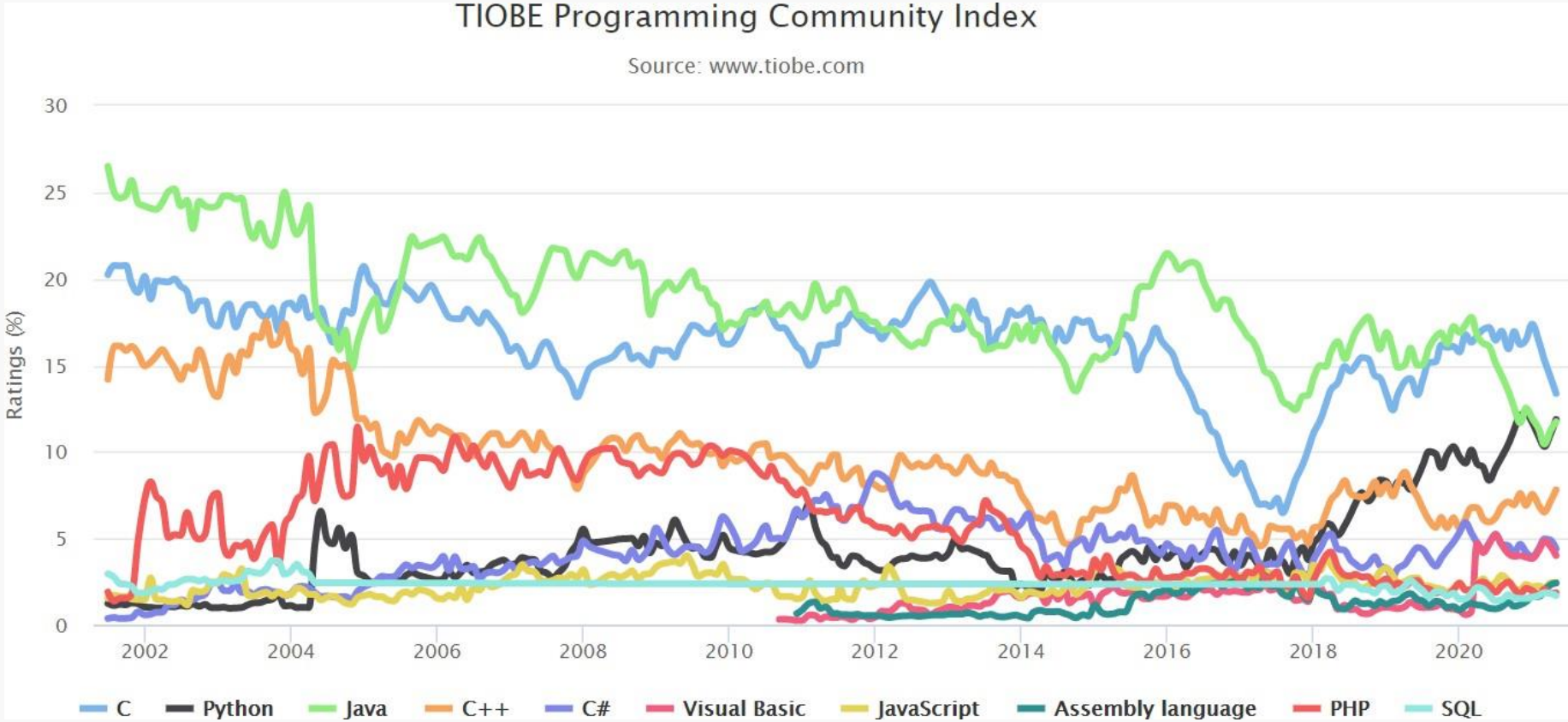
What is Java

- **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.

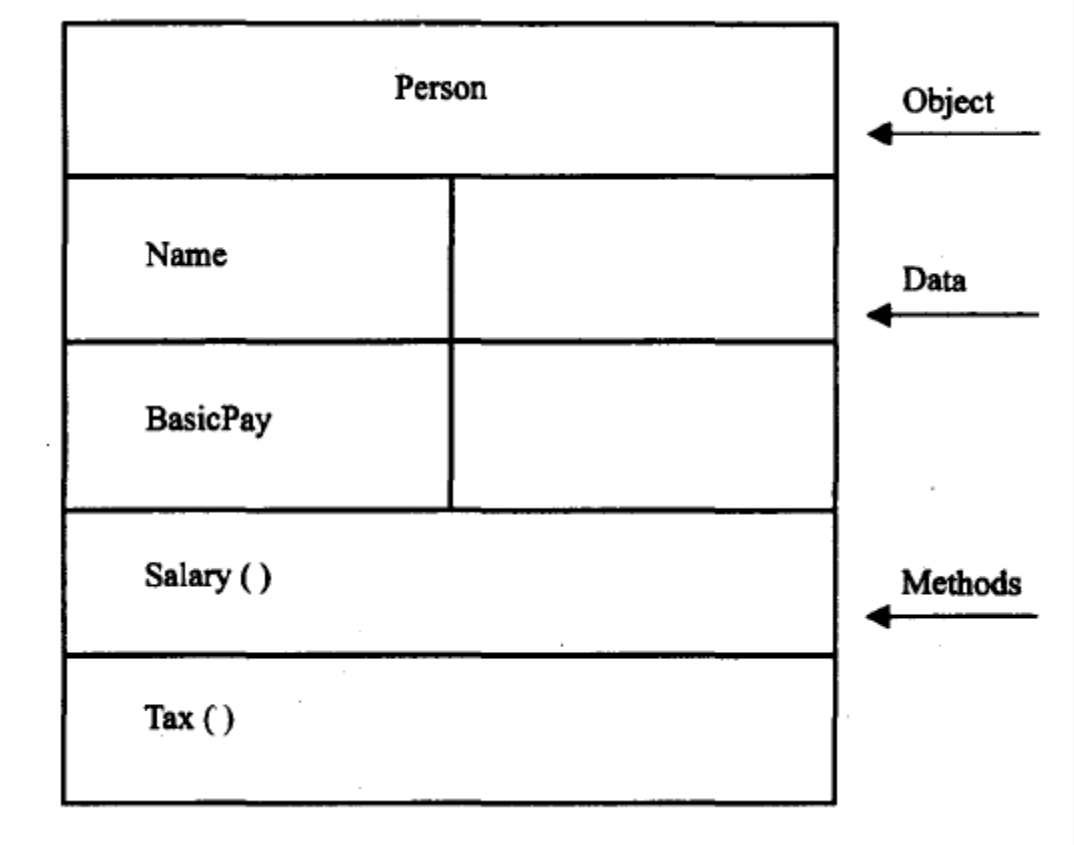
Programming Language	2021	2016	2011	2006	2001	1996	1991	1986
C	1	2	2	2	1	1	1	1
Java	2	1	1	1	3	15	-	-
Python	3	5	6	8	25	24	-	-
C++	4	3	3	3	2	2	2	6
C#	5	4	5	7	13	-	-	-
Visual Basic	6	13	-	-	-	-	-	-
JavaScript	7	7	10	9	9	20	-	-
PHP	8	6	4	4	10	-	-	-

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

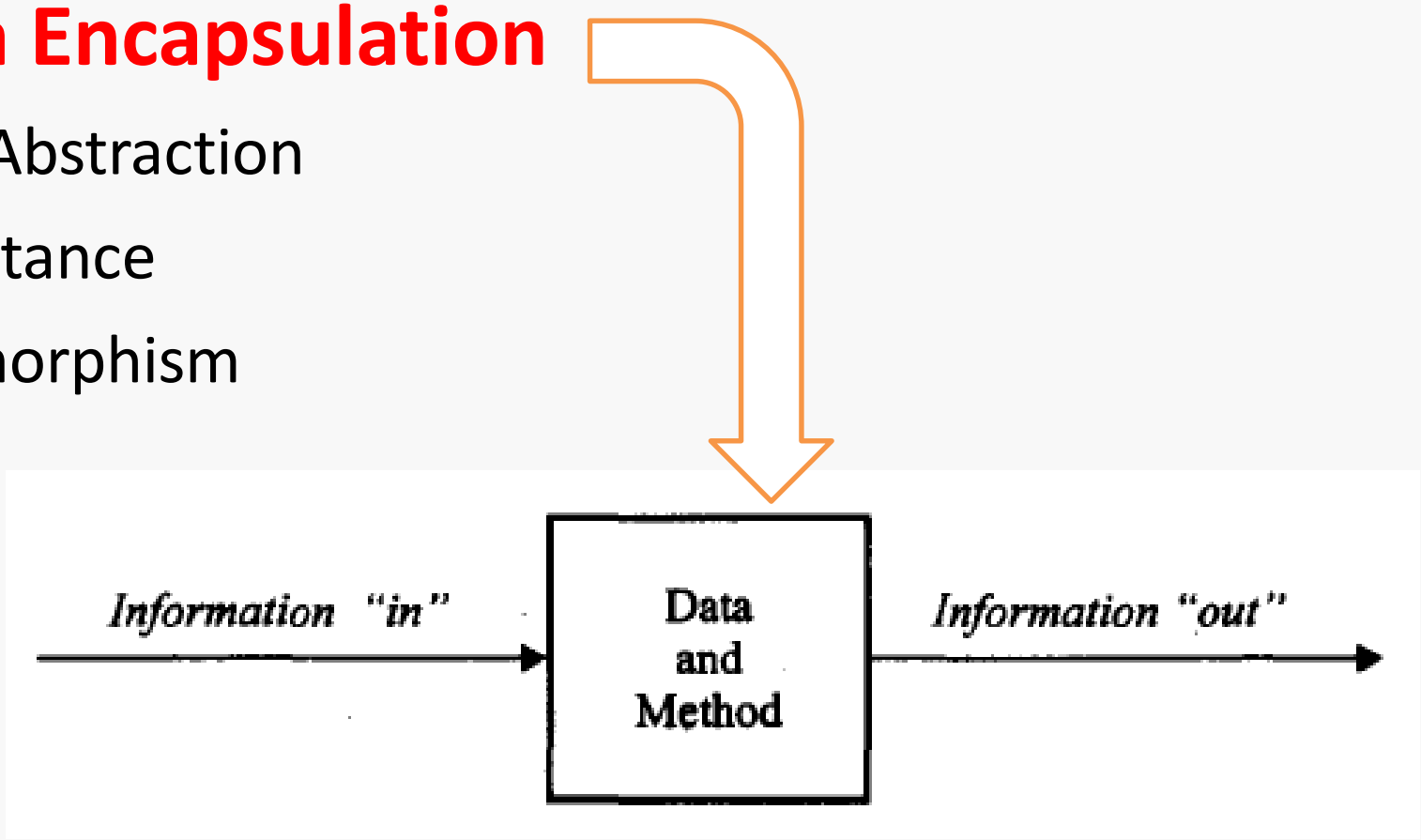
OOP Paradigm

- Class
- Object
- Methods
- Data



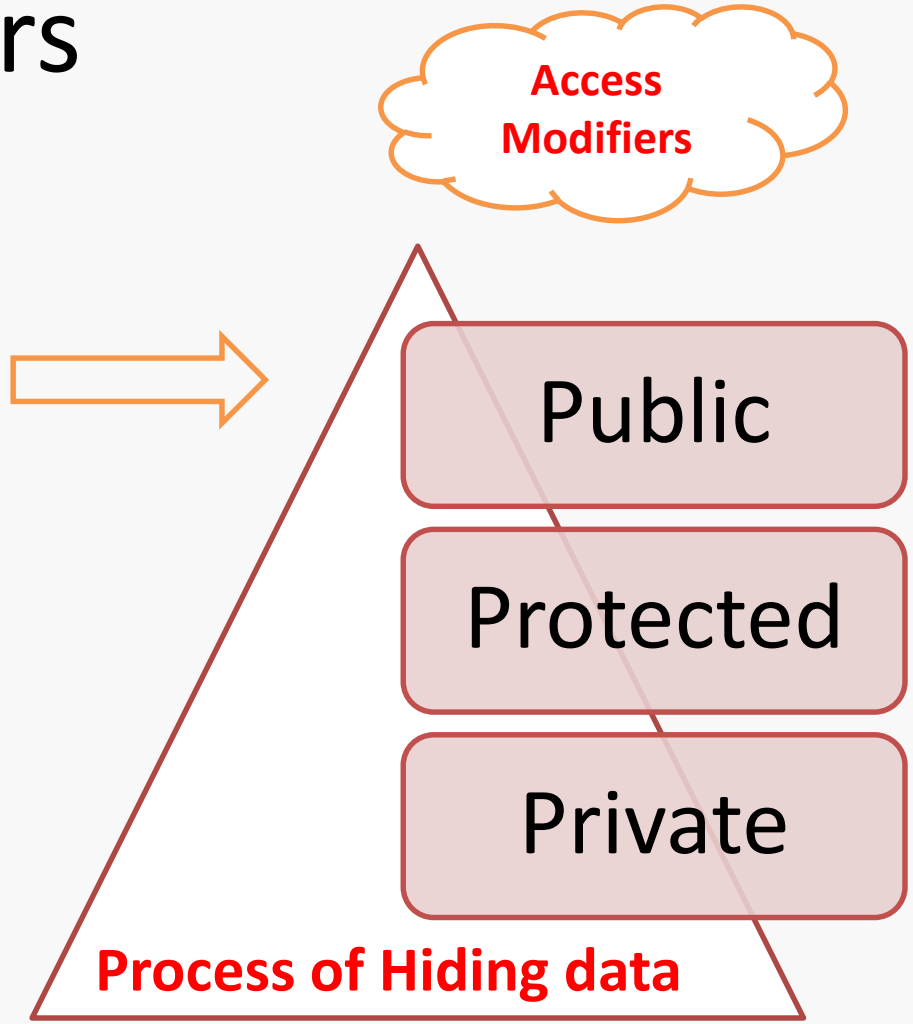
OOP Pillars

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



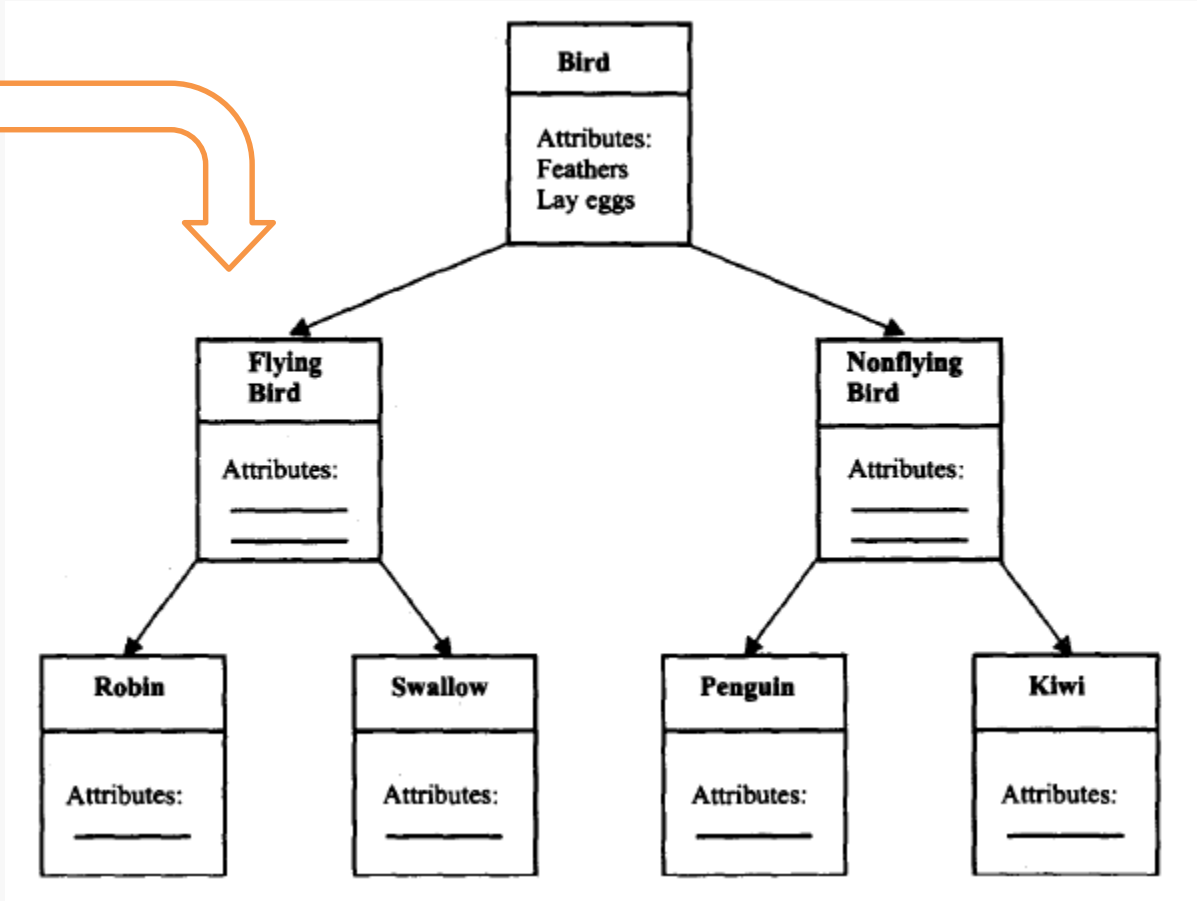
OOP Pillars

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



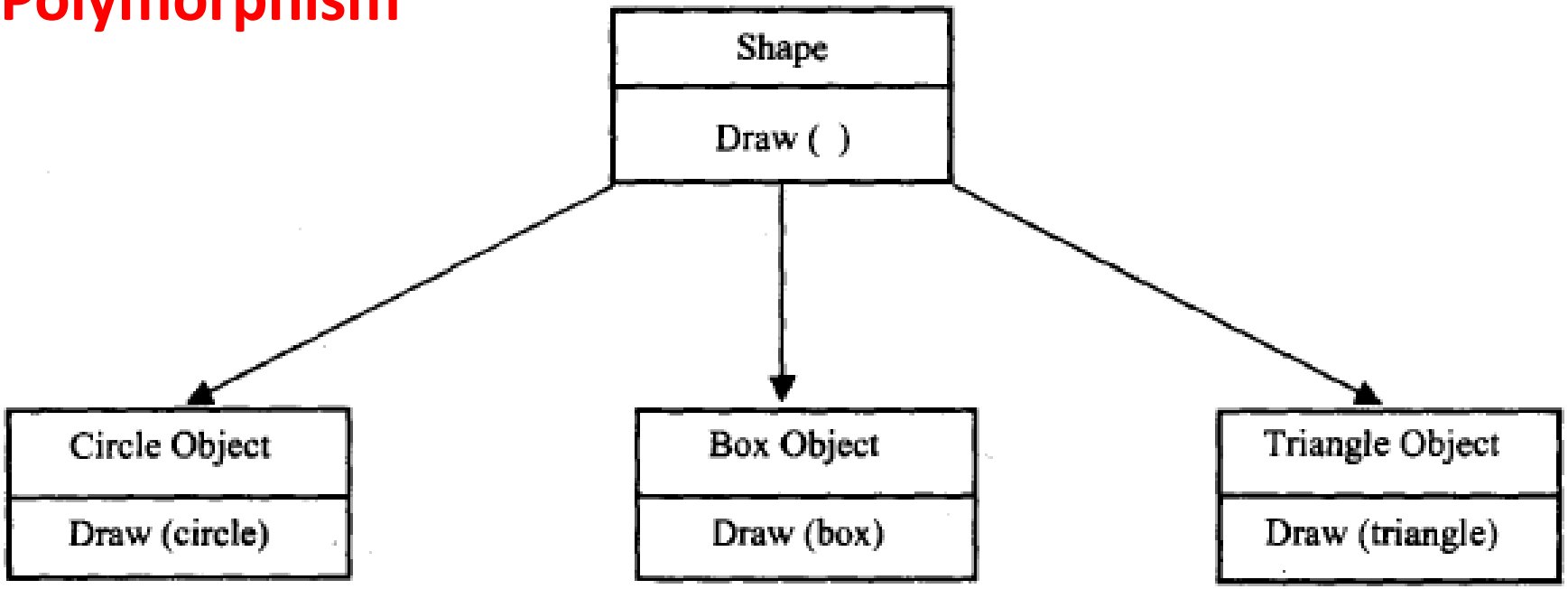
OOP Pillars

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



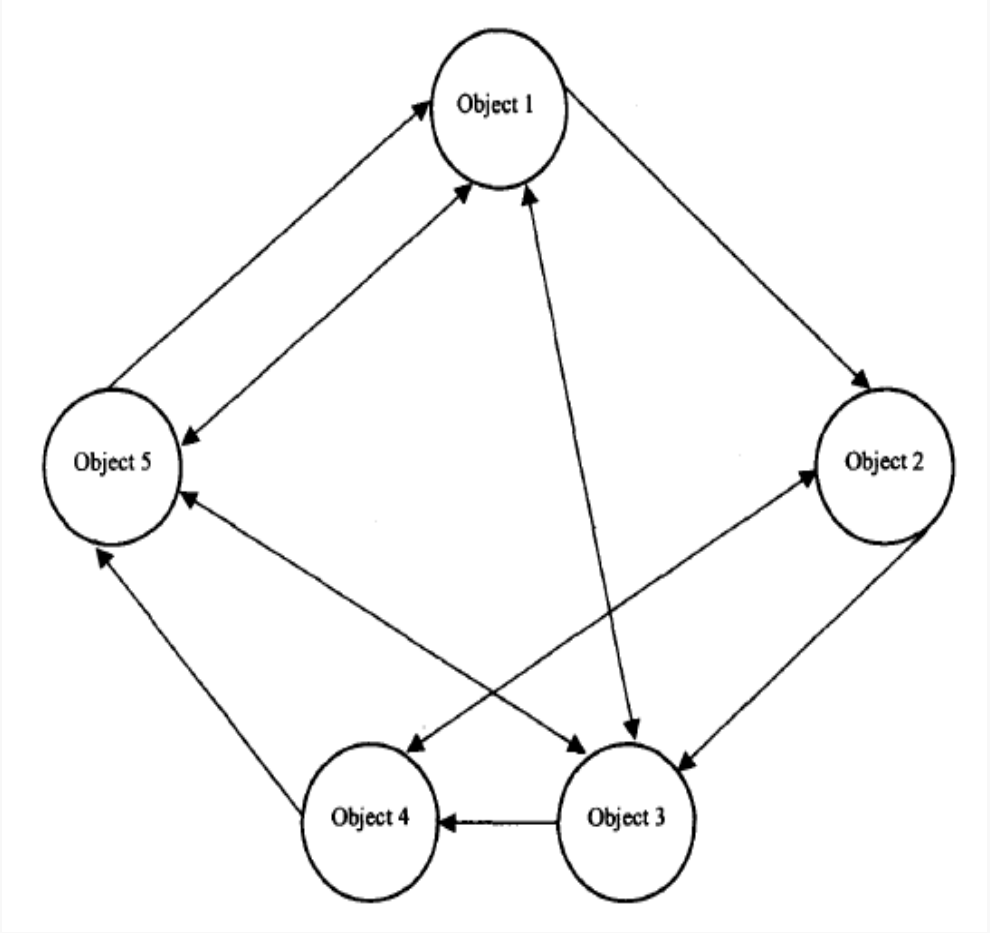
OOP Pillars

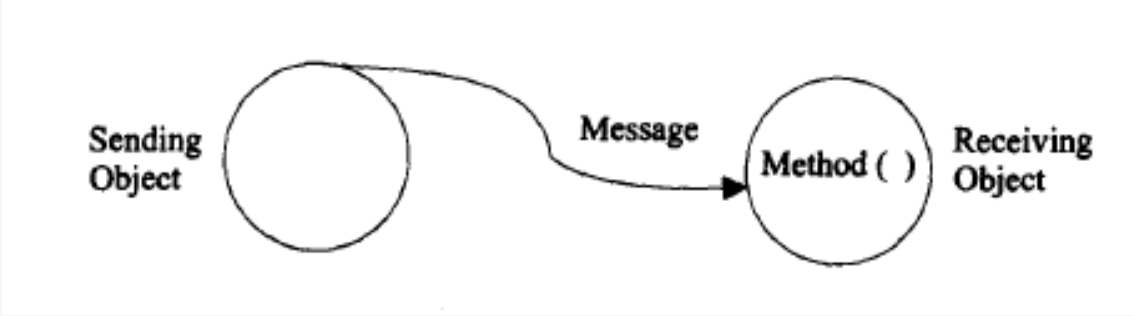
- Data Encapsulation
- Data Abstraction
- Inheritance
- **Polymorphism**



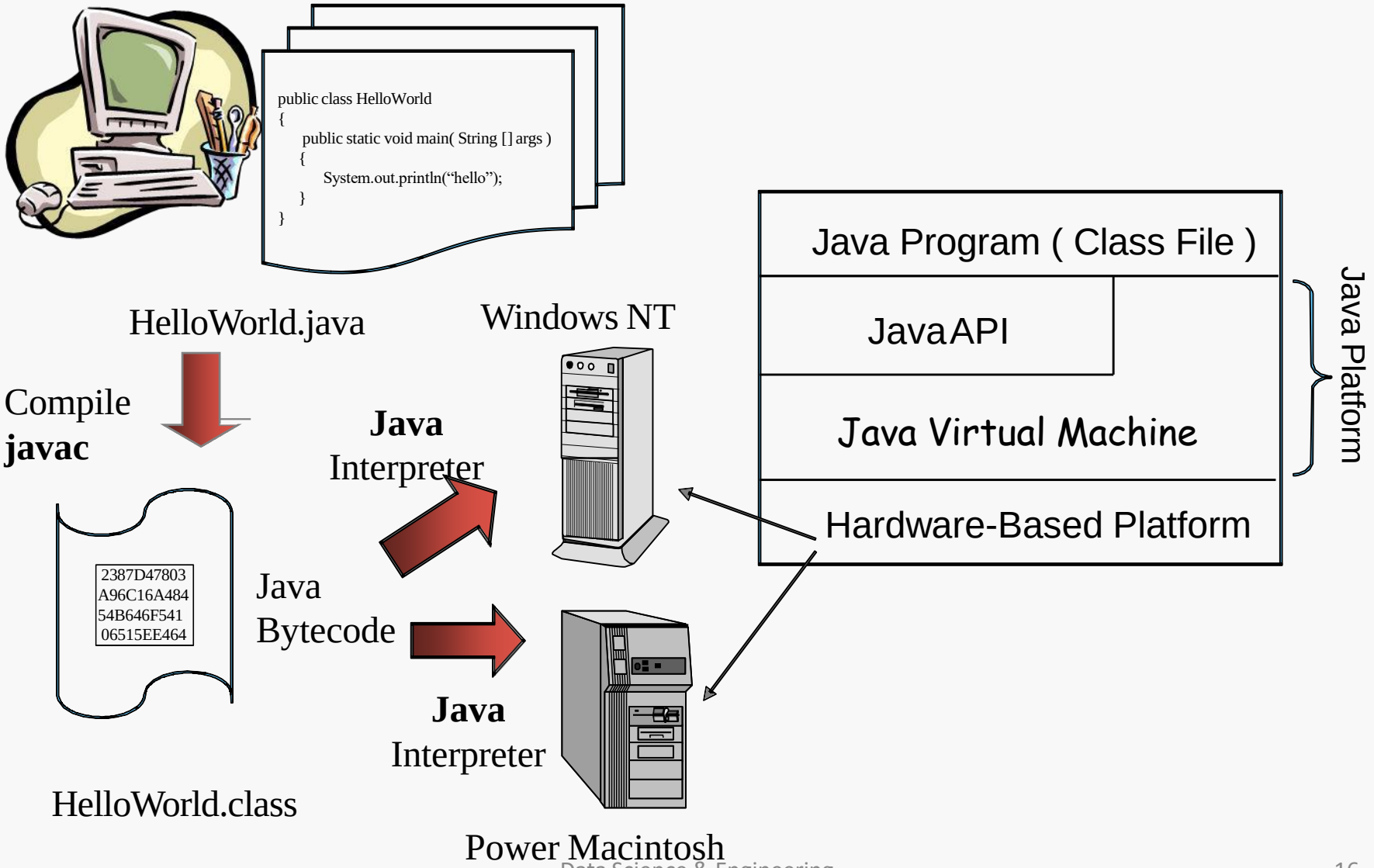
Message Communication

- 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.

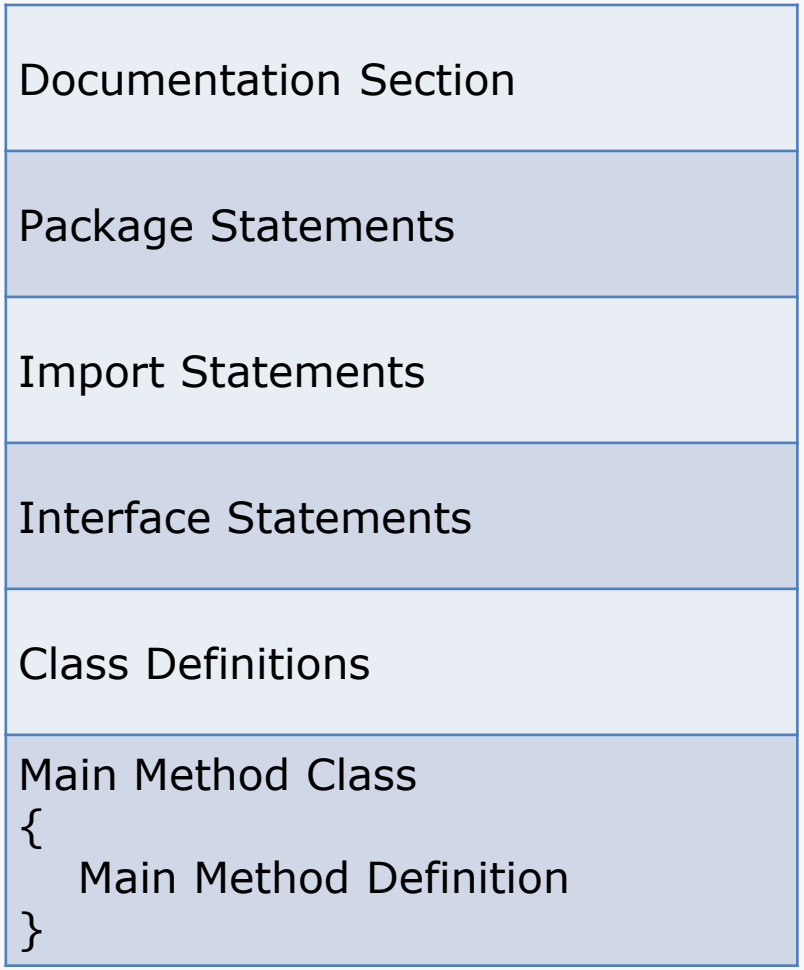




Java Execution Procedure



Java Program Structure



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

helloWorld.java | firstProgram.java

```
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

- ***System.out.println()***
  - Used to print a line of text followed by a new line***(ln)***
  - **System** is a class in java.lang package
  - **out** is a public static member of class System
  - **out** represents the standard output stream
  - **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

READING INPUT FROM KEYBOARD

```
int a;
Scanner sc = new Scanner(System.in);
 a = sc.nextInt();
```

1) int nextInt()

It is used to read an integer value from the keyboard.

2) float nextFloat()

It is used to read a float value from the keyboard.

3) long nextLong()

It is used to read a long value from the keyboard.

```
import java.util.Scanner;
```

4) String next()

It is used to read string value from the keyboard.

Scanner example

```
import java.util.Scanner;

class test

{       public static void main(String args[])

        {       int a,b,c;

                Scanner sc = new Scanner(System.in);

               System.out.println("Enter a first number");

                a = sc.nextInt();

                System.out.println("Enter a second number");

                b = sc.nextInt();

                c = a+ b;

                System.out.println("sum is :"+c);

         }

 }
```

Scanner example-2

```
import java.util.Scanner;
class GetInputFromUser{
  public static void main(String args[])  {
        int a;
        float b;
        String s;
        Scanner in = new Scanner(System.in);
        System.out.println("Enter a string");
        s = in.nextLine();
        System.out.println("You entered string "+s);
        System.out.println("Enter an integer");
        a = in.nextInt();
        System.out.println("You entered integer "+a);
        System.out.println("Enter a float");
        b = in.nextFloat();
        System.out.println("You entered float "+b);
  }
```

```
System.out.println("Enter character: ");
char charInput = sc.next().charAt(0);
```

Data Types and Variables

Java Keywords

abstract	continue	for	new	switch
assert	default	goto	package	synchronized
boolean	do	if	private	this
break	double	implements	protected	throw
byte	else	import	public	throws
case	enum	instanceof	return	transient
catch	extends	int	short	try
char	final	interface	static	void
class	finally	long	strictfp	volatile
const	float	native	super	while

Comments

- // for single line, /* and */ for multiline

Data Types and Variables

Primitive Data Types

- **Integers**:
  - **Java does not support unsigned integers**

Name	Width in bits	Range	
long	64	-9,223,372,036,854,775,808	9,223,372,036,854,775,807
int	32	-2,147,483,648	2,147,483,647
short	16	-32,768	32,767
byte	8	-128	127

- **Floating-Point**:

Name	Width in bits	Approximate Range	
double	64	4.9e-324	1.8e+308
float	32	1.4e-045	3.4e+038

- **Character**: char 16 (Unicode)
- **Boolean**: boolean 8 (true, false)

Data Types and Variables

Identifiers

- Used for naming variables, methods, classes, interfaces and packages
- Sequence of uppercase and lowercase letters, numbers, underscore and dollar-sign characters
- Keywords cannot be used
- Must not begin with a number
- Case sensitive
- Conventions:
  - **Variables and Methods**: Mixed Case
    - first letter of each word except the first word in uppercase, others in lowercase
  - **Interfaces and Classes**: Camel Case
    - first letter of each word in uppercase, others in lowercase
  - **Packages**: Lower Case

Question:

```
2  class BoolTest
3  {
4  public static void main(String args[])
5  {
6      boolean b;
7      b = false;
8      System.out.println("b is " + b);
9      b = true;
10     System.out.println("b is " + b);
11     if(b)
12         System.out.println("This is executed.");
13     b = false;
14     if(b)
15         System.out.println("This is not executed.");
16     System.out.println("10 > 9 is " + (10 > 9));
17     }
18 }
```

```
b is false
b is true
This is executed.
10 > 9 is true
```

Data Types and Variables

Scope and Lifetime of Variables

- **Example:**

```
void test()
{
  int x = 10;
  if (x == 10)
        {
              int y = 20;          // y = 20
              x = y * 2;           // x = 40
              System.out.println("x = " + x);
              System.out.println("y = " + y);
        }
  y = 100;                  // cannot find symbol
  x = x + 15;
  System.out.println("x = " + x);
}
```

Operators

Arithmetic and Relational Operators

Operator	Result
+	Addition
-	Subtraction (also unary minus)
*	Multiplication
/	Division
%	Modulus
++	Increment
--	Decrement
+=	Addition assignment
-=	Subtraction assignment
*=	Multiplication assignment
/=	Division assignment
%=	Modulus assignment

Operator	Result
==	Equal to
!=	Not equal to
>	Greater than
<	Less than
>=	Greater than or equal to
<=	Less than or equal to

Operator precedence Groups

highest

Operator Category	Operators	Associativity
Unary operators	+ - + + - - !	R→L
Arithmetic operators	* / %	L→R
Arithmetic Operators	+ -	L→R
Shift Operators	<< >>	L→R
Relational operators	< <= > >=	L→R
Equality operators	== !=	L→R
Bitwise AND	&	L→R
Bitwise XOR	^	L→R
Bitwise OR	|	L→R
Logical AND	&&	L→R
Logical OR	||	L→R
Conditional expression	? :	R→L
Assignment operator	= += -= *= /= %=	R→L

lowest

Control Statements

Selection statements

- The *if* statement

  Syntax: Same as in C and C++

  - ***if* statements can be nested**
  - ***if-else-if* ladder can be used**

- The *switch* statement

  Syntax: Same as in C and C++

  - ***switch* statements can be nested**

  Note:

  From JDK 7 onwards, strings can be used as case labels in 'switch' statement

Iteration statements

- The *while* statement

  Syntax: Same as in C and C++

- The *do-while* statement

  Syntax: Same as in C and C++

- The *for* statement

  Syntax: Same as in C and C++

Control Statements

Jump (transfer of control) statements

- **Basic form of the *break* statement**

  Syntax: Same as in C and C++

  - **Used with switch statement and loops**

- **Labeled *break* statement**

  Syntax: ***break*** **label;**

Control Statements

```
1  class break_example
2  {
3    public static void main(String args[])
4    {
5      for (int i = 0; i < 2; i++)
6      {
7          for (int j = 0; j < 3; j++)
8          {
9              if ( j == 1 )
10                 break;
11             System.out.println ("In");
12         }
13
14         System.out.println ("Mid");
15     }
16
17     System.out.println ("Out");
18
19   }
20 }
```

OUTPUT

```
In
Mid
In
Mid
Out
```

Type Conversion and Casting

- **Automatic Conversion: Conditions**
  - **Two types are compatible**
    - **Numeric types (integer and floating-point) are compatible with each other**
  - **Destination type is larger than source type**
- **Examples:**
  - **byte to int – possible**
  - **Any numeric type to char/boolean – not possible**
  - **char and boolean – not compatible with each other**
- **Automatic type conversion is done when a literal integer constant is stored into variables of type byte, short, long and char**

Type conversion example:

```
1. int  a = 2;
2. float  b = 2.5f;
3. double  c = 11.11;
4. a = c;       // Error
5. b = c;       // Error
6. c = a;       // OK
7. c = b;       // OK
```

BitwiseAdd.java
DataTypeConversion.java
DataTypeCon2.java

Data Types and Variables

Type Conversion and Casting (Continued ...)

- Syntax: (target-type) value
- Example: int a; byte b; b = (byte) a;

- Truncation in case of floating-point values
  - Example: 1.23 assigned to integer → 1 (0.23 truncated)
- Examples:

```
byte b;
int i = 257;
double d = 323.142;
b = (byte) i;        // 1 (remainder of special type of division)
i = (int) d;               // 323 (0.142 lost)
b = (byte) d;        // 67 (0.142 lost and reduced to modulo)
```

Data Types and Variables

Automatic Type Promotion in Expressions

- Depends on precision required
  - Precision required by an intermediate value exceeds the range of either operand
- Example 1:
  - byte a = 40, b = 50, c = 100; int d = a * b / c;
    - Result of a * b exceeds range of byte
    - Promotes byte, short operand to int during evaluation
    - a * b is performed using integers and …
- Example 2:
  - byte b = 50; b = b * 2;
    - Error, cannot assign an int to a byte (operands promoted to int)
    - Use explicit type-casting

```
byte b = 50;
b = (byte) (b * 2);
```

Arrays

One-Dimensional Arrays

- **Syntax:** type var-name[];
  - Only declaration, memory not allocated
  - Allocate memory using new operator

    array-var = new type[size]
- **Example 1:**

  int one[];

  one = new int [5];
- **Example 2:**

  int one[] = new int [12];
- **Example 3:**

  int one[] = {1, 2, 3, 4, 5};

Arrays

Two-Dimensional Arrays

- **Syntax: type var-name[][];**
  - Only declaration, memory not allocated
  - Allocate memory using new operator

    array-var = new type[size][size]
- **Example 1:**

  int two[][];

  two = new int [3][2];
- **Example 2:**

  int two [][] = new int [3][2];
- **Example 3:**

  int two[][] = {{1, 2}, {3, 4}, {5, 6}};

Arrays

Two-Dimensional Arrays (Continued …)

- **Example 4:**

```
int two[][] = new int [3][];
two [0] = new int [2];
two [1] = new int [2];
two [2] = new int [2];
```

- **Example 5:**

```
int two [][] = new int [3][];
two [0] = new int [1];
two [1] = new int [3];
two [2] = new int [2];
```

(Differing-size second dimension)

Array Example:

```
2  class ArrayDemo
3  {
4      public static void main( String []args)
5      {
6          int A[], size;
7          Scanner S = new Scanner(System.in);
8          System.out.println("Enter the size of array:");
9          size = S.nextInt();
10
11         A = new int[size];
12
13         System.out.println("Enter elements: ");
14         for( int i = 0 ; i < size ; i++ )
15             A[i] = S.nextInt();
16
17         System.out.println("Array elements are: ");
18         for( int i = 0 ; i < A.length ; i++ )
19             System.out.println( A[i] );
20     }
21 }
```

OUTPUT

```
Enter the size of array:
4
Enter elements:
11 22 33 44
Array elements are:
11
22
33
44
```

2-D Array example:

```
1  class Array2DTest
2  {
3      public static void main( String []args )
4      {
5          int M[][] = { { 11 , 22 , 33 } ,
6                        { 44 , 55 , 66 }
7                      };
8          for( int i = 0 ; i < M.length ; i++)
9          {
10             for( int j = 0 ; j < M[i].length ; j++ )
11                 System.out.printf("%d\t", M[i][j] );
12             System.out.println();
13         }
14     }
15 }
```

```
11      22      33
44      55      66
```

2-D Array example-2:

```
1  class Array2DTest
2  {
3      public static void main( String []args )
4      {
5          int M[][] = { { 11 , 22 , 33 } ,
6                        { 44 } ,
7                        { 55 , 66 }
8                      };
9          for( int i = 0 ; i < M.length ; i++)
10         {
11             for( int j = 0 ; j < M[i].length ; j++ )
12                 System.out.printf("%d\t", M[i][j] );
13             System.out.println();
14         }
15     }
16 }
```

```
11      22      33
44
55      66
```

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.