

Core Java Language Fundamentals

By

Anand Kulkarni

anand.pune38@gmail.com

Contents

| Module | Topic |
|-----------|--------------------------------------|
| Module 1 | Introduction to Java |
| Module 2 | Classes & objects |
| Module 3 | OOP concepts in Java |
| Module 4 | Inheritance & Polymorphism |
| Module 5 | Interfaces |
| Module 6 | Packages |
| Module 7 | Wrapper classes |
| Module 8 | String, StringBuffer & StringBuilder |
| Module 9 | Reflection |
| Module 10 | Annotations |
| Module 11 | Enums |
| Module 12 | Nested classes |

Introduction to Java

Java History

- In 1991, a small group of Sun Microsystem engineers called the 'Green Team' was formed. 'Green Team' was led by James Gosling.
- 'Green Team' initiated a revolutionary task to develop a language for controlling consumer devices such as set-top boxes, televisions etc.
- Later on it was found that this language is suited for internet programming.
- Earlier name of this language was 'Greentalk', then changed to 'Oak' & finally in 1995, it was named as 'Java'.
- 'Java' is an island of Indonesia where first coffee was produced (called java coffee).



Java Version History

JDK Alpha and Beta (1995)

JDK 1.0 (23rd Jan, 1996)

JDK 1.1 (19th Feb, 1997)

J2SE 1.2 (8th Dec, 1998)

J2SE 1.3 (8th May, 2000)

J2SE 1.4 (6th Feb, 2002)

J2SE 5.0 (30th Sep, 2004)

Java SE 6 (11th Dec, 2006)

Java SE 7 (28th July, 2011)

Java SE 8 (18th March, 2014)

Java Features

- Simple
- Object-Oriented
- Platform independent
- Secure
- Robust
- Architecture neutral
- Portable
- Dynamic
- Multithreaded
- Distributed

Java Features continue...

- *Simple*

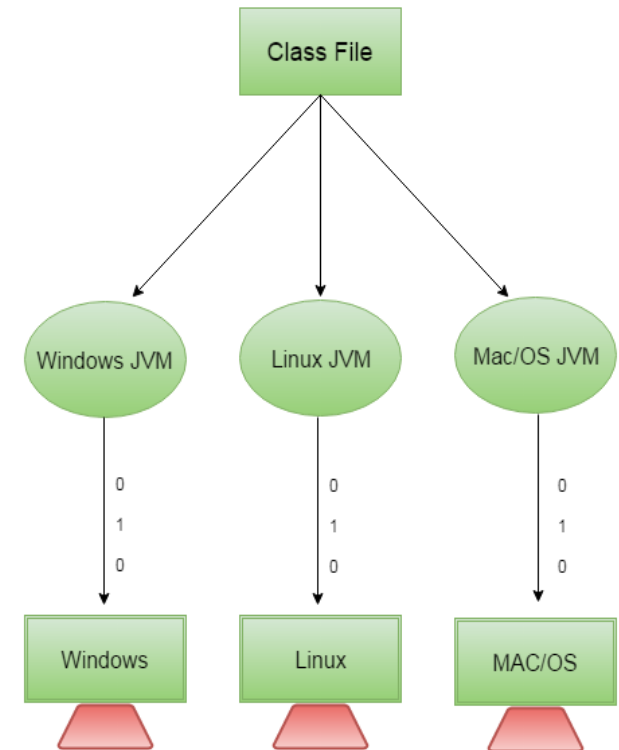
Java syntax is based upon C++. However, java has removed several complex topics from C++ like pointers, virtual base class, friend functions, structures, operator overloading, private inheritance etc.

- *Object-Oriented*

Java is an object oriented language. It supports basic pillars of OOP like class, object, data abstraction, encapsulation, inheritance & polymorphism.

- *Platform independent*

- ✓ Compiling java source file generates .class file, also called as byte code.
- ✓ The byte code is a platform independent code. It means that the same byte code can run on any platform like windows, linux, mac etc.
- ✓ Java provides JVM (Java Virtual Machine) which is an abstract computing machine that enables a computer to run a Java program.



Java Features continue...

- *Secure*

- ✓ Java is more secure than C or C++ because Java does not support explicit pointer.
- ✓ When we run a java program, it is loaded by classloader then the byte code verified by 'byte code verifier' & finally 'security manager' checks the security of the program.

- *Robust*

Robust language is a language where the program withstands in worst scenario. Java is robust because it uses strong memory management. Java developer can only allocate memory but memory deallocation is taken care by java using 'garbage collector (GC)'.

- *Architecture neutral*

Java provides fix size of every primitive. For example integer takes 4 bytes irrespective of operating system or underlying hardware architecture.

- *Portable*

Java is portable because we can run byte code on any machine & any operating system. Also, memory consumption is same on all platforms since primitive data size is platform independent.

Java Features continue...

- *Dynamic*

In Java, all methods are by default virtual & it makes java a dynamic language. Java dynamically allocates memory for a method only when it is called.

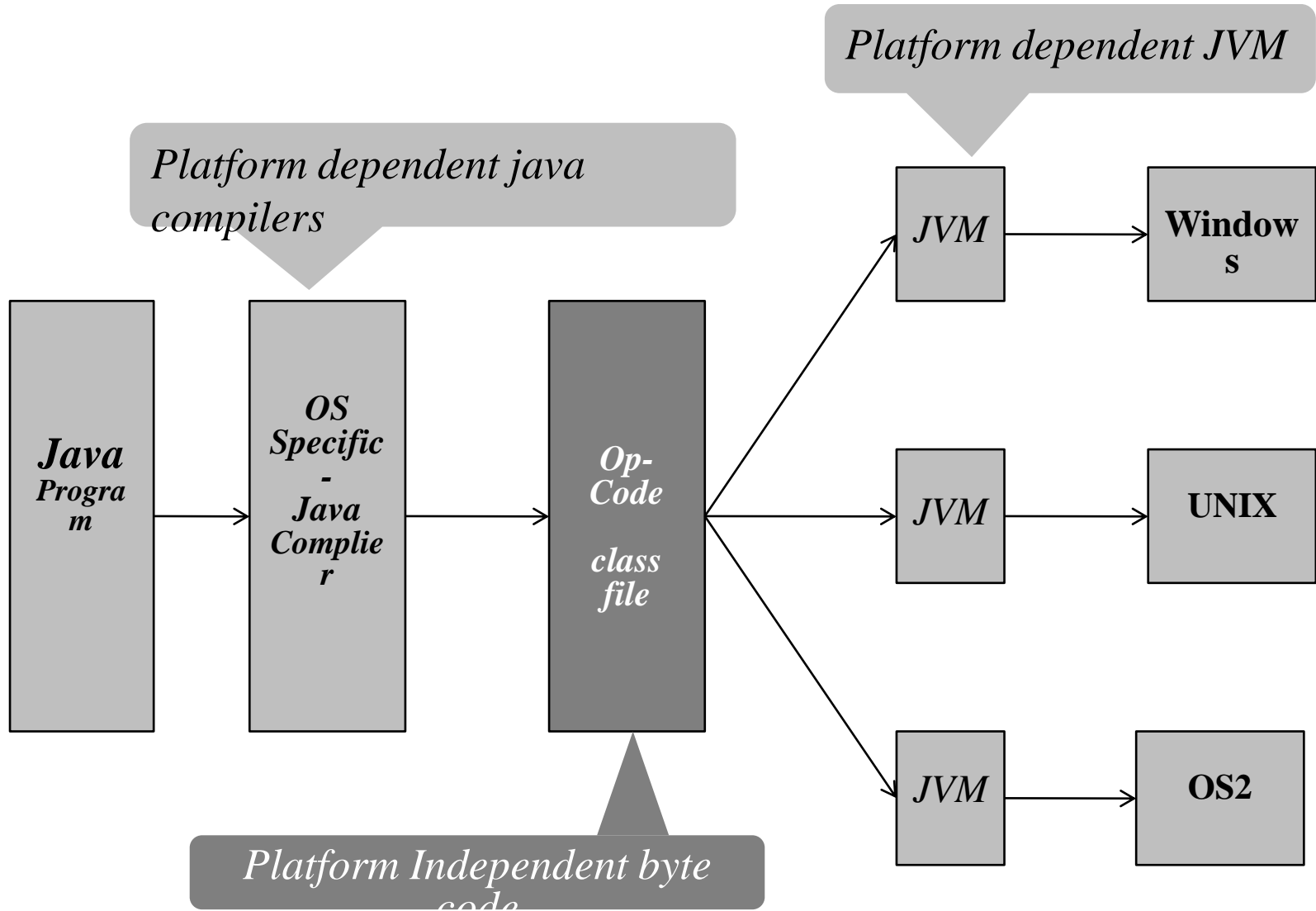
- *Multithreaded*

Java provides us rich APIs to work on multithreaded application. Using java APIs, we can create a new thread, control its priority, apply synchronization etc.

- *Distributed*

Distributed application provides us communication between two java processes. We can create a distributed application in Java using RMI (Remote Method Invocation).

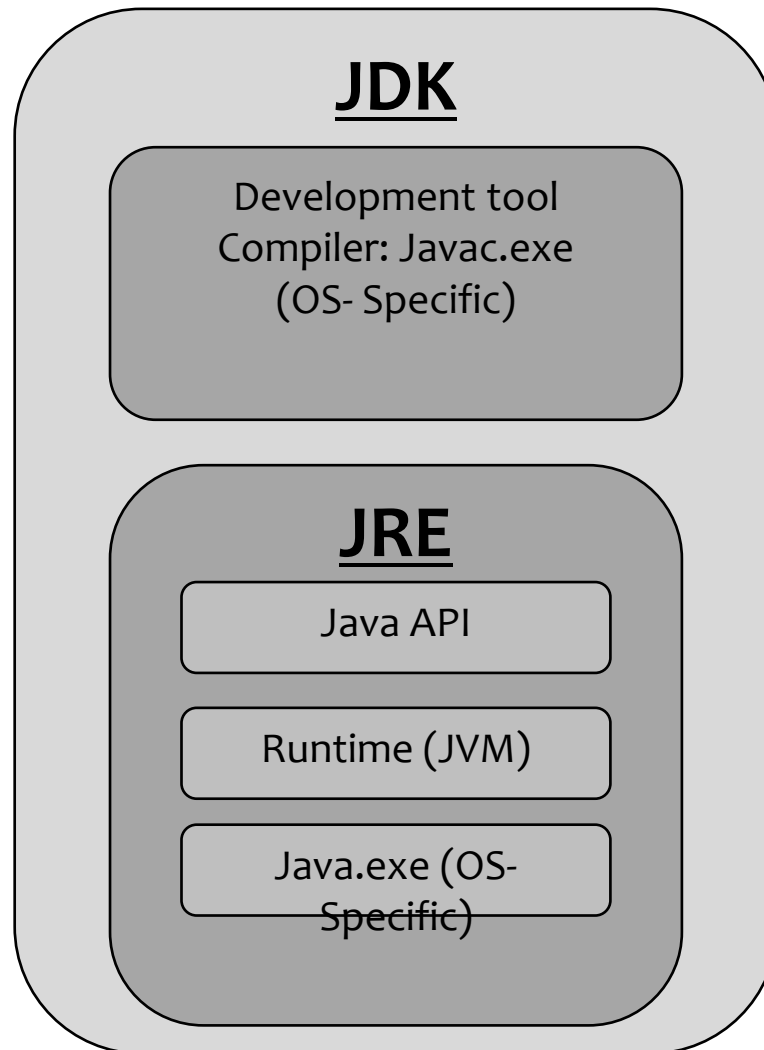
JVM (Java Virtual Machine)



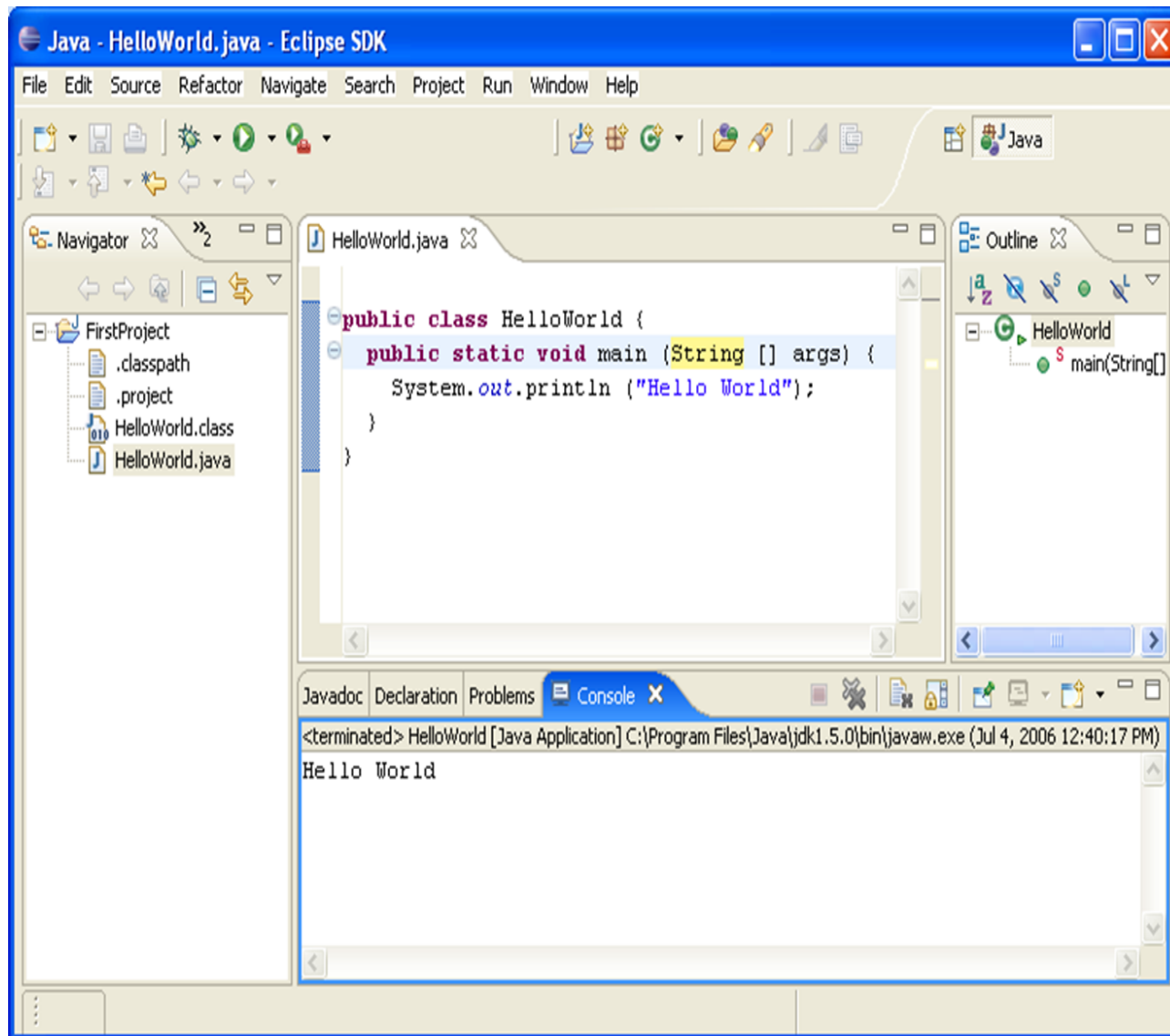
JVM (Java Virtual Machine)

- JVM is an abstract computing machine that enables a computer to run a Java program.
- JVM is a specification. You can find different implementations of JVM i.e. Oracle's Hotspot, BEA System's JRockit etc.
- JVM implementation is platform dependent.
- JVM provides Java its cross-platform capabilities.
- JVM consists of JIT (Just-in-time) compiler & interpreter. JIT compiler compiles byte code into the instructions understood to underlying platform where as interpreter interprets them one by one.

Important terms in Java



IDE (Integrated Development Environment)



Popular IDEs

- NetBeans
- Eclipse
- IntelliJ
- jDeveloper

‘Hello World’ program

```
public class HelloWorld {  
    public static void main(String args[]) {  
        System.out.println("Hello World!!");  
    }  
}
```

Note:

The class in which we write main() method, that class name should be given to the name of the file. For example: HelloWorld.java

A java source file can have maximum only one public class.

Compiling & running a program

- Set the environment variable PATH to Java's bin directory.
- To compile, at the command prompt, type:
javac -d . HelloWorld.java
- If there are no errors, there should be a file called **HelloWorld.class** in your working directory.
- To run the program, at the command prompt, type:
java HelloWorld

Naming conventions in Java

Classes:

First character of every word should be capital while other characters should be small. Need not use an Underscore. Ex : class HelloWorld.

Variables or Methods:

First character of every word except first word should be capital while other characters should be small. Need not use Underscore. Ex: method:- void showData(){
} variable:- int empNo = 100;

Packages:

All characters should be small. Ex: package threading;

Constants:

All characters should be capital. Ex : float PI = 3.142;

Java Data Types

| Primitive data types | User defined data types |
|----------------------|-------------------------|
| | |
| byte | class |
| short | enum |
| int | Array |
| long | |
| float | |
| double | |
| char | |
| boolean | |

Primitive Data Types

| byte | 8-bit integer (signed) Size (-2^7 to 2^7-1) |
|---------|--|
| short | 16-bit integer (signed) Size (-2^{15} to $2^{15}-1$) |
| int | 32-bit integer (signed) Size (-2^{31} to $2^{31}-1$) |
| Long | 64-bit integer (signed) Size (-2^{63} to $2^{63}-1$) |
| Float | 32-bit floating-point. Precision to 7-8th digit |
| Double | 64-bit floating-point. Precision to 16-18th digit |
| boolean | either true or false |
| char | 16-bit Unicode |

Comments in Java

```
public class Temperature {  
    /** The program is written by  
    @ Author Ivan Ericsson  
    */  
    public static void main (String [ ] args) {  
        //Variable declaration  
        /* double centigrade;  
        double fahrenheit;  
        */  
        double centigrade;  
        double fahrenheit;  
        centigrade = 33.33;  
        fahrenheit = (centigrade * 9 / 5) + 32;  
        System.out.println("Centigrade = "  
        +fahrenheit + " Fahrenheit.");  
    }  
}
```

documentation comment

Single line comment

Multiple line comment

Arithmetic Operators

| | |
|---|----------------|
| + | addition |
| - | subtraction |
| * | multiplication |
| / | division |
| % | remainder |

Unary minus (-) for negation

Unary plus (+).

Increment and Decrement Operators

```
public class IncOp {  
    public static void main(String[] args) {  
        int i = 1;  
        System.out.println (++i + " " + i++ + " " + i);  
    }  
}
```

What will the output of this program?

Assignment Operators

Let initial value of j be 15,

`i = j;`

`i += 5;`

`i = i + 5;`

`i -= 5;`

`i *= 5;`

`i /= 5;`

`i %= 5;`

What would be the final value for 'i'?

Conditional and Comparison Operators

== Comparison Operator

!= Not Equal To Operator

< , > Greater than and Less than operators

<= , >= Greater than or equal to / Less than or equal to

Logical and Boolean Operators

```
public class Test {  
    public static void main (String [ ] args) {  
        if( getConnection() && openFile()){  
            System.out.println("true ");  
        }  
        else{  
            System.out.println("false ");  
        }  
    }  
    public static boolean getConnection() {  
        System.out.println("connecting...");  
        return false;  
    }  
    public static boolean openFile(){  
        System.out.println("opening file");  
        return true;  
    }  
}
```

The if...else Structure

```
if (expression){  
    statement1;  
}  
else {  
    statement2;  
}
```

The if...else Structure (Cont...)

```
class Larger {  
    public static void main (String [ ] args) {  
        int a = 10;  
        int b = 15;  
        if (a > b){  
            System.out.println ("A is Larger.");  
        }  
        else{  
            System.out.println ("B is Larger.");  
        }  
    }  
}
```

Nested if...else

```
class LargestOutOfThree {  
    public static void main(String[] args) {  
        int a = 25, b = 15, c = 10, largest;  
        if (a > b) {  
            if (a > c)  
                largest = a;  
            else  
                largest = c;  
        } else {  
            if (b > c)  
                largest = b;  
            else  
                largest = c;  
        }  
        System.out.println("Largest : " + largest);  
    }  
}
```

Another Example For if...else if... Blocks

```
public class DayOfWeek {  
    public static void main(String[] args) {  
        int dayOfWeek = Integer.parseInt(args[0]);  
        if (dayOfWeek == 0)  
            System.out.println("Sunday");  
        else if (dayOfWeek == 1)  
            System.out.println("Monday");  
        else if (dayOfWeek == 2)  
            System.out.println("Tuesday");  
        else if (dayOfWeek == 3)  
            System.out.println("Wednesday");  
        else if (dayOfWeek == 4)  
            System.out.println("Thursday");  
        else if (dayOfWeek == 5)  
            System.out.println("Friday");  
        else if (dayOfWeek == 6)  
            System.out.println("Saturday");  
    }  
}
```

The switch Statement (Contd..)

```
switch (dayOfWeek) {  
    case 0: System.out.println ("Sunday");  
    case 1: System.out.println ("Monday");  
    case 2: System.out.println ("Tuesday");  
    case 3: System.out.println ("Wednesday");  
    case 4: System.out.println ("Thursday");  
    case 5: System.out.println ("Friday");  
    case 6: System.out.println ("Saturday");  
  
    default : System.out.println ("ERROR!");  
}
```

The switch Statement

```
switch (dayOfWeek) {  
    case 0: System.out.println ("Sunday"); break;  
    case 1: System.out.println ("Monday");break;  
    case 2: System.out.println ("Tuesday");break;  
    case 3: System.out.println ("Wednesday");break;  
    case 4: System.out.println ("Thursday");break;  
    case 5: System.out.println ("Friday");break;  
    case 6: System.out.println ("Saturday");break;  
  
    default : System.out.println ("ERROR!");  
}
```

The while Loop

```
public class WhileLoop {  
    public static void main(String[] args) {  
        int i = 1;  
        while (i <= 19) {  
            System.out.println (i);  
            i += 2;  
        }  
    }  
}
```


The do...while Loop

```
public class DoWhileLoop {  
  
    public static void main(String[] args) {  
        int i = 0;  
        do {  
            System.out.println (i);  
            i += 2;  
        } while (i <= 19);  
    }  
  
}
```

The for Loop

```
public class ForLoop {  
  
    public static void main(String[] args) {  
        int i;  
        for (i = 1; i<=10; i++){  
            System.out.println (i);  
        }  
    }  
}
```

break and continue Statements

```
public class TestBreakContinue {  
  
    public static void main(String[] args) {  
        for (int i = 1; i <= 70; i++) {  
            if (i % 7 == 0)  
                continue;  
            System.out.print(" " + i);  
  
            if (i % 40 == 0) {  
                System.out.println("Terminating  
Loop");  
                break;  
            }  
        }  
    }  
}
```

Labeled break and continue Statements

```
public class LabeledBreak {  
  
    public static void main(String[] args) {  
        outer:  
        for (int i = 1; i <= 10; i++) {  
            for (int j = 1; j <= 5; j++) {  
                System.out.print("\t" + (i * j));  
                if ((i * j) == 18) {  
                    break outer;  
                }  
            }  
            System.out.println();  
        }  
    }  
}
```

Classes & objects

What is a class?

- A class is nothing but a blueprint or a template for creating different objects which defines its properties and behaviors.
- A **class** can contain fields and methods to describe the behavior of an object.

Sample class

```
public class Date {
```

```
    private int day;
```

```
    private int month;
```

```
    private int year;
```

```
    public Date() {
```

```
        this.day = 25;
```

```
        this.month = 7;
```

```
        this.year = 2010;
```

```
    }
```

```
    public Date(int day, int month, int year) {
```

```
        this.day = day;
```

```
        this.month = month;
```

```
        this.year = year;
```

```
    }
```

```
    public int getDay() {
```

```
        return this.day;
```

```
    }
```

```
}
```

Attributes

Default constructor

Parameterized constructor

Method

Creating an object

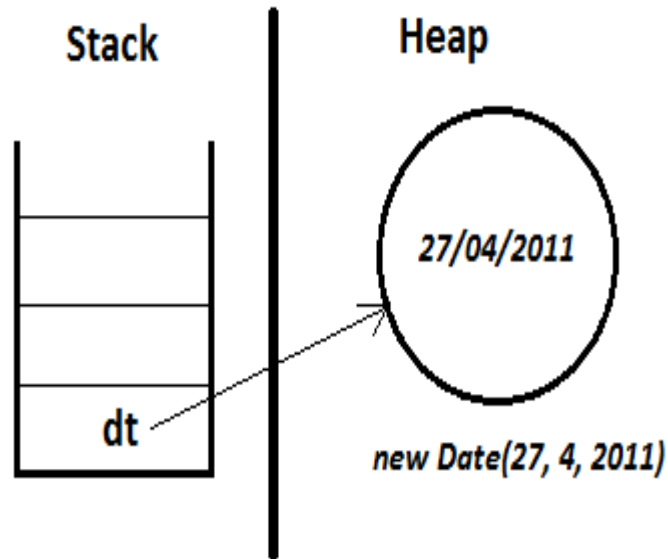
```
public class DateTest {  
    public static void main(String args[]) {  
        Date date1 = new Date(); //Calling default constructor  
        Date date2 = new Date(17, 4, 1995); //Calling parameterized  
constructor  
    }  
}
```


Creating an object continue...

In order to create java object, we call default or parameterized constructor on the class.

In java, objects are always created on heap segment of the process. For example:

```
Date dt = new Date(27, 4, 2011);
```



Var-Args

```
public class VarArgs {  
    static void test(int ... v) {  
        System.out.println("Number of arguments :  
                            "+v.length+" Contains : ");  
        for(int x : v){  
            System.out.println(x+" ");  
        }  
    }  
  
    public static void main(String[] args){  
        test(10);  
        test(1,435,78);  
        test();  
    }  
}
```

'static' keyword

'static' keyword in java can be used in 4 ways:

- ✓ Static as variable
- ✓ Static as method
- ✓ Static as class
- ✓ Static as block

'static' variables

```
public class Date {
```

```
    private int day;
```

```
    private int month;
```

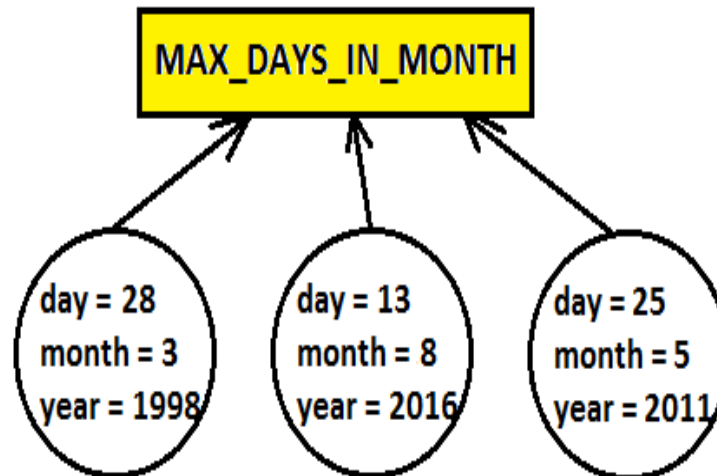
```
    private int year;
```

```
    private static MAX_DAYS_IN_MONTH = 31;
```

```
}
```

Instance variables/object variables/non-static variables

static variable/class variable



'static' variables continue...

- 'static' variables belong to the class & not to a specific instance.
- 'static' variables of a class always has single copy, irrespective of number of objects.
- The value of static variable can be changed.
- 'static' variables should be accessed using class name instance of object reference.

For example: `Date.MAX_DAYS_IN_MONTH = 31;`

'static' methods

- 'static' methods are used to manipulate static variables of a class.
- 'static' method can be called without creating any object of the class.
- 'static' method should be accessed using class name instead of object reference.

For example: `Date.setMaxDaysInMonth(31);`

- 'static' methods cannot access instance variables of a class because it does not have access to 'this' pointer.


'static' class

```
class OuterClass {  
    static class NestedClass {  
    }  
}
```

- 'static' keyword can be applied only on inner classes & not on outer.
- Like static class methods, a static nested class cannot refer directly to instance variables or methods defined in its enclosing class: it can use them only through an object reference.
- Static nested classes are accessed using the enclosing class name:
OuterClass.NestedClass nestedObject = new OuterClass.NestedClass();

'static' block

```
class Test {  
    private static int ary[] = new int[50]; //Array declaration  
    static {  
        for(int i=0; i<ary.length; i++) {  
            ary[i] = i * 3;  
        }  
    }  
}
```



static block

'static' block continue...

- Static block is initialized implicitly by JVM when JVM loads the class into memory.
- Thus, the entry point in java is not a main() method but static block.
- Static block is initialized once & only once.
- Static block cannot be called explicitly.
- A class can have multiple static blocks. However, JVM combines them together into a single block & initializes as per their order in source code.
- Static block can access only static variables & not instance variables because it does not have access to *'this'* pointer.
- Developers use static block to execute the code which you wish to execute once & only once.

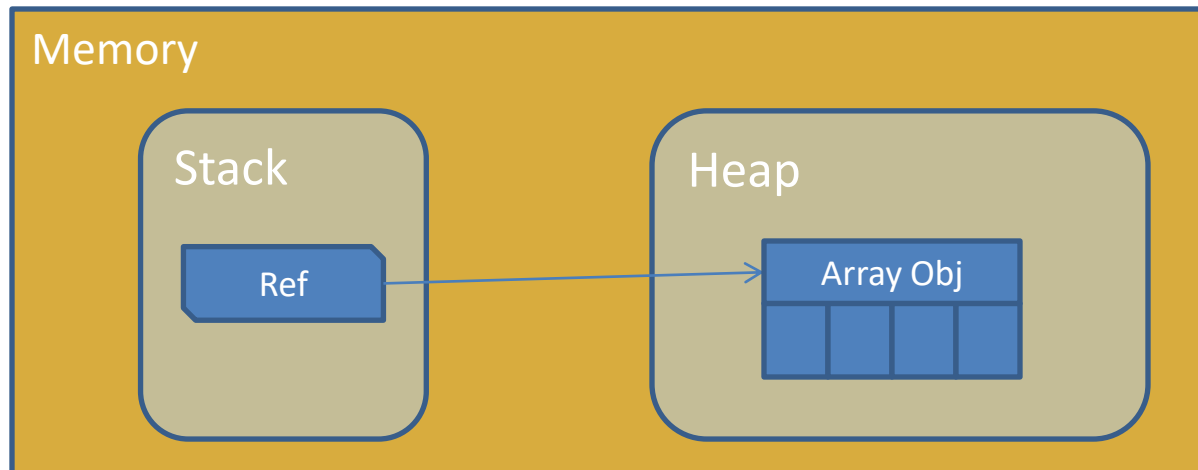
Arrays

Arrays

- In java, array is an object.
- Array Declaration

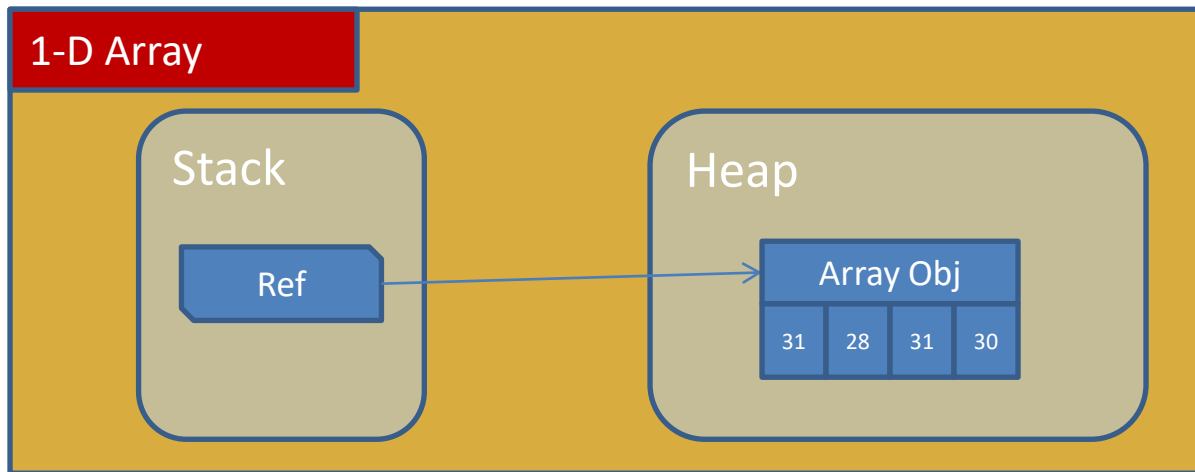
```
int [ ] intArray = new int [5];
int [ ][ ] array2D = new int [4][4];
```
- Length of an array

```
for (int i = 0; i < intArray.length; i++)
    System.out.println (intArray [i]);
```



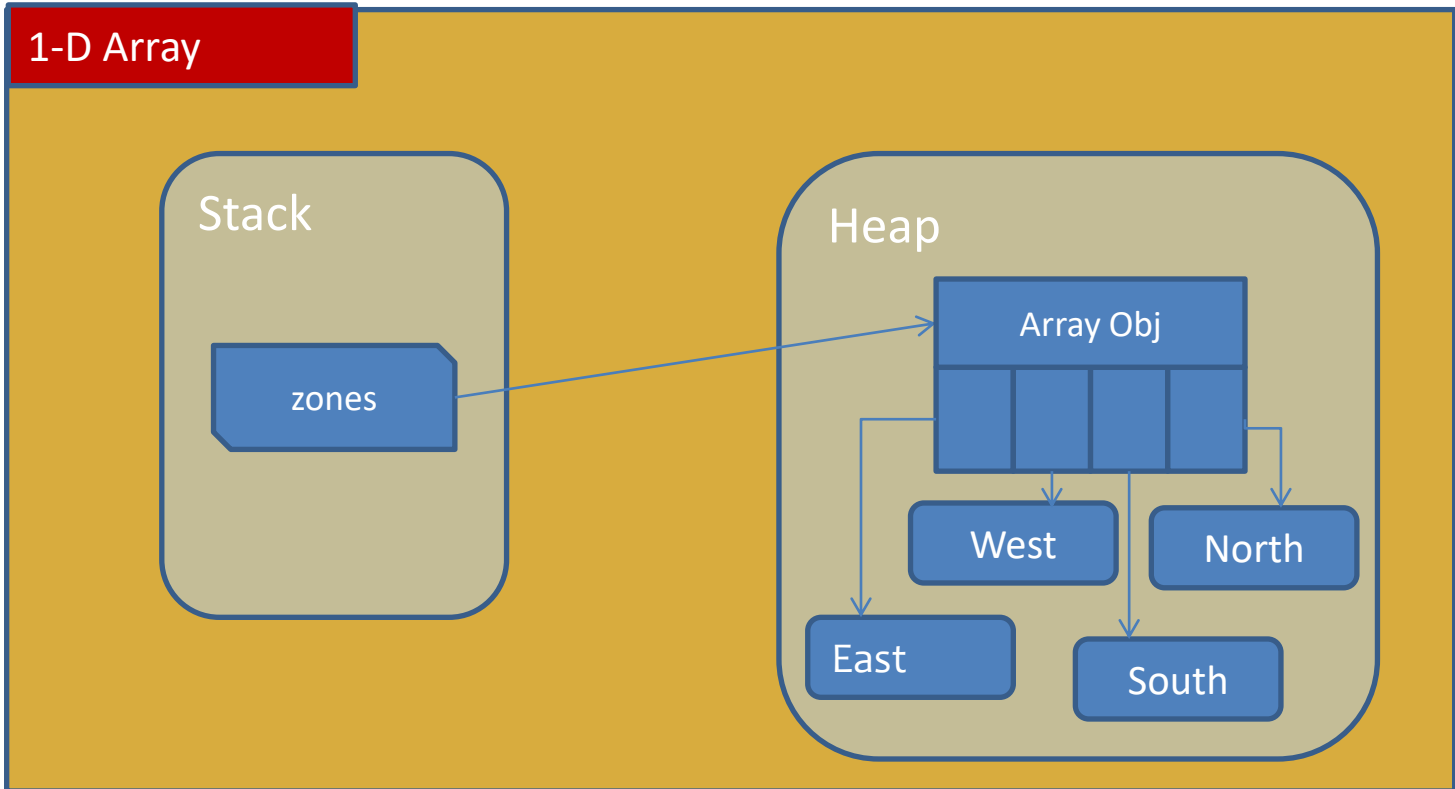
Arrays continue...

- Array Initialization
 - `int [] daysInMonths = { 31, 28, 31, 30, };`



Array Memory Map

- String [] zones = { "East", "West", "North", "South" } ;



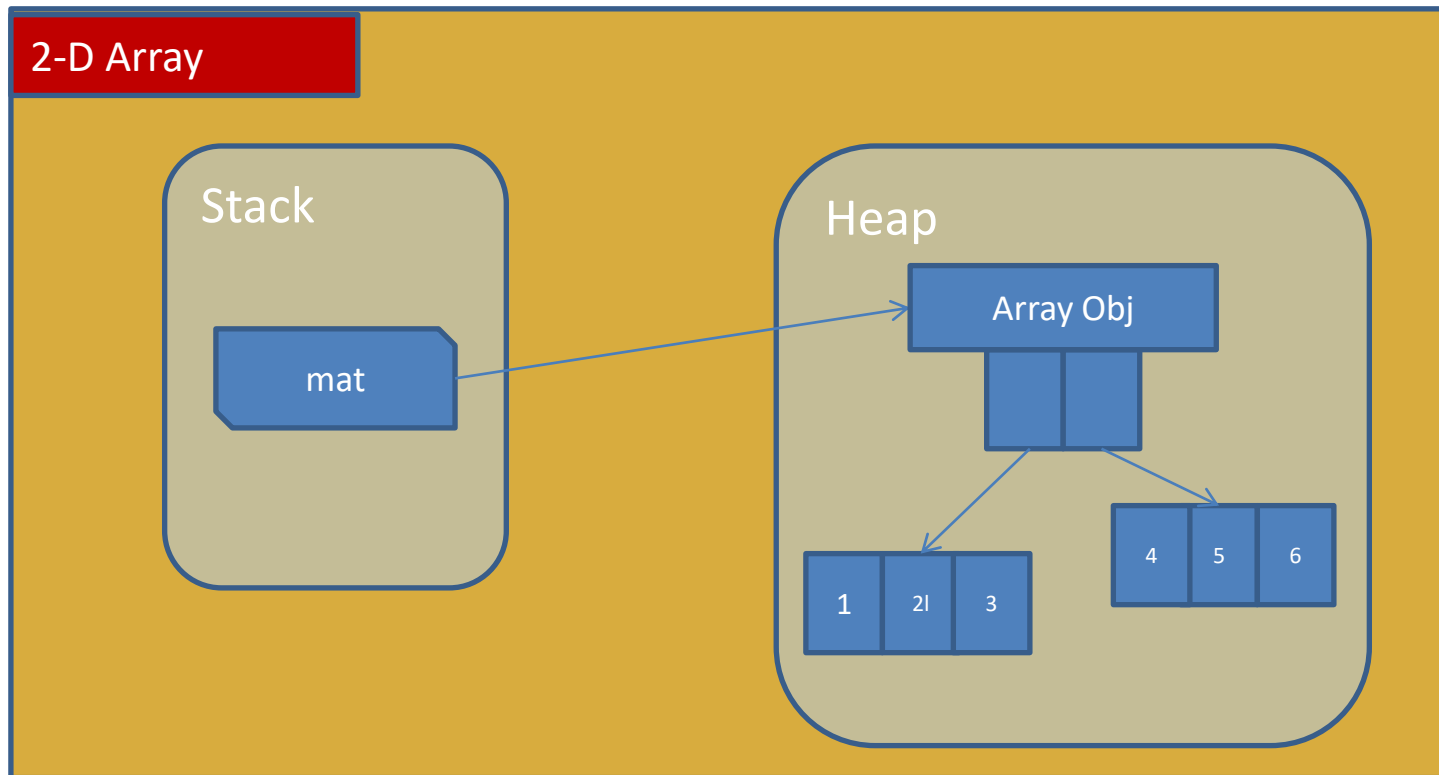
Arrays of Array

```
int [ ][ ] pascalsTriangle = {  
    {1},  
    {1, 1},  
    {1, 2, 1},  
    {1, 3, 3, 1},  
    {1, 4, 6, 4, 1}  
};
```

```
int[ ][ ] array2D = new array2D [ 5 ][ ]; // First subscript is mandatory.
```

Memory Map of 2-D array

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



OOP concepts

Introduction to OOP concepts

- In Object oriented programming, developer writes program to create & manipulate an object.
- Human being sees this world as a set of objects like fan, tube light, laptop, building, bus, car etc. OOP believes that the same concept we can use while writing program. Hence OOP concepts are based upon natural way of thinking. i.e. the way in which human think about this world, the same thought process is followed while writing program in OOP concepts. Due to this, developers feel object oriented language easier than a procedural language.
- Object oriented language is based upon four pillars:
 1. Data abstraction
 2. Encapsulation
 3. Inheritance
 4. Polymorphism

Data abstraction

- Data abstraction is a process of exposing only useful attributes of a class & keeping other attributes hidden.
- For example for a car object, one may expose car model, car name, car price & car color attributes to his friends where as other attributes like car insurance details, car engine number etc. can be kept hidden.

Encapsulation

- Encapsulation is a mechanism that binds together code and data in manipulates, and keeps both safe from outside interference and misuse.
- In encapsulation, the class becomes the 'capsule' or container for the data and operations.
- In short, a developer can achieve data abstraction using encapsulation.

Inheritance

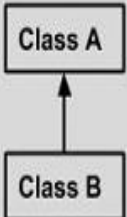
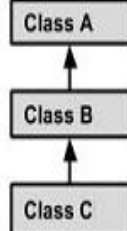
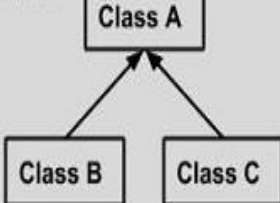
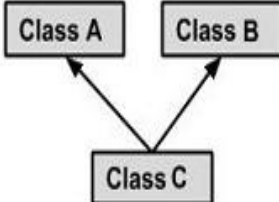
- Using inheritance, one object can acquire all properties and behaviors of another object also known as 'parent object'.
- Inheritance provides code reusability.

Polymorphism

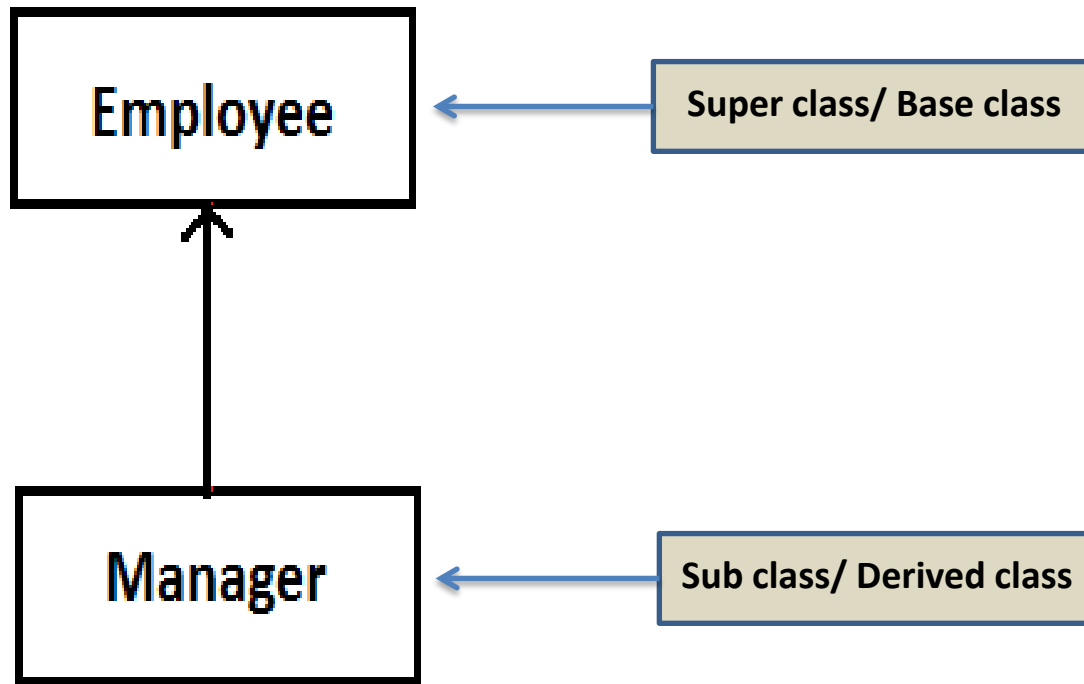
- The word '*poly*' means many & '*morphism*' means forms. Thus, polymorphism is '*one name many forms*'.
- Polymorphism example can be a 'shape'. Shape can be circle, triangle, rectangle etc. Thus, shape is one name but having multiple forms.
- In object-oriented programming, polymorphism refers to a programming language's ability to process objects differently depending on their data type or class.

Inheritance & Polymorphism

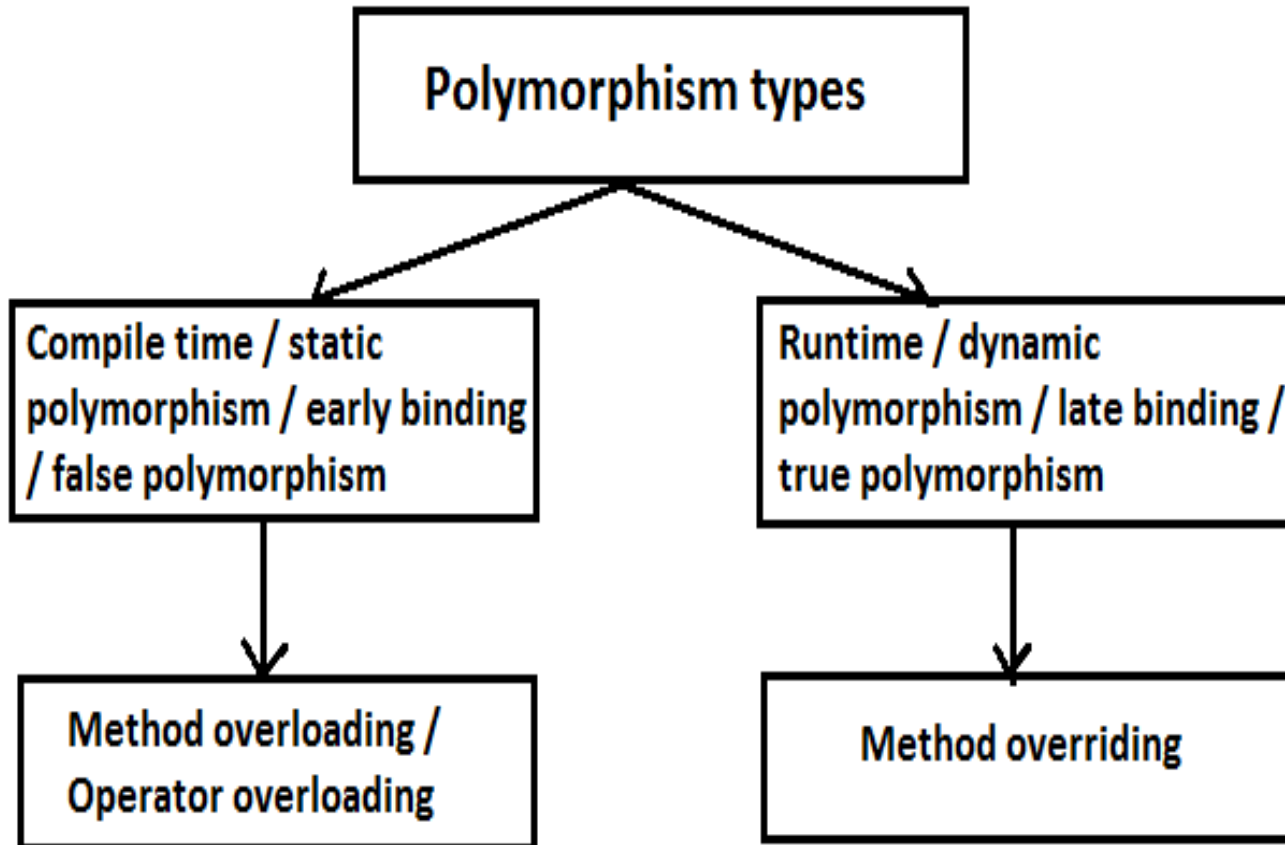
Types of Inheritance

| | |
|--|---|
| Single Inheritance  <pre>graph BT; B[Class B] --> A[Class A]</pre> | <pre>public class A { } public class B extends A { }</pre> |
| Multi Level Inheritance  <pre>graph BT; C[Class C] --> B[Class B]; B --> A[Class A]</pre> | <pre>public class A {} public class B extends A {.....} public class C extends B {..... }</pre> |
| Hierarchical Inheritance  <pre>graph BT; B[Class B] --> A[Class A]; C[Class C] --> A</pre> | <pre>public class A {} public class B extends A {.....} public class C extends A {..... }</pre> |
| Multiple Inheritance  <pre>graph BT; C[Class C] --> A[Class A]; C --> B[Class B]</pre> | <pre>public class A {} public class B {} public class C extends A,B { } // Java does not support multiple Inheritance</pre> |

Inheritance relationship



Polymorphism types



Method overloading

```
class Shape {
```

```
    public int getArea(int radius) {
```

```
        //calculates circle area
```

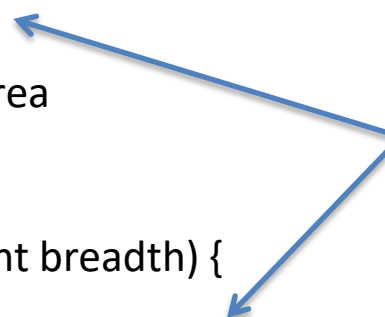
```
    }
```

```
    public int getArea(int length, int breadth) {
```

```
        //calculates rectangle area
```

```
    }
```

```
}
```



getArea() method is overloaded

Method overloading continue...

- We can achieve compile time polymorphism using method overloading.
- In method overloading, we write a class having multiple methods with the same name but different arguments.
- Method overloading is NOT dependent upon method's return type.
- Compiler changes name of every method, also called as 'name mangling'. Thus, methods having same name at source code level, might have different names in byte code level. This means when we run java program, JVM never considers overloaded methods with same name & hence method overloading is also called as 'false polymorphism'.
- Java does not support operator overloading. However, java has internally overloaded the plus (+) operator.

Method overriding

```
class Point {  
    public void draw() {  
        //draws a point  
    }  
}
```

```
class Circle extends Point {  
    public void draw() {  
        //draws a circle  
    }  
}
```



draw() method is overridden

Method overriding continue...

- In method overriding, the method signature (method name & arguments) in super class & sub class is exactly same.
- Overridden method's return type can be exactly same in sub class or return type can be sub class of overridden method's return type in super class. For example, if draw() method in class Point returns 'Object' then it can return 'Integer' in the class Circle.
- Method overriding is a true polymorphism because after method name mangling, the mangled name is same for super & sub class.
- When we call overridden method using sub class object, JVM always calls overridden method belongs to sub class only.

'final' keyword

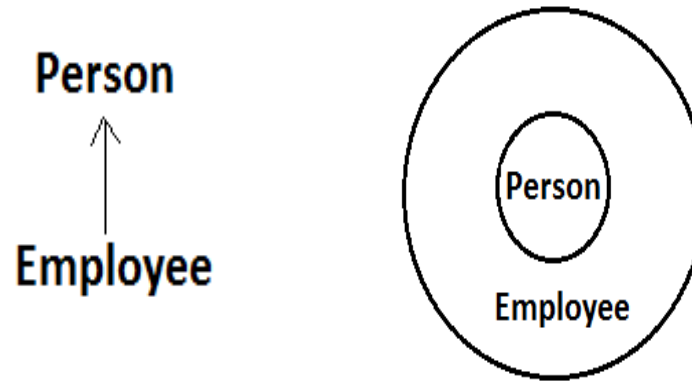
- 'final' keyword can be used for a resource whose value is constant & can never be changed.
- Developer can use 'final' keyword at three places:
 - ✓ 'final' variable
 - ✓ 'final' method &
 - ✓ 'final' class
- ✓ 'final' variable cannot be changed once assigned
- ✓ 'final' method cannot be overridden.
- ✓ 'final' classes cannot be inherited.

Singleton class

- Singleton class is special class that can be instantiated only once.
- In order to make a class singleton, the most important thing is stopping users to create its object using 'new' keyword. This is achieved using private constructor. Please refer the code below:

```
class SampleSingleton {  
    private static SampleSingleton ref = null;  
    private SampleSingleton() { }  
    public static SampleSingleton getInstance() {  
        if(ref == null)  
            ref = new SampleSingleton();  
        return ref;  
    }  
}
```

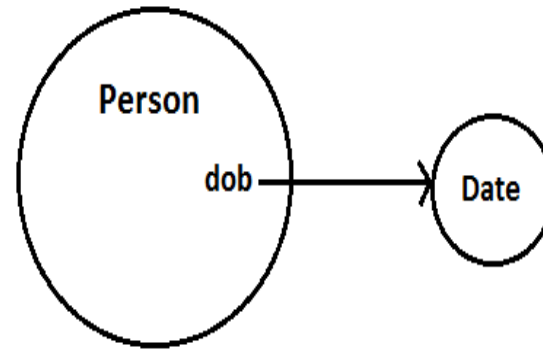
is-a relationship



- Is-a relationship in java is represented in terms of inheritance.
- If class employee inherits class Person then we say that 'every employee *is a* person'.
- In is-a relationship, super class object is embedded inside sub class object. It means that you cannot imagine existence of employee object unless have person inside.
- You can also see is-a relationship as tight coupling between two objects.

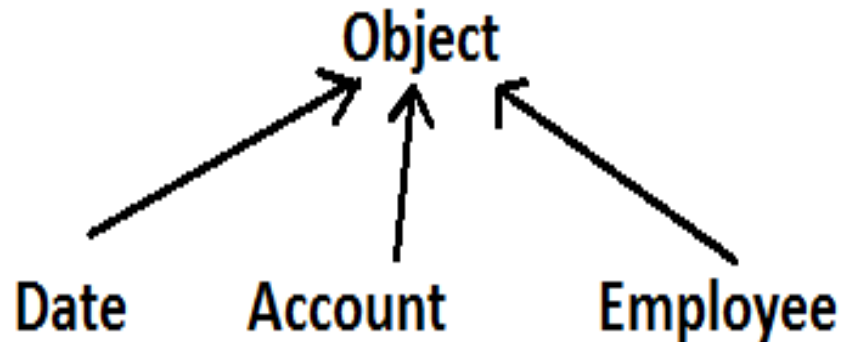
has-a relationship

```
class Person {  
    Date dob;  
}
```



- has-a relationship in java is represented in terms object having an attribute of another object reference. If class Person has an attribute of class Date then we say that ‘every person **has a** date of birth’.
- In has-a relationship, one object only holds reference of another object i.e. object outside object. It means that you can imagine existence of person object without having date associated.
- You can also see has-a relationship as loose coupling between two objects.
- Has-a relationship is also known as ‘Composition’. If a class has list of another object type then it is called as ‘Aggregation’. For example, Organization object has list of employee objects.

'Object' class



- Every java class directly or indirectly inherits a class called 'Object'. Thus, 'Object' is a super most or cosmic super class in java.
- Naturally, methods defined inside 'Object' class can be called on any java object.

'Object' class methods

➤ hashCode()

Every java object is assigned a hash code. You can find it out by calling `obj.hashCode()` method.

➤ equals()

The `equals()` method compares two objects whether they are same or not. For example:

```
String s1 = "Hello";  
String s2 = "Hello";  
if (s1.equals(s2)==true) { //s1.equals(s2) will be TRUE  
    //logic  
}
```

➤ clone()

Cloning is a process of creating an exact copy of an object. You can clone java object by calling `obj.clone()` method.

'Object' class methods continue...

➤ toString()

The toString() method returns the string representation of any java object. The toString() defined in class Object, returns a hash code of that object. If you wish to define different string representation of you object then you should override toString() method in your class. For example:

```
class Date {  
    public String toString() {  
        return day + "/" + month + "/" + year;  
    }  
}
```

➤ finalize()

The finalize() method is called implicitly by JVM when an object is being garbage collected.

'super' keyword

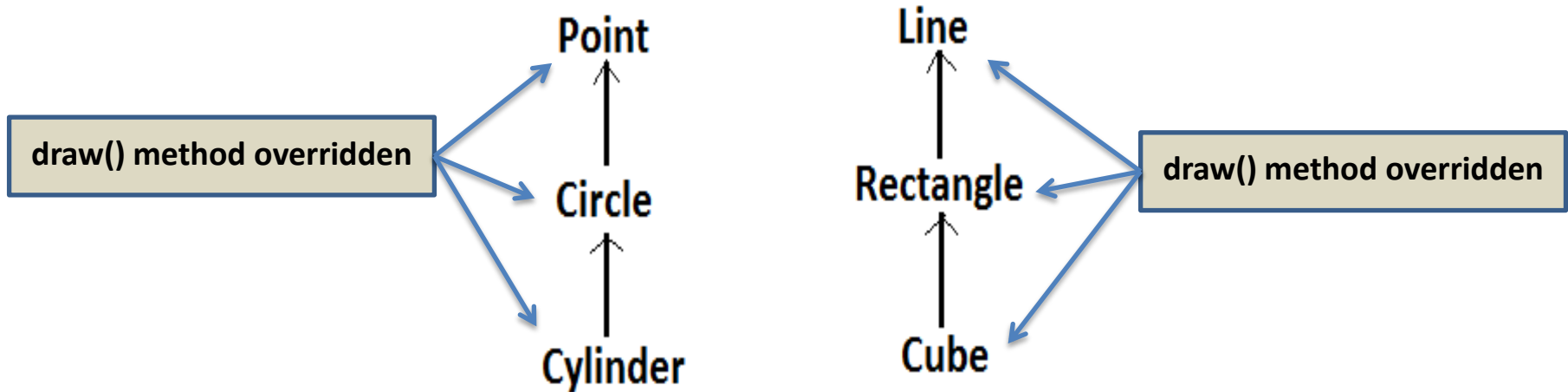
- 'super' keyword can be used to call a constructor, method or a field of immediate super class. For example:

```
class DateTime extends Date {  
    private int hours;  
    private int minutes;  
    private int seconds;  
    public DateTime(int day, int month, int year, int hours, int minutes, int seconds)  
{  
        super(day, month, year); //Calling super class constructor  
        this.hours = hours;  
        this.minutes = minutes;  
        this.seconds = seconds;  
    }  
    public String toString() {  
        return super.toString() + " " + hours + ":" + minutes + ":" + seconds;  
        //Calling super class method  
    }  
}
```

Garbage collector

- Java developer can only allocate memory but deallocation is taken care by JVM itself using garbage collector.
- Garbage collector is a low priority thread which starts automatically when we run any java program.
- Garbage collector's job is to continuously scan heap memory & destroy those objects who are having reference count zero.
- Developer cannot force garbage collector on JVM. However, we can request JVM to run garbage collector by calling *System.gc()* method.
- If you want JVM to notify your object before getting destroyed then the object needs to override *finalize()* method.

Abstract classes

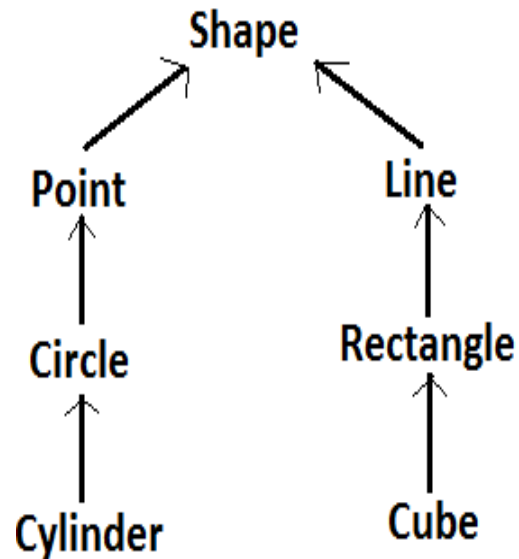


- Suppose there are two multilevel hierarchy of classes as shown above. All classes have overridden the draw() method. Now, we want to call draw() method on all objects then we will write the following code:

```
Point p[] = new Point[3];  
p[0] = new Point();  
p[1] = new Circle();  
p[2] = new Cylinder();  
for(int i=0; i<p.length; i++)  
    p[i].draw();
```

```
Line ln[] = new Line[3];  
ln[0] = new Line();  
ln[1] = new Rectangle();  
ln[2] = new Cube();  
for(int i=0; i<ln.length; i++)  
    ln[i].draw();
```

Abstract classes continue...



- In the earlier program, we had created two arrays (Point & Line) of three elements each. Instead of this, can we create a single array of six elements? Yes. This is possible by enforcing a common base class on top of Point & Line known as Shape. Now the program will be written as follows:

```
Shape s[] = new Shape[6];
```

```
s[0] = new Point();
```

```
s[5] = new Cube();
```

```
for(int i=0; i<s.length; i++)
```

```
    s[i].draw();
```


Writing abstract class

- Now let us focus on the definition of class Shape. In order to compile our previous code, we must add draw() method inside Shape class. Here the question arises is 'Can Shape class define draw() method?'. Truly speaking NO because unless you tell which shape you want to draw, we cannot implement draw() method.
- Thus any method you are forced to write inside a class which you cannot define then such a method is called as abstract method.
- If class has one or more methods abstracts then you must declare the class as abstract.

```
abstract class Shape {
```

```
    abstract void draw(); //Abstract methods do not have body.
```

```
}
```

Facts about abstract classes

- If class has one or more methods abstracts then you must declare the class as abstract.
- Abstract classes may have non abstract methods.
- Abstract classes cannot be instantiated.
- If a class extends any abstract class then the sub class must either override all abstract methods from super class or declare itself as abstract class.
- Abstract methods do not have body.
- Abstract methods cannot be private.
- Abstract methods cannot be final.
- If a class does not have any abstract method still developer can declare it as abstract if wishes.

Interfaces

What is an interface?

- Interface is a special type of abstract class.
- Interface is a fully abstraction of a class. It means interface can not have method definition possible.
- In interfaces, all methods are by default '*public abstract*' & all variables are by default '*public static final*'.
- Interface won't lead to fragile base class problem.
- If a class inherits an interface then it has to override all its abstract methods or declare itself as an abstract class.
- A class can inherit many interfaces.

Interface definition

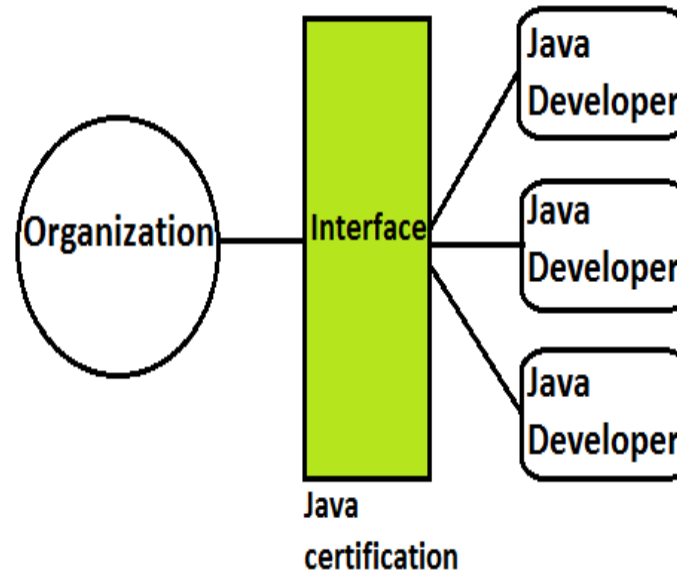
Java provides us a keyword called 'interface' to define a user defined interface. For example:

```
public interface Printable {  
    void print();  
}  
public class Date implements Printable {  
    public void print() { //prints date }  
}
```

We have added a method print(). However, we did not declare it '*public abstract*' because it is implicitly understood once '*interface*' keyword is used.

A class uses 'implements' keyword in order to inherit an interface.

Understanding interfaces



- Interfaces are service based i.e. whenever you want to expose any service, you have to use interfaces. This is because interface sign a contract between service provider & service user. For example if an organization wants to recruit java developers who are 'java certified' then java certification acts as an interface between java developer & the organization.
- Interfaces are generally designed by third party. For example in above diagram, 'java certification' is provided by 'Oracle Inc.'

Understanding interfaces continue...

- Interfaces gather irrelevant objects together. For example, '*Printable*' interface can be implemented by Circle, Employee, Date, Account objects. Note that all these are irrelevant objects. However, you can gather them together by making a common array of Printable type as follows:

```
Printable p[] = new Printable[4];
```

```
p[0] = new Circle();
```

```
p[1] = new Employee();
```

```
p[2] = new Date();
```

```
p[3] = new Account();
```

```
for(int i=0; i<p.length; i++)
```

```
p[i].print();
```

Marker interface

- Marker interface is an interface having no method inside. It means that a sub class implementing a marker interface need not override any method. For example:
 - `interface Cloneable { }`
- Marker interfaces are permission granting interfaces. It means they grant permission to perform certain operation. For example, if you wish to clone any java object, you simply call `object.clone()` method. However, java does not allow to clone any java object unless object gives permission. So, here the object must implement 'Cloneable' interface in order to grant permission to JVM.
- There are several marker interfaces provided by java APIs like Cloneable, Serializable, SingleThreadModel, Remote etc.

Quiz

Suppose we have three classes A, B, C & three interfaces Intf1, Intf2, Intf3. Now choose the correct statement:

- class B extends A

Yes

- class C extends A, B

No

- class B extends Intf1

No

- class B extends A implements Intf1

Yes

- class B implements Intf1, Intf2

Yes

Quiz continue...

- interface Intf1 extends A

No

- interface Intf1 implements A

No

- interface Intf2 implements Intf1

No

- interface Intf2 extends Intf1

Yes

- interface Intf3 extends Intf1, Intf2

Yes

Packages

What is a package?

- Package is a group of similar types of classes, interfaces and sub-packages.
- Package is used to categorize the classes and interfaces so that they can be easily maintained.
- Package provides access protection.
- Package removes naming conflict.
- Package in java can be categorized in two form, built-in package and user-defined package.

Create a package

```
package mypack;
```

```
import java.util.*;
```

```
public class Main{
```

```
    public static void main(String args[]){
```

```
        System.out.println("Welcome to package mypack");
```

```
    }
```

```
}
```

- Package statement must be a first statement in the source file.
- According to naming convention, package name should be all lowercase letters.
- If you do not use the package statement, the classes and interfaces of a source file become a member of an unnamed default package.
- Finally, compile the source file as follows:

```
javac -d . Main.java
```

Java in-built packages

java.lang (default)

System
Thread
Exception
String
StringBuffer

java.io

Reader
Writer
InputStream
OutputStream
PrintWriter

java.net

Socket
ServerSocket
URLConnection
InetAddress
SocketImpl

java.util

HashMap
Set
Vector
List
ArrayList

java.awt

Applet
Frame
Button
TextField
Checkbox

Access Specifiers

| Access | Private | Default | Protected | Public |
|--------------------------------|---------|---------|------------------------------------|--------|
| Same Class | Yes | Yes | Yes | Yes |
| Same package Subclass | No | Yes | Yes | Yes |
| Same package Non-Subclass | No | Yes | Yes | Yes |
| Different package Subclass | No | No | Yes (But only through Inheritance) | Yes |
| Different package Non-Subclass | No | No | No | Yes |

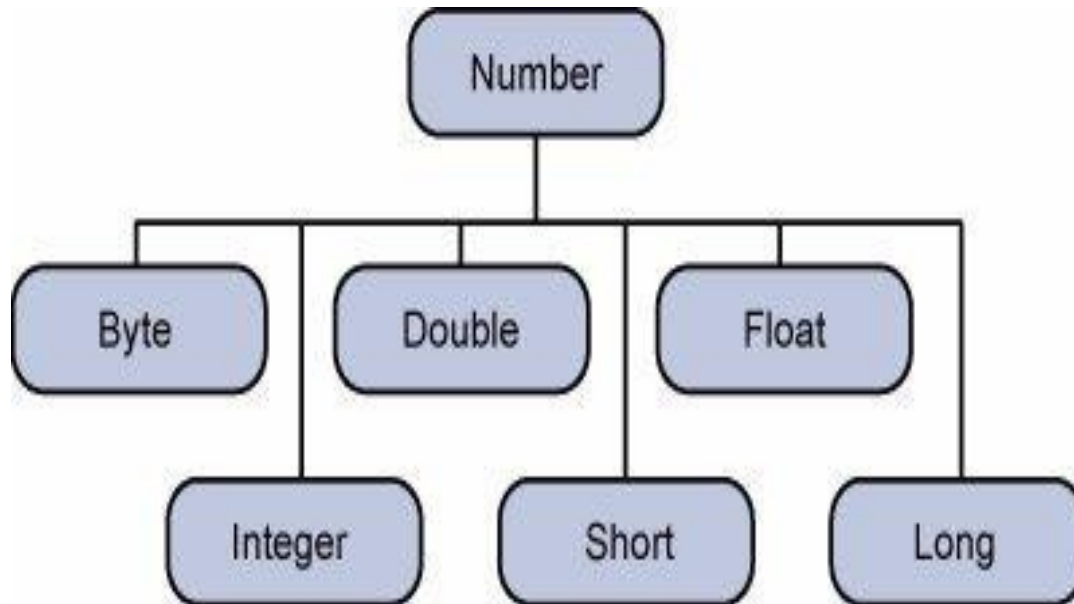
Wrapper classes

Wrapper class

- Wrapper class wraps a primitive datatype & provides the mechanism *to convert primitive into object and object into primitive*.
- Java provides wrapper class for every primitive data type. For example:

| Primitive datatype | Wrapper class |
|--------------------|---------------|
| byte | Byte |
| short | Short |
| int | Integer |
| long | Long |
| float | Float |
| double | Double |
| char | Character |
| boolean | Boolean |

Wrapper class hierarchy



- Most of the wrapper classes extend the class `java.lang.Number`.
- Wrapper classes are final classes.
- Wrapper class 'Boolean' & 'Character' directly extend class `Object`.

Utility methods

Wrapper classes also provide us following utility methods:

- Convert string into integer primitive.

```
int x = Integer.parseInt("25");
```

- Convert string into integer object.

```
Integer obj = Integer.valueOf("25");
```

- Finding greater number.

```
int maxNo = Integer.max(12, 25); //25
```

- Finding smaller number.

```
int minNo = Integer.min(12, 25); //12
```

Autoboxing & unboxing

- Wrapper classes frequently need to apply boxing & unboxing operations. For example:

```
int x = 20;
```

```
Integer intObj = new Integer(x); //Boxing
```

```
int y = intObj.intValue(); //Unboxing
```

- Now, the question arises is, can JVM implicitly take care boxing & unboxing operations? The answer is YES. It is because from JDK 1.5, java has introduced auto-boxing & auto-unboxing features.
- Autoboxing is a process of converting of primitive data types into its equivalent Wrapper type.

```
Integer intObj = 20; //Autoboxing
```

```
int y = intObj; //Auto-unboxing
```

String, StringBuffer & StringBuilder

'String' in Java

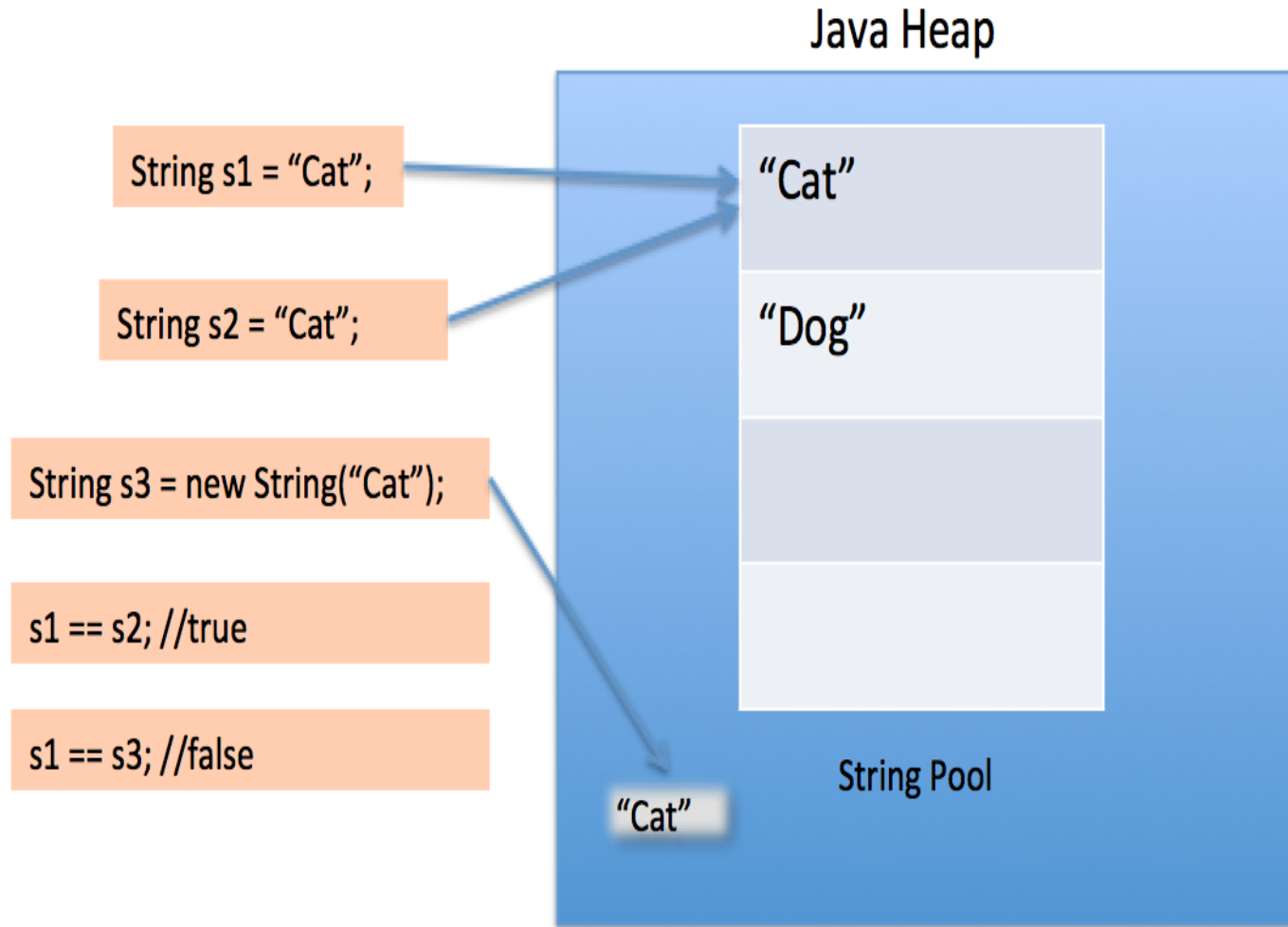
- Java provides a class called String to hold string data. Thus, in java string is an object instead of character array.
- The class 'String' is final class.
- Strings are immutable. It means, once String object is created, that object cannot be changed.
- String can be created in 2 ways:

```
String str = new String("Hello");
```

OR

```
String str = "Hello";
```

String Pool



String methods

length()

The length() method is used to calculate length of a string.

```
int len = "Hello".length(); //returns 5
```

trim()

Removes leading and trailing whitespaces of a string.

```
String str = " Hello "; //returns "Hello"
```

substring()

Returns a string that is a substring of this string.

```
String str = "Hello".substring(0, 2); //returns "He"
```

startsWith()

Tests if this string starts with the specified prefix.

```
boolean b = "Hello".startsWith("he"); //returns false
```


String methods continue...

endsWith()

Tests if this string ends with the specified suffix.

```
boolean b = "Hello".endsWith("lo"); //returns true
```

charAt()

Returns the char value at the specified index.

```
char ch = "Hello".charAt(1); //returns 'e'
```

equals()

Compares this string with another string.

```
boolean b = "Hello".equals("hello"); //returns false
```

concat()

Concatenates the specified string to the end of this string.

```
String str = "Hello".concat(" World"); //returns "Hello World"
```

String methods continue...

contains()

Returns true if the string contains the specified sequence of char values.

```
boolean b = "Hello".contains("ell"); //returns true
```

getBytes()

Converts every character of a string into byte & finally returns array of bytes.

```
byte b[] = "ABCD".getBytes(); //returns [65, 66, 67, 68]
```

indexOf()

Returns the index within this string of the first occurrence of the specified substring.

```
int x = "Hello".indexOf("lo"); //returns 3
```

replace()

Replaces each occurrence of target string with specified replacement string.

```
String str = "I wake up early. I go to office.".replace("I", "We"); //returns "We wake up  
early. We go to office."
```

String methods continue...

split()

Splits the string around matches of the given regular expression.

```
String tokens[] = "Hello World".split(" "); //returns "Hello" & "World"
```

toUpperCase()

Converts all characters of a string into upper case.

```
String str = "Hello".toUpperCase(); //returns "HELLO"
```

toLowerCase()

Converts all characters of a string into lower case.

```
String str = "Hello".toLowerCase(); //returns "hello"
```

Mutable strings (StringBuffer & StringBuilder)

- String is an immutable class. Hence we should use the string only if it is not changing frequently. However, few applications demand frequent string manipulation & hence we should use 'StringBuffer' or 'StringBuilder'.
- Thus, StringBuffer and StringBuilder classes are used when there is a necessity to make a lot of modifications to Strings of characters.

```
StringBuilder sb = new StringBuilder("Hello");
```

```
sb.append(" World");
```

```
System.out.println(sb); //prints "Hello World"
```

- The default capacity of StringBuffer & StringBuilder is 16. However it is extensible depending upon your data.
- Methods of StringBuffer & StringBuilder are similar to the class String itself.

StringBuffer vs StringBuilder

| StringBuffer | StringBuilder |
|--|--|
| StringBuffer is synchronized i.e. thread safe. It means two threads can't call the methods of StringBuffer simultaneously. | StringBuilder is non-synchronized i.e. not thread safe. It means two threads can call the methods of StringBuilder simultaneously. |
| StringBuffer is less efficient than StringBuilder. | StringBuilder is more efficient than StringBuffer. |
| In multithreaded application, we should use StringBuffer in order to overcome data corruption. | In single threaded application, we should use StringBuilder. |

Reflection

What is Reflection?

- Java Reflection is used to inspect classes, interfaces, fields and methods at runtime.
- Using reflection, it is also possible to instantiate new objects, invoke methods and get/set field values.
- There are several applications where reflection can be useful. For example:
 1. Debugger tools
 2. Servers
 3. Middleware (example RMI)

Reflecting a class

Here is a sample program to analyze a class String:

```
import java.lang.reflect.*; //import reflection package
```

```
Class c = Class.forName("java.lang.String"); //loads the class forcefully into memory
```

```
Constructor con[] = c.getDeclaredConstructors(); //returns all constructors of String class
```

```
Method m[] = c.getDeclaredMethods(); //returns all methods of String class
```

```
Field f[] = c.getDeclaredFields(); //returns all fields of String class
```


'Class' object

- Java provides a class called 'Class'. It plays vital role in reflecting any java class.
- How to object class 'Class' object?

```
Class strClass = String.class;
```

OR

```
Class strClass = Class.forName("java.lang.String");
```

- Useful methods of class 'Class':

```
int modifiers = strClass.getModifiers();
```

```
Modifier.isAbstract(modifiers);
```

```
Modifier.isPublic(modifiers);
```

```
Modifier.isFinal(modifiers);
```

```
String packageName = strClass.getPackage(); //returns package name
```

```
Class interfaces[] = strClass.getInterfaces(); //returns all implemented interfaces
```

```
Class superClass = strClass.getSuperClass(); //returns base class
```

Access private resources

Reflection APIs are very powerful & they even allow us to access the value of private fields or call private methods etc. Here is a sample code:

```
class Sample {  
    private String messageTxt = "Welcome";  
}
```

```
Class sClass = Sample.class;
```

```
Field messageField = sClass.getDeclaredField("messageTxt");
```

```
messageField.setAccessible(true);
```

```
System.out.println("messageText = "+ messageField.get(new Sample())); //prints  
‘Welcome’
```

If you do not want your classes getting reflected at runtime then set security policy to stop reflection API usage.

Java Annotations

What are annotations?

- Annotation feature was added from Java 1.5.
- Annotation provides metadata for your java program. For example:

`@Entity`

```
public class Account {  
  
    //fields  
  
}
```

- Java annotations are typically used for the following purposes:
 1. Compiler instructions
 2. Build-time instructions
 3. Runtime instructions

Annotation basics

- Annotation elements are similar to attributes of a class. For example:

```
@Table(name='ACC_MASTER', primaryKey='accno')
```

- Annotation can be placed at following levels:

1. Class level
2. Interface level
3. Method level
4. Field level
5. Method parameter level &
6. Local variable level

Java built-in annotations

➤ @Deprecated

The @Deprecated annotation is used to mark a class, method or field as deprecated, meaning it should no longer be used.

➤ @Override

The @Override Java annotation is used above methods that override methods in a superclass.

➤ @SuppressWarnings

The @SuppressWarnings annotation makes the compiler suppress warnings for a given method.

Custom annotations

```
@Retention(RetentionPolicy.RUNTIME)
```

```
@Target({ElementType.METHOD})
```

```
public @interface MyAnnotation {
```

```
    String value() default "";
```

```
    String name();
```

```
    int age();
```

```
    String[] newNames();
```

```
}
```

Custom annotations continue...

@interface

@interface signals to the Java compiler that this is a Java annotation definition.

Default

Using 'default', we can assign default values to an element.

@Retention

@Retention will allow us to specify whether the annotation will be available at runtime for reflection or not.

@Target

@Target can be used to specify at what level you want to apply the custom annotation. i.e. method level, class level, method parameter level etc.

Enums

Java enum prior 1.5

```
class FruitName {  
    public static final int APPLE = 1;  
    public static final int BANANA = 2;  
    public static final int MANGO = 3;  
    public static final int ORANGE = 4;  
}  
  
class Food {  
    private int fruit;  
}
```

Limitations:

- Possible assigning of incorrect values i.e. food.fruit = 7;
- No meaningful printing. i.e. food.fruit = 3;
- Need prefix class name in order to access the constant i.e. FruitName.APPLE

Java enum

```
public enum fruitName { APPLE, BANANA, MANGO, ORANGE };
```

- Always add curly braces around enum constants because enum is like a class.
- Enum constants are implicitly 'static final'.
- You cannot change the value of constants once created.
- Enum can be used inside switch statement.

Enum features

- Enum is type-safe:

```
public enum FruitNames { APPLE,BANANA,MANGO,ORANGE};  
FruitNames fruit = FruitNames.BANANA;  
fruit = 5; //compilation error
```

- Enum in Java are reference type:

Java enum is like a class or interface & hence you can declare constructor, method & variables inside enum.

- Enum constant values:

We can specify the value of enum constants at the creation time.

```
enum FruitNames { APPLE(10), BANANA(5), MANGO(8), ORANGE(3)};
```

Enum features continued...

- You can declare constructor in enum. However it must be private since it is called within enum only.
- In order to get the value of enum item, you can write `getValue()` method inside enum.
- Enum can be used with switch cases-

```
FruitNames fruit = FruitNames.MANGO;
```

```
Switch(fruit) {
```

```
    case APPLE: System.out.println("Apple"); break;
```

```
    case BANANA: System.out.println("Banana"); break;
```

```
}
```

Enum features continued...

- You can compare enum values with '=='

```
FruitNames fruit = FruitNames.MANGO;
```

```
If (fruit == FruitNames.MANGO) //TRUE
```

- You can override toString() inside enum as follows:

```
public enum FruitNames {
```

```
APPLE(4), BANANA(2), MANGO(7), ORANGE(10);
```

```
public String toString() {
```

```
    switch(this) {
```

```
        case APPLE: System.out.println("Fruit: " + value); break;
```

```
    }
```

```
}
```

Nested classes

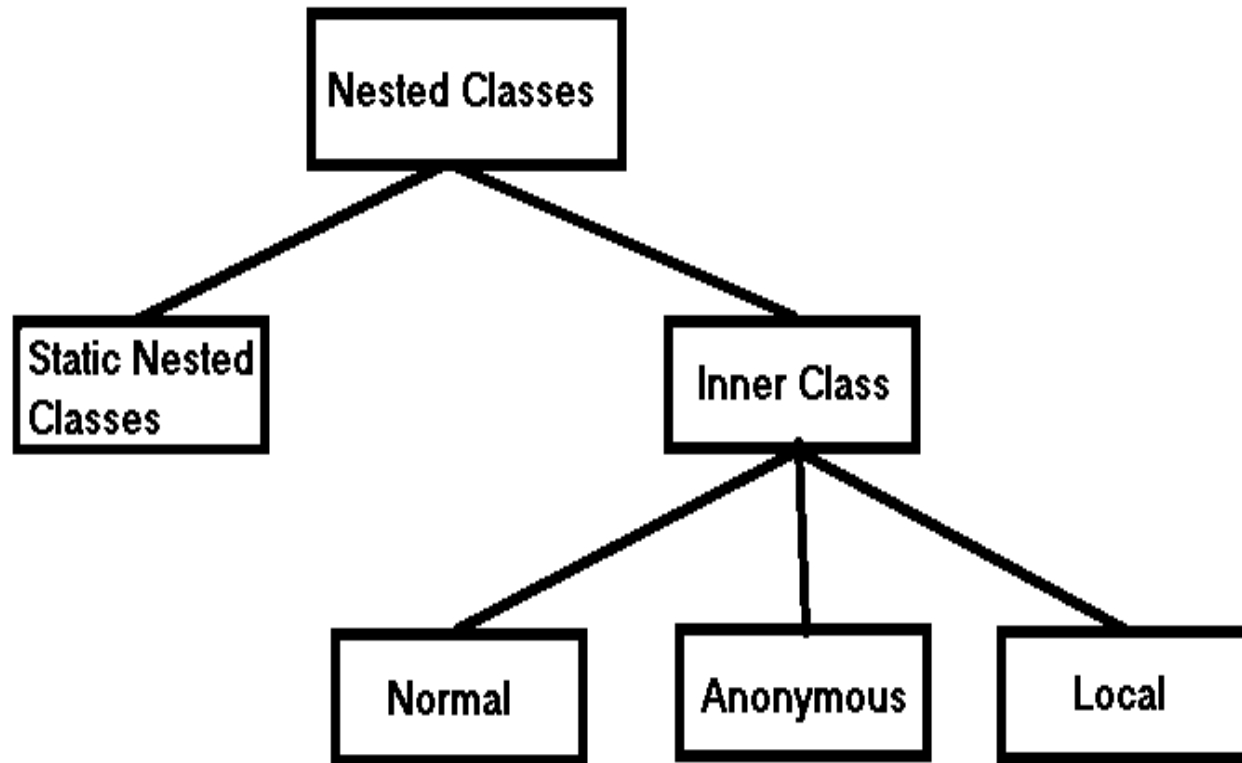
What is Nested Class?

Java allows you to define a class within another class. Such a class is called a nested class.

```
class OuterClass {  
    class NestedClass {  
    }  
}
```

Outer classes can only be declared as public or package private. Where as, Nested class can be declared private, public, protected, or package private.

Types of Nested Classes



Why to use Nested classes?

- Logically grouping the classes at one place.
- Encapsulation advantage
- More readable & maintainable code.

Static Nested classes

```
class OuterClass {  
    static class NestedClass {  
    }  
}
```

Like static class methods, a static nested class cannot refer directly to instance variables or methods defined in its enclosing class: it can use them only through an object reference.

Static nested classes are accessed using the enclosing class name:

```
OuterClass.StaticNestedClass nestedObject = new OuterClass.StaticNestedClass();
```

Inner classes (Non-static nested classes)

```
class OuterClass {  
    class NestedClass {  
    }  
}
```

Inner class has direct access to the outer class fields & methods. Inner class is instantiated as follows:

```
OuterClass.InnerClass innerObject = outerObject.new InnerClass();
```

Local classes

```
public void performArithOpr(int x, int y) {  
    class ArithmeticOpr {           //Local class  
        public int add(int a, int b) {  
            return a + b;  
        }  
    }  
}
```

1. Local class has access to the members of its enclosing class & also to local variables.
2. Local classes can be declared inside method, if condition, loops etc.

Anonymous inner classes

```
Printable printableCircle = new Printable() {  
    public void print() {  
        System.out.println("Circle printed..");  
    }  
};
```

1. Anonymous class makes your code brief but comprehensive.
2. Anonymous class enables to declare & instantiate a class at the same time.
3. Anonymous class is a local class with no name.
4. Anonymous class is used if you need local class only once.