Core Java

- Akshita Chanchlani

Trainer Introduction

- **Name**: Mrs.Akshita S.Chanchlani
- **Designation** : Associate Head Technical
- **Education** :
    - PhD (Pursuing) : Computer Science and Engineering
    - Masters of Engineering (ME) in Information Technology
    - B.Tech in Computer Engineering, From VJTI Mumbai
- **Training Experience**
    - PreCAT Batches at Sunbeam
    - C, C++ , core java, python
- **Professional Experience**
    - **11+ years**
- **Email** : akshita.chanchlani@sunbeaminfo.com

Documentation

- **JDK download:**
  - https://adoptopenjdk.net/
- **Spring Tool Suite 3 download:**
  - https://github.com/spring-projects/toolsuite-distribution/wiki/Spring-Tool-Suite-3
- **Oracle Tutorial:**
  - https://docs.oracle.com/javase/tutorial/
- **Java 8 API Documentation:**
  - https://docs.oracle.com/javase/8/docs/api/
- **MySQL Connector:**
  - https://downloads.mysql.com/archives/c-j/
- **Core Java Tutorials:**
  1. http://tutorials.jenkov.com/java/index.html
  2. https://www.baeldung.com/java-tutorial
  3. https://www.journaldev.com/7153/core-java-tutorial

Java History

- **James Gosling, Mike Sheridan** and **Patrick Naughton** initiated the Java language project in June 1991.
- **Java** was originally **developed by James Gosling** at **Sun Microsystems** and **released in 1995.**
- The language was initially called **Oak** after an oak tree that stood outside Gosling's office.
- Later the project went by the name ***Green*** and was finally renamed ***Java***, from Java coffee, a type of coffee from Indonesia.
- Gosling and his team did a brainstorm session and after the session, they came up with several names such as **JAVA, DNA, SILK, RUBY, etc.**
- Sun Microsystems released the first public implementation as Java 1.0 in 1996.

Java History

- The Java programming language is a general-purpose, concurrent, class-based, object-oriented language.
- The Java programming language is a high-level language.
- The Java programming language is related to C and C++ but is organized rather differently, with a number of aspects of C and C++ omitted and a few ideas from other languages included.
- **It is intended to be a production language, not a research language.**
- The Java programming language is statically typed.
- It promised **Write Once, Run Anywhere** (**WORA**) functionality.
- Standardizing Java Language Specification(JLS) is a job of Java Community Process(**JCP**).

Version History

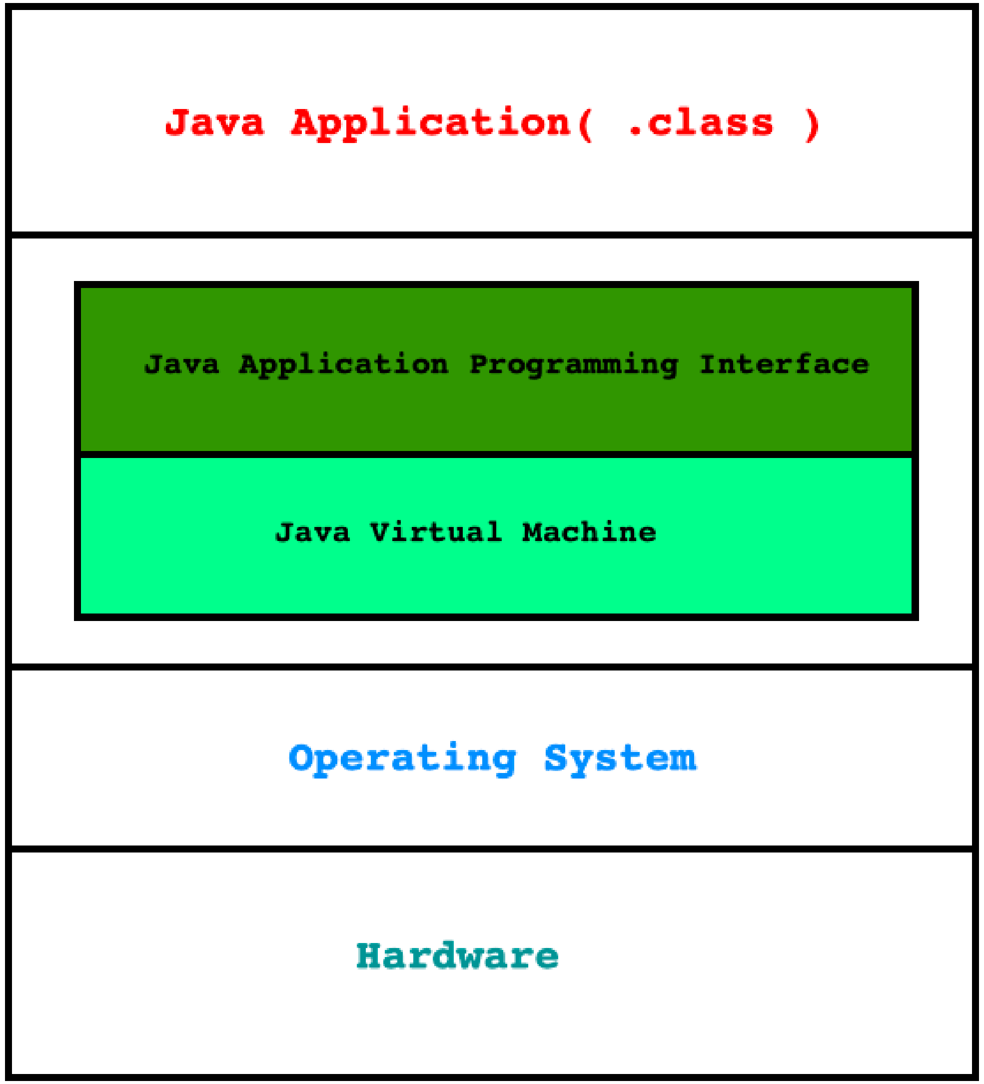
Version	Date
JDK Beta	1995
JDK1.0	January 23, 1996[39]
JDK 1.1	February 19, 1997
J2SE 1.2	December 8, 1998
J2SE 1.3	May 8, 2000
J2SE 1.4	February 6, 2002
J2SE 5.0	September 30, 2004
Java SE 6	December 11, 2006
Java SE 7	July 28, 2011
Java SE 8	March 18, 2014
Java SE 9	September 21, 2017
Java SE 10	March 20, 2018
Java SE 11	September 25, 2018[40]
Java SE 12	March 19, 2019
Java SE 13	September 17, 2019
Java SE 14	March 17, 2020
Java SE 15	September 15, 2020[41]
Java SE 16	March 16, 2021

- The first version was released on January 23, 1996.
- The acquisition of Sun Microsystems by Oracle Corporation was completed on January 27, 2010
- As of September 2020, Java 8 and 11 are supported as Long Term Support (LTS) versions
- In September 2017, Mark Reinhold, chief Architect of the Java Platform, proposed to change the release train to "one feature release every six months".
- OpenJDK (Open Java Development Kit) is a free and open source implementation of the (Java SE). It is the result of an effort Sun Microsystems began in 2006.
- Java Language and Virtual Machine Specifications: https://docs.oracle.com/javase/specs/

Java Platforms

1. **Java SE**
    - Java Platform Standard Edition.
    - It is also called as Core Java.
    - For general purpose use on Desktop PC's, servers and similar devices.
2. **Java EE**
    - Java Platform Enterprise Edition.
    - It is also called as advanced Java / enterprise java / web java.
    - Java SE plus various API's which are useful client-server applications.
3. **Java ME**
    - Java Platform Micro Edition.
    - Specifies several different sets of libraries for devices with limited storage, display, and power capacities.
    - It is often used to develop applications for mobile devices, PDAs, TV set-top boxes and printers.
4. **Java Card**
    - A technology that allows small Java-based applications (applets) to be run securely on smart cards and similar small-memory devices.

Components of the Java platform



Java Platform
[Software Platform]

[Hardware Based Platform]

SDK, JDK, JRE, JVM

- **SDK** = Development Tools + Documentation + Libraries + Runtime Environment.

- **JDK** = Java Development Tools + Java Docs + **rt.jar** + JVM.
    - JDK : Java Development Kit.
    - It is a software, that need to be install on developers machine.
    - We can download it from oracle official website.

- **JDK** = Java Development Tools + Java Docs + **JRE**[**rt.jar + JVM**].
    - JRE : Java Runtime Environment.
    - rt.jar and JVM are integrated part of JRE.
    - JRE is a software which comes with JDK. We can also download it separately.
    - To deploy application, we should install it on client’s machine.

- rt.jar file contains core Java API in **compiled form**.

- **JVM** : An engine, which manages execution of Java application. (also called as Execution Engine)

JDK’s Installation Directory Structure

- It contains following sub directories:
    1. bin
        - It contains Java language tools.
        - Example : javac, javap, javah, java etc.
    2. include
        - JNI stands for Java Native Interface.
        - In the context of Java, C/C++ code is called as native code.
        - Using JNI, if we want to access native code in Java then some header files are required. These files are kept into include directory.
    3. lib
        - It contains library files which is required to use Java language tools.
    4. src
        - Java is a open source technology.
        - If we extract src.zip file then src directory gets created.
        - It contains source code of Java API.
    5. docs
        - It contains documentation of java API
        - Online help is available at : https://docs.oracle.com/javase/8/docs/api/
    6. jre
        - It contains JVM and rt.jar file.
    7. db
        - It contains database specific files(Driver, Sample database etc.)

C++ versus Java terminology

C++ Terminology	Java Terminology
Class	Class
Data Member	Field
Member Function	Method
Object	Instance
Pointer	Reference
Access Specifier	Access Modifier
Base Class	Super Class
Derived Class	Sub Class
Derived From	Extended From
Runtime Polymorphism	Dynamic Method Dispatch

Simple Hello Application

```java
//File Name : Program.java
class Program{
    public static void main(String[] args) {
        System.out.println("Hello World");
    }
}
```

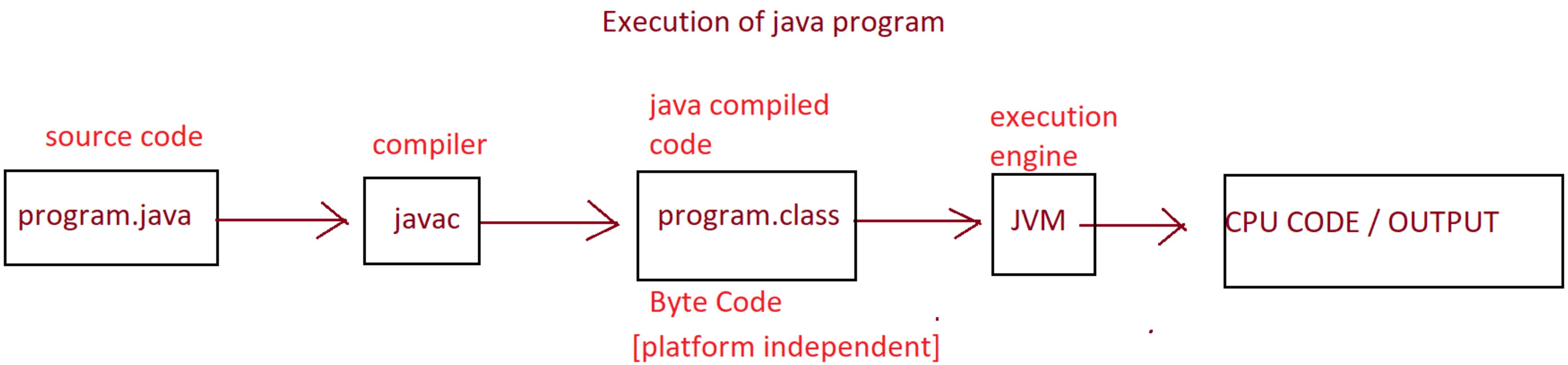
```
Compilation=> javac Program.java   //Output : Program.class
Execution=>   java Program
```

```
System     :   Final class declared in java.lang package
out        :   public static final field of System class. Type of out is PrintStream
println    :   Non static method of java.io.PrintStream class
```

To view class File :

javap -c Program.class

Java application flow of execution



Comments

- Comments should be used to give overviews of code and provide additional information that is not readily available in the code itself. Comments should contain only information that is relevant to reading and understanding the program.
- Types of Comments:
  - **Implementation Comment**
    - Implementation comments are those found in C++, which are delimited by /*...*/, and //.
      1. Single-Line Comment
      2. Block Comment(also called as multiline comment)
  - **Documentation Comment**
    - Documentation comments (known as "doc comments") are Java-only, and are delimited by **/**...*/**.
    - Doc comments can be extracted to HTML files using the javadoc tool.

Entry point method

- Syntax:
  1. **public static void main(String[] args)**
  2. **public static void main(String... args)**

- Java compiler do not check/invoke main method. JVM invoke main method.

- When we start execution of Java application then JVM starts execution of two threads:
  1. Main thread : responsible for invoking main method.
  2. Garbage Collector : responsible for deallocating memory of unused object.

- We can overload main method in Java.

- We can define main method per class. But only one main method can be considered as entry point method.

Data Types

- Data type of any variable decide following things:
    1. **Memory:** How much memory is required to store the data.
    2. **Nature:** Which kind of data is allowed to store inside memory.
    3. **Operation:** Which operations are allowed to perform on the data stored in memory.
    4. **Range:** Set of values that we can store inside memory.

- The Java programming language is a statically typed language, which means that every variable and every expression has a type that is known at compile time.
    - Types of data type:
        1. **Primitive type(also called as value type)**
            - **boolean** type
            - Numeric type
                1. Integral types(**byte, char, short, int, long**)
                2. Floating point types(**float, double**
        2. **Non primitive type(also called as reference type)**
            - **Interface, Class, Type variable, Array**

Data Types

Sr.No.	Primitive Type	Size[In Bytes]	Default Value[For Field]	Wrapper Class
1	boolean	Isn't specified	FALSE	Boolean
2	byte	1	0	Byte
3	char	2	\u0000	Character
4	short	2	0	Short
5	int	4	0	Integer
6	float	4	0.0f	Float
7	double	8	0.0d	Double
8	long	8	0L	Long

Note : Char datatype supports UNICODE character set, so 2 bytes .

Variables

- The name of some **location of memory** used to hold a data value
- **Different types** of data require **different amounts** of memory. The compiler’s job is to reserve sufficient memory
- Variables need to be declared once
- Variables are **assigned** values, and these values may be changed later
- Each variable has a type, and **operations can only be performed between compatible types**

Operators

- Java provides a rich set of operators to manipulate variables.
- We can divide all the Java operators into the following groups.

  - Arithmetic Operators
  - Relational Operators
  - Bitwise Operators
  - Logical Operators
  - Assignment Operators

Arithmetic Operators

Operator	Description
+	Addition - Adds values on either side of the operator
-	Subtraction - Subtracts right hand operand from left hand operand
*	Multiplication - Multiplies values on either side of the operator
/	Division - Divides left hand operand by right hand operand
%	Modulus - Divides left hand operand by right hand operand and returns remainder
++	Increment - Increases the value of operand by 1
--	Decrement - Decreases the value of operand by 1

Relational Operator

Operator	Description	Example
==	Checks if the values of two operands are equal or not, if yes then condition becomes true.	(A == B) is not true.
!=	Checks if the values of two operands are equal or not, if values are not equal then condition becomes true.	(A != B) is true.
>	Checks if the value of left operand is greater than the value of right operand, if yes then condition becomes true.	(A > B) is not true.
<	Checks if the value of left operand is less than the value of right operand, if yes then condition becomes true.	(A < B) is true.
>=	Checks if the value of left operand is greater than or equal to the value of right operand, if yes then condition becomes true.	(A >= B) is not true.
<=	Checks if the value of left operand is less than or equal to the value of right operand, if yes then condition becomes true.	(A <= B) is true.

Bit Wise Operators

Bitwise operator works on bits and performs bit-by-bit operation. Assume if a = 60; and b = 13; now in binary format they will be `a = 0011 1100` and `b = 0000 1101`.

```
a&b = 0000 1100
a|b = 0011 1101
a^b = 0011 0001
~a  = 1100 0011
```

Operator	Description	Example
&	Binary AND Operator copies a bit to the result if it exists in both operands.	(A & B) will give 12 which is 0000 1100
|	Binary OR Operator copies a bit if it exists in either operand.	(A | B) will give 61 which is 0011 1101
^	Binary XOR Operator copies the bit if it is set in one operand but not both.	(A ^ B) will give 49 which is 0011 0001
~	Binary Ones Complement Operator is unary and has the effect of 'flipping' bits.	(~A) will give -61 which is 1100 0011 in 2's complement form due to a signed binary number.
<<	Binary Left Shift Operator. The left operands value is moved left by the number of bits specified by the right operand.	A << 2 will give 240 which is 1111 0000
>>	Binary Right Shift Operator. The left operands value is moved right by the number of bits specified by the right operand.	A >> 2 will give 15 which is 1111
>>>	Shift right zero fill operator. The left operands value is moved right by the number of bits specified by the right operand and shifted values are filled up with zeros.	A >>>2 will give 15 which is 0000 1111

Logical Operators

Operator	Description	Example
&&	Called Logical AND operator. If both the operands are non-zero, then the condition becomes true.	(A && B) is false.
||	Called Logical OR Operator. If any of the two operands are non-zero, then the condition becomes true.	(A || B) is true.
!	Called Logical NOT Operator. Use to reverses the logical state of its operand. If a condition is true then Logical NOT operator will make false.	!(A && B) is true.

Assignment Operator

Operator	Description	Example
=	Simple assignment operator, Assigns values from right side operands to left side operand	C = A + B will assign value of A + B into C
+=	Add AND assignment operator, It adds right operand to the left operand and assign the result to left operand	C += A is equivalent to C = C + A
-=	Subtract AND assignment operator, It subtracts right operand from the left operand and assign the result to left operand	C -= A is equivalent to C = C - A
*=	Multiply AND assignment operator, It multiplies right operand with the left operand and assign the result to left operand	C *= A is equivalent to C = C * A
/=	Divide AND assignment operator, It divides left operand with the right operand and assign the result to left operand	C /= A is equivalent to C = C / A
%=	Modulus AND assignment operator, It takes modulus using two operands and assign the result to left operand	C %= A is equivalent to C = C % A
<<=	Left shift AND assignment operator	C <<= 2 is same as C = C << 2
>>=	Right shift AND assignment operator	C >>= 2 is same as C = C >> 2
&=	Bitwise AND assignment operator	C &= 2 is same as C = C & 2
^=	bitwise exclusive OR and assignment operator	C ^= 2 is same as C = C ^ 2
|=	bitwise inclusive OR and assignment operator	C |= 2 is same as C = C | 2

Other Operators

- **Conditional Operator (? :) / Ternary Operator**

```
variable x = (expression) ? value if true : value if false
```

- **instanceOf Operator**

The operator checks whether the object is of a particular type(class type or interface type).

The **instanceOf** operator is wriiten as:

```
( Object reference variable ) instanceOf  (class/interface type)
```

Example :

```
String name = = ‘Akshita';
boolean result = name instanceOf String;
// This will return true since name is type of String
```

Control Statements

Loops

Java has very flexible three looping mechanisms. You can use one of the following three loops:

- while Loop
- do...while Loop
- for Loop

Other Keywords

- Break
- continue

Decision Making

- If
- If..else
- Nested if else
- switch

Control Statements

Loops

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Wrapper class

- In Java, primitive types are not classes. But for every primitive type, Java has defined a class. It is called wrapper class.

- All wrapper classes are final.

- All wrapper classes are declared in **java.lang** package.

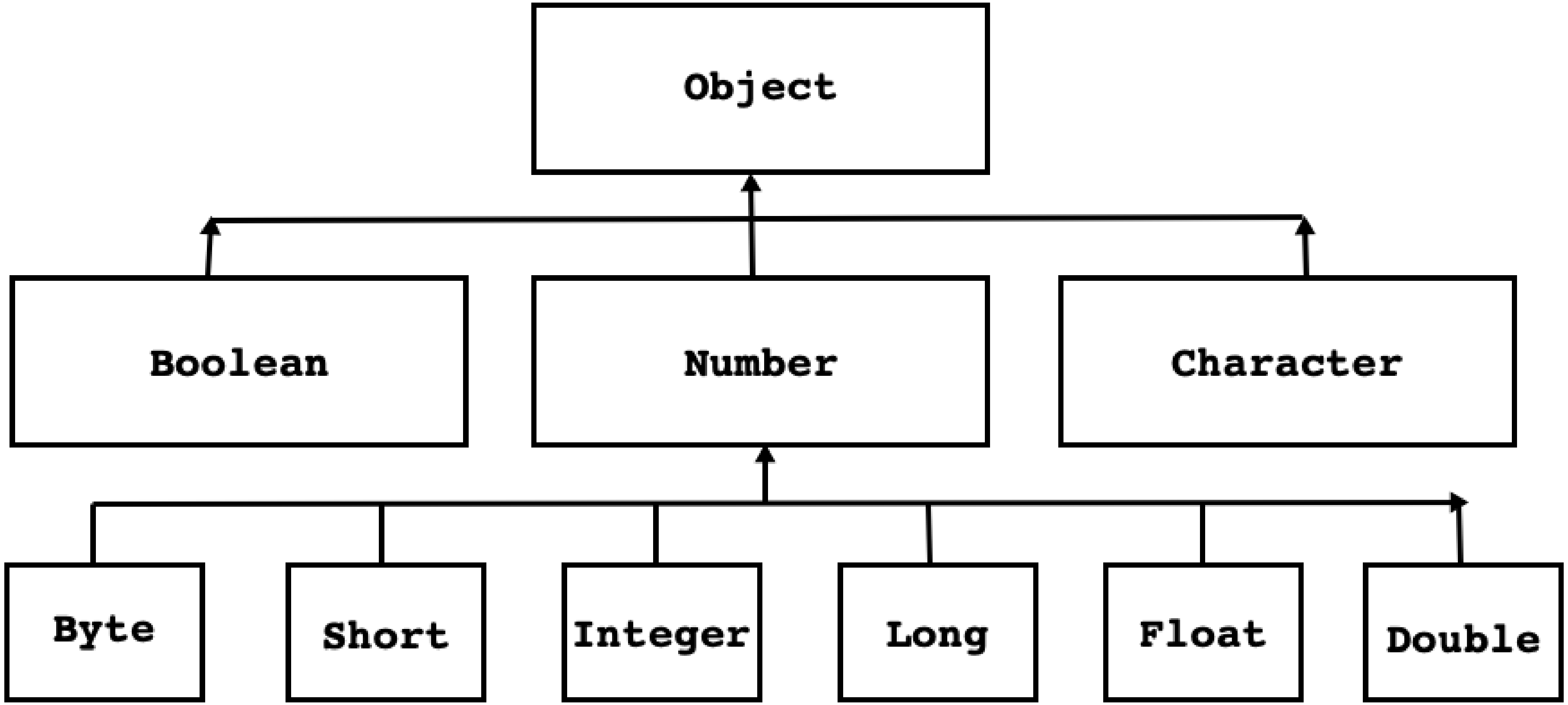
- Uses of Wrapper class
  1. To parse string(i.e. to convert state of string into numeric type).

     example :

     ```
     int num = Integer.parseInt("123")
     float val = Float.parseFloat("125.34f");
     double d = Double.parseDouble("42.3d");
     ```

  1. To store value of primitive type into instance of generic class, type argument must be wrapper class.
     - **Stack<int> stk = new Stack<int>( );   //Not OK**
     - **Stack<Integer> stk = new Stack<Integer>( );   //OK**

Wrapper class



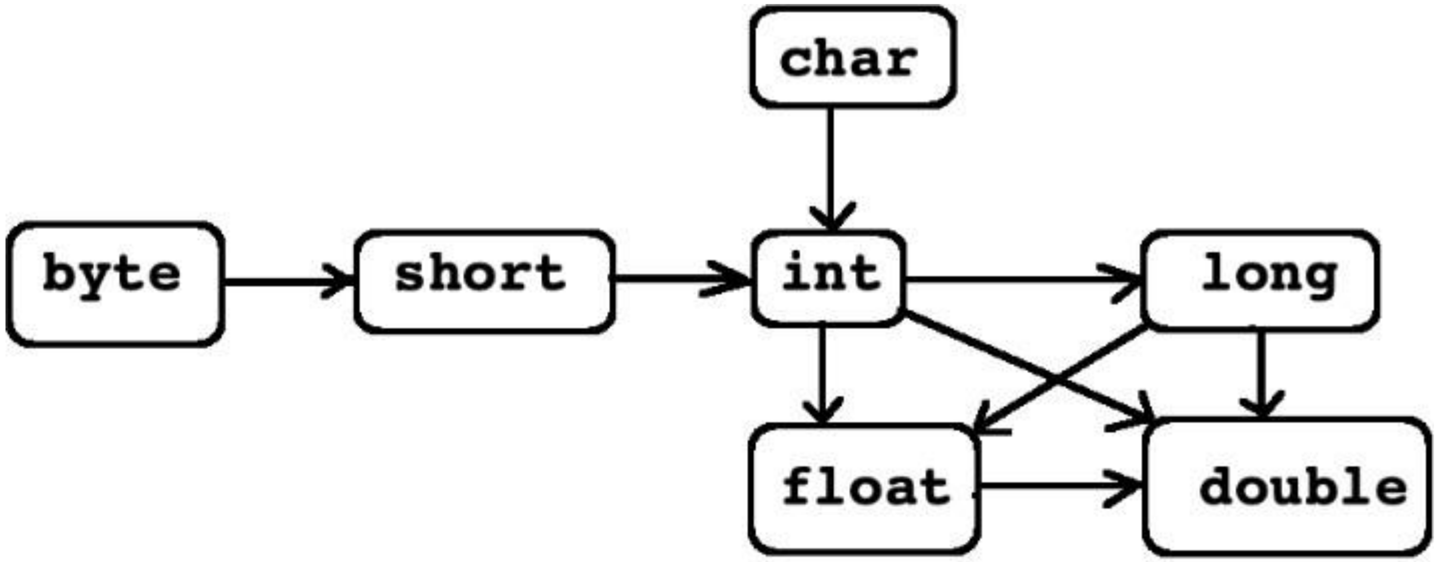
Widening

- Process of converting value of variable of narrower type into wider type is called widening.
- E.g. Converting int to double
-

```
public static void main(String[] args) {
    int num1 = 10;
    //double num2 = ( double )num1;     //Widening : OK
    double num2 = num1;     //Widening : OK
    System.out.println("Num2     :    "+num2);
}
```

- In case of widening, there is no loss of data
- So , explicit type casting is optional.

Widening



Widening Conversion

Narrowing

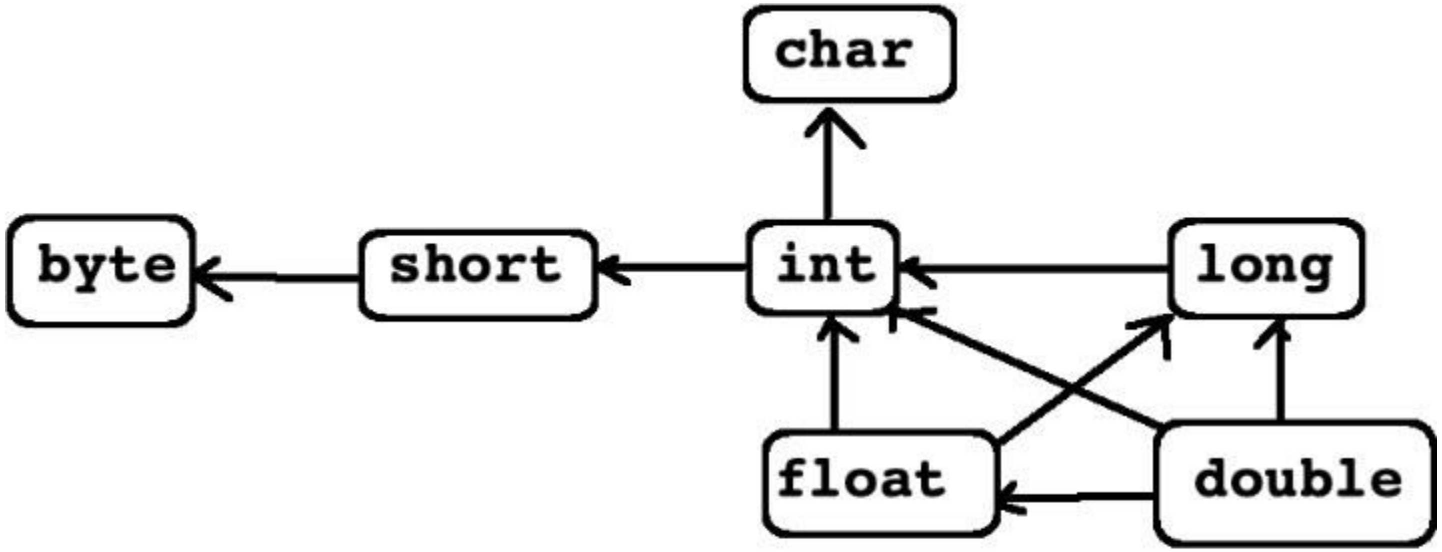
- Process of converting value of variable of wider type into narrower type is called narrowing.

```
public static void main(String[] args) {
    double num1 = 10.5;
    int num2 = ( int )num1;  //Narrowing : OK
    //int num2 = num1;  //Narrowing : NOT OK
    System.out.println("Num2    :    "+num2);
}
```

- In case of narrowing, explicit type casting is mandatory.

Note : In case of narrowing and widening both variables are of primitive

Narrowing



Narrowing Conversion.

Boxing

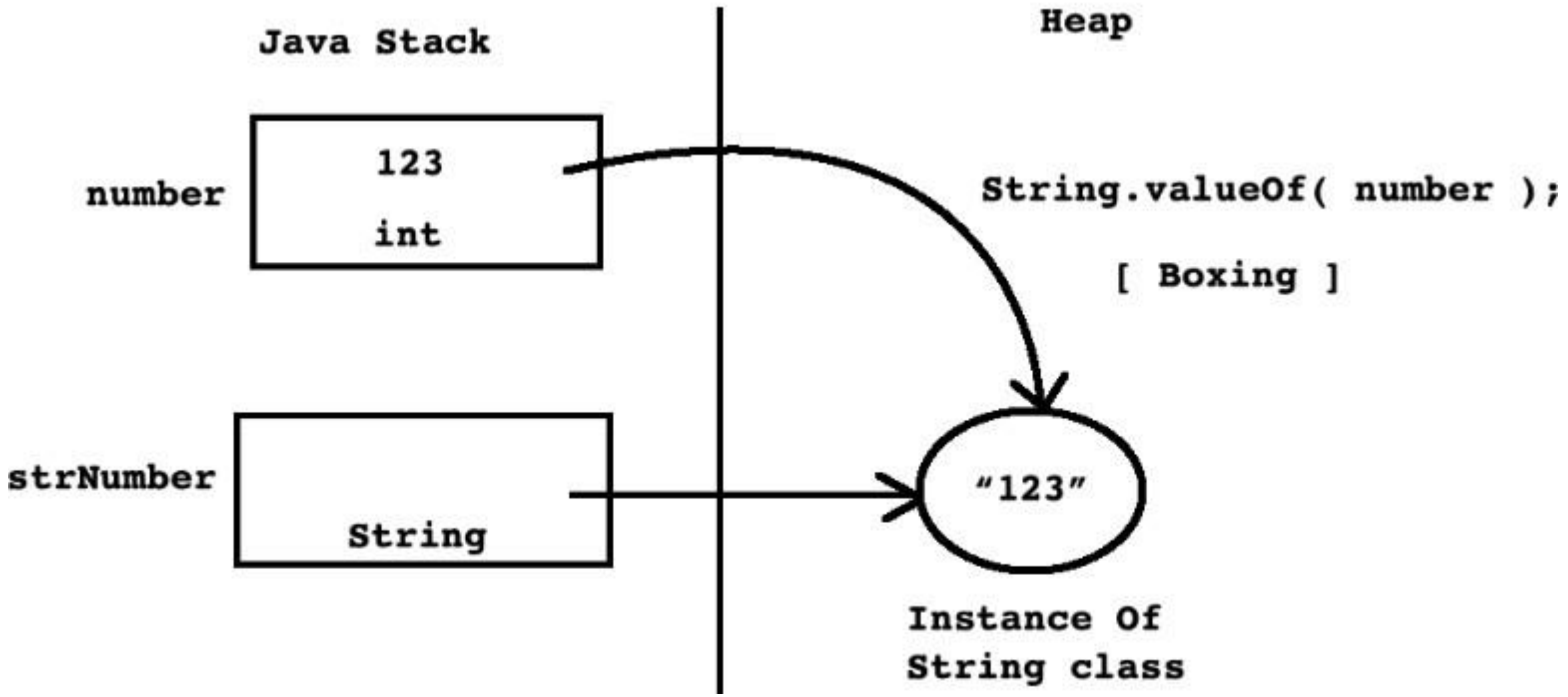
- Process of converting value of variable of primitive type into non primitive type is called **boxing.**

```
public static void main(String[] args) {
    int number = 123;
    //String str = Integer.toString( number );     //Boxing : OK
    String str = String.valueOf(number);          //Boxing : OK
    System.out.println("Str :    "+str);
}
```

  - int n1=10; float f=3.5f; double d1=3.45
  - String str1=String.valueOf(n1);
  - String str2=String.valueOf(f);
  - String str3=String.valueOf(d1);

Boxing

```java
int number = 123;
String strNumber = String.valueOf( number ); //Boxing
```



Unboxing

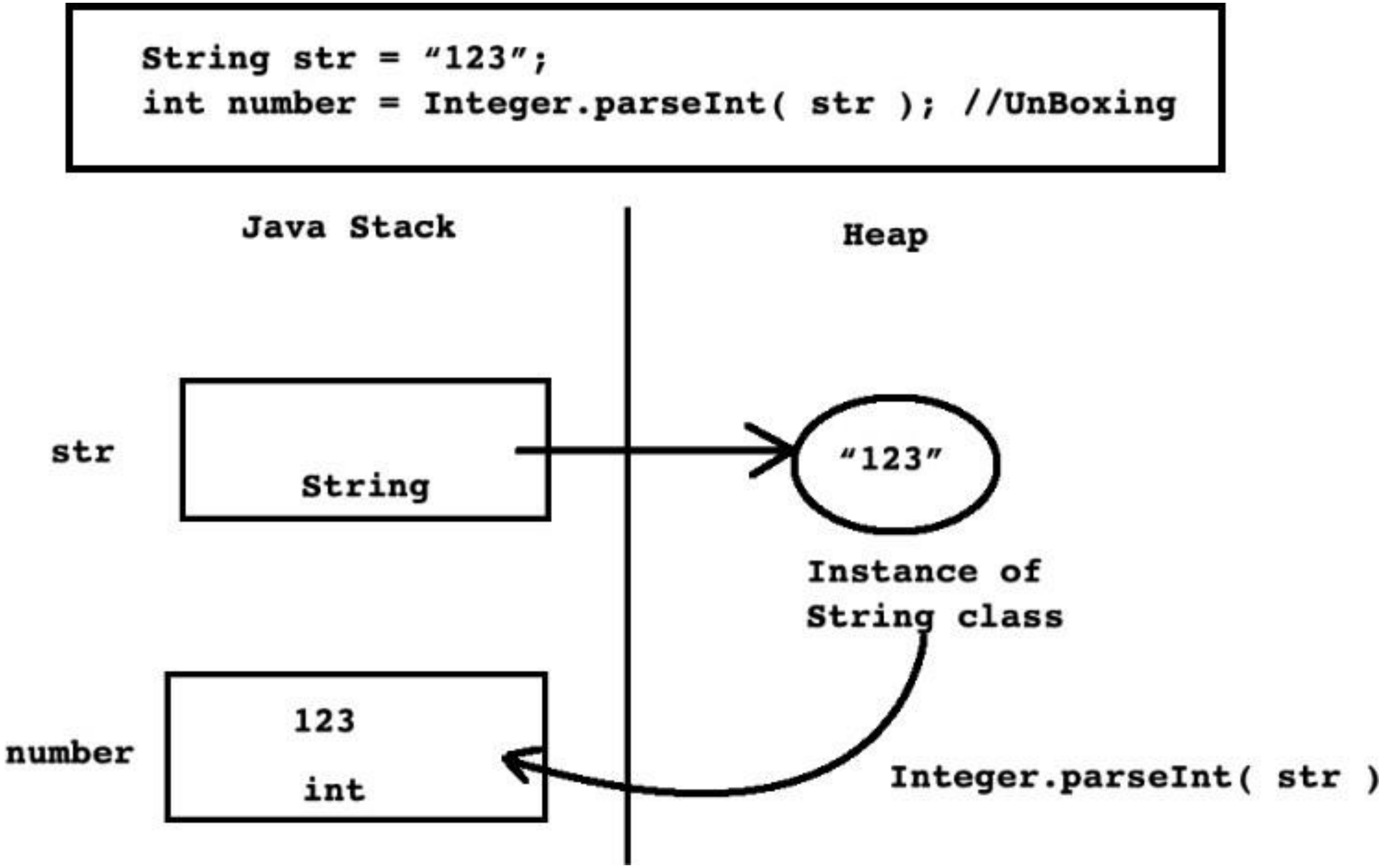
- Process of converting value of variable of non primitive type into primitive type is called unboxing.

```
public static void main(String[] args) {
    String str = "123";
    int number = Integer.parseInt(str); //UnBoxing
    System.out.println("Number  :   "+number);
}
```

- If string does not contain parseable numeric value then **parseXXX( )** method throws **NumberFormatException.**

```
String str = "12c";
int number = Integer.parseInt(str); //UnBoxing : NumberFormatException
```

Unboxing



Note : In case of boxing and unboxing one variable is primitive and other Is not primitive

Command line argument

```
class Program{
    public static void main( String[] args ){
        int num1      = Integer.parseInt(args[0]);
        float num2    = Float.parseFloat(args[1]);
        double num3   = Double.parseDouble(args[2]);
        double result = num1 + num2 + num3;
        System.out.println("Result : "+result);
    }
}
```

```
+ User input from terminal:
    - java Program 10 20.3f 35.2d (Press enter key)
```

Java Buzzwords

1. Simple
2. Object Oriented
3. Architecture Neutral
4. Portable
5. Robust
6. Multithreaded
7. Dynamic
8. Secure
9. High Performance
10. Distributed

Simple

- Java is **simple** programming language.
  - **Syntax of Java is simpler than syntax of C/C++ hence it is considered as simple**

    - Ø No need of header files and macros.
    - Ø We can not define anything global
    - Ø Do not support structure and union. operator overloading.
    - Ø Do not support copy constructor and assignment operator function constructor member initializer list and default argument constant data member and constant member function.
      Delete operator, destructor , friend function, friend class.
      Multiple class (Multiple inheritance)
    - Ø No diamond problem and virtual base class.
    - Ø Do not support pointer and pointer arithmetic.

  - **Size of software(JDK), that is required to develop Java application is small hence Java is considered as simple programming language.**

Object Oriented

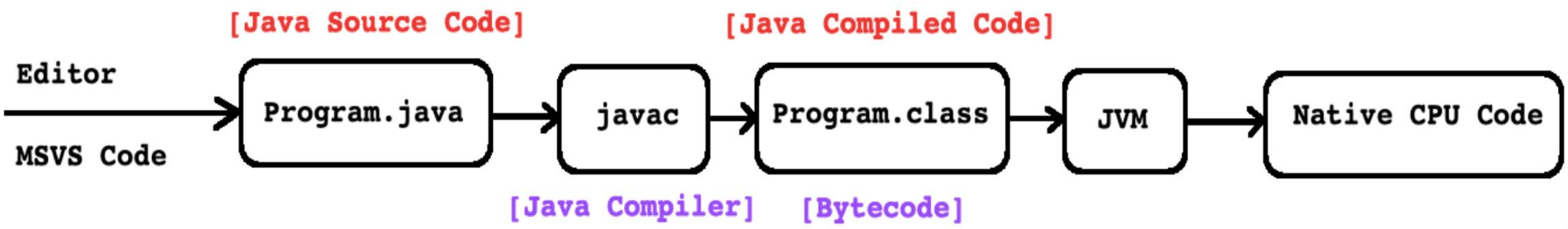
- Java is **object oriented** programming language.
  - Java Supports all the major and minor pillars of oops hence it is considered as object oriented programming language.

  - **Major pillars of oops.**
    1. Abstraction
    2. Encapsulation
    3. Modularity
    4. Hierarchy

  - **Minor pillars of oops.**
    1. Typing / Polymorphism
    2. Concurrency
    3. Persistence.

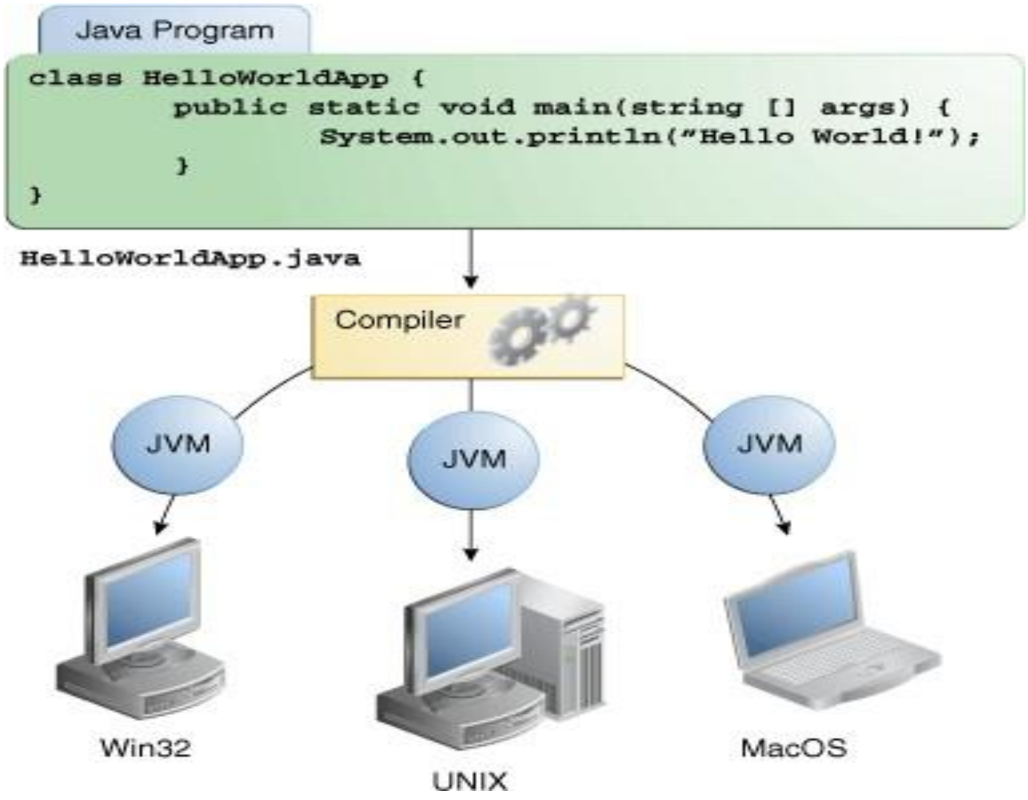
Architecture Neutral

- Java is object **architecture neutral** programming language.
    - o Java technology is designed to support applications that will be deployed into heterogeneous network environments. In such environments, applications must be capable of executing on a variety of hardware architectures. Within this variety of hardware platforms, applications must execute on the top of a variety of operating systems. To accommodate the diversity of operating environments, the Java Compilerproduct generates *bytecodes*--an *architecture neutral* intermediate format designed to transport code efficiently to multiple hardware and software platforms.



Portable

- Java is **portable** programming language.
  - Architecture neutrality is just one part of a truly *portable* system.



Portable

- Java is **portable** programming language.
  - o Java technology takes portability a stage further by being strict in its definition of the basic language.
- o Java technology puts a stake in the ground and specifies the sizes of its basic types and the behavior of its data arithmetic operators.
- o Your programs are the same on every platform--there are no data type

  incompatibilities across hardware and software architectures.

Sr.No.	Primitive Type	Size	Default Value For Field
1	boolean	Isn't Defined	FALSE
2	byte	1 Byte	0
3	char	2 Bytes	\u0000'
4	short	2 Bytes	0
5	int	4 Bytes	0
6	float	4 Bytes	0.0f
7	double	8 Bytes	0.0d
8	long	8 Bytes	0L

Robust

- Java is **robust** programming language.
  - The Java programming language is designed for creating highly *reliable* software. It provides extensive compile-time checking, followed by a second level of run- time checking.
  - Java is robust because of following features:

1. *Architecture Neutral.*
   - Ø Java developer is free from developing H/W or OS specific coding.
2. *Object orientation.*
   - Ø Reusability reduces developer’s effort.
3. *Automatic memory management.*
   - Ø Developer need not to worry about memory leakage / program crashes.
4. *Exception handling.*
   - Ø Java compiler helps developer to provide try-catch block.

Multithreaded

- Java is **multithreaded** programming language.
    - o When we start execution of Java application then JVM starts execution threads hence Java is considered as multithreaded.
        1. Main thread
            - Ø It is user thread / non daemon thread.
            - Ø It is responsible for invoking main method.
            - Ø Its default priority is 5(Thread.NORM_PRIORITY).
        2. Garbage Collector / Finalizer
            - Ø It is daemon thread / background thread.
            - Ø It is responsible for releasing / deallocating memory of unused objects.
            - Ø Its default priority is 8(Thread.NORM_PRIORITY + 3).
    - o The Java platform supports multithreading at the language level with the addition of sophisticated synchronization primitives: the language library provides the Thread class, and the run-time system provides monitor and condition lock primitives. At the library level, moreover, Java technology's high-level system libraries have been written to be thread safe: the functionality provided by the libraries is available without conflict to multiple concurrent threads of execution.

Dynamic

- Java is **dynamic** programming language.
  - While the Java Compiler is strict in its compile-time static checking, the language and run-time system are *dynamic* in their linking stages. Classes are linked only as needed. New code modules can be linked in on demand from a variety of sources, even from sources across a network.
  - Java is designed to adapt to an evolving environment.
  - Libraries can freely add new methods and instance variables without any effect on their clients.
  - In Java finding out runtime type information is straightforward.
  - In Java, all the methods are by default virtual.

Secure

- Java is **secure** programming language.
  - Java is intended to be used in networked/distributed environments. Toward that end, a lot of emphasis has been placed on security. Java enables the construction of virus-free, tamper-free systems.
  - From the beginning, Java was designed to make certain kinds of attacks impossible, among them:
    1. Overrunning the runtime stack—a common attack of worms and viruses
    2. Corrupting memory outside its own process space
    3. Reading or writing files without permission

High Performance

- Java

  is **high performance** programming language.

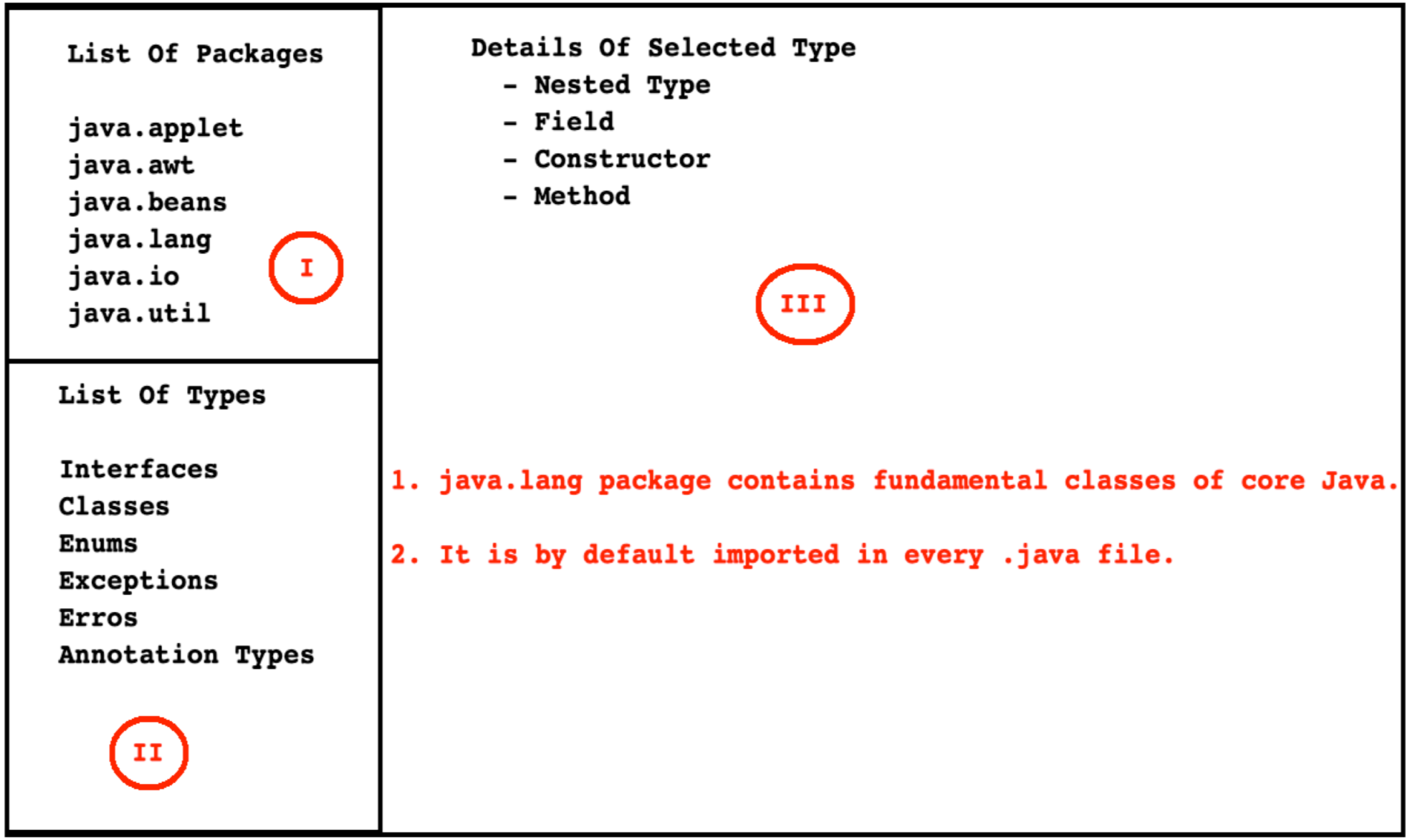
  - The Java platform achieves superior performance by adopting a scheme by which the interpreter can run at full speed without needing to check the run-time environment.
  - The *automatic garbage collector* runs as a low-priority background thread, ensuring a high probability that memory is available when required, leading to better performance.
  - Applications requiring large amounts of compute power can be designed such that compute-intensive sections can be rewritten in native machine code as required and interfaced with the Java platform.
  - In general, users perceive that interactive applications respond quickly even though they're interpreted.

Distributed

- Java is **distributed** programming language.
- Java has an extensive library of routines for coping with protocols like HTTP , TCP/IP and FTP.
- Java applications can open and access objects across the Net via URL with the same ease as when accessing a local file system.

  - Nowadays, one takes this for granted, but in 1995, connecting to a web server from a C++ or Visual Basic program was a major undertaking.

Java DOCS


List Of Packages
java.applet
java.awt
java.beans
java.lang
java.io
java.util
I
List Of Types
Interfaces
Classes
Enums
Exceptions
Erros
Annotation Types
II
Details Of Selected Type
- Nested Type
- Field
- Constructor
- Method
III
1. java.lang package contains fundamental classes of core Java.
2. It is by default imported in every .java file.

java.lang.System class

```
package java.lang;
import java.io.*;
public final class System{
    public static final InputStream in;
    public static final OutputStream out;
    public static final OutputStream err;

    public static Console console();
    public static void exit(int status);
    public static void gc();
}
```

Stream

- Stream is an abstraction(object) which either produce(write)/consume(read) information from source to destination.
- Standard stream objects of Java which is associated with console:
  1. **System.in**
     - Ø It represents keyboard.
  2. **System.out**
     - Ø It represents Monitor.
  3. **System.err**
     - Ø Error stream which represents Monitor.

How to access members of package?

Package : p1

```
public class Complex{
  //TODO
}
```

```
public class Program{
  public static void main( String[] args ){
    p1.Complex c1 = new p1.Complex( );
  }
}
```

1

```
import p1.Complex;
public class Program{
  public static void main( String[] args ){
    Complex c1 = new Complex( );
  }
}
```

2

User Input Using Console class

- Console is class declared in java.io package.
- console( ) is a static method of System class which returns reference of java.io.Console class
  - public static Console console( );
- **public String readLine( )** is a method of java.io.Console class.

```
java.io.Console console = System.console( );
String name = console.readLine( );
int empid = Integer.parseInt( console.readLine( ) );
float salary = Float.parseFloat( console.readLine( ) );
```

```
import java.io.Console;
Console console = System.console( );
String name = console.readLine( );
int empid = Integer.parseInt( console.readLine( ) );
float salary = Float.parseFloat( console.readLine( ) );
```

User Input Using Scanner class.

- Scanner is a final class declared in java.util package.
- Methods of Scanner class:

```
1. public String nextLine()
2. public int nextInt()
3. public float nextFloat()
4. public double nextDouble()
```

- How to user Scanner?

```
Scanner sc = new Scanner(System.in);
String name = sc.nextLine( );
int empid = sc.nextInt( );
float salary = sc.nextFloat( );
```

Modifier

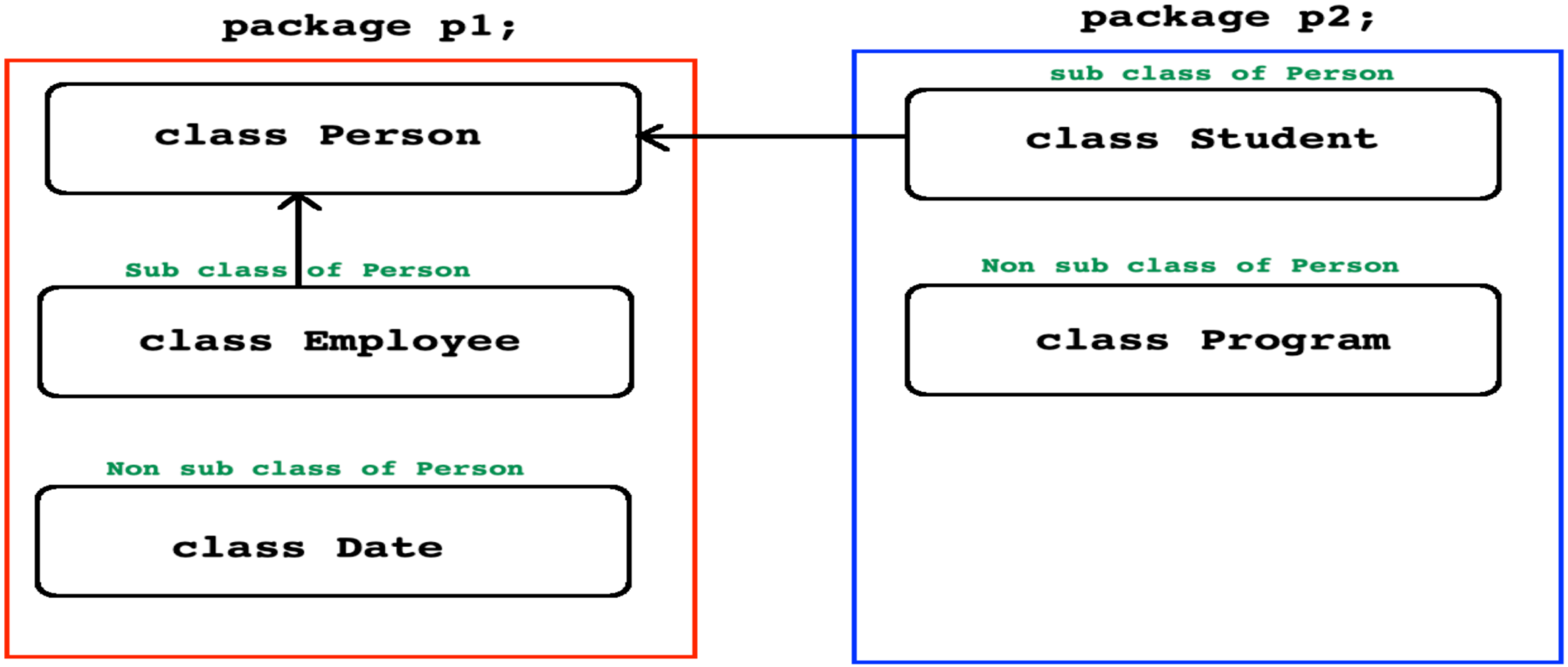
1. ABSTRACT
2. FINAL
3. INTERFACE
4. NATIVE
5. PRIVATE
6. PROTECTED
7. PUBLIC
8. STATIC
9. STRICT
10. SYNCHRONIZED
11. TRANSIENT
12. VOLATILE

Access Modifier

- If we want to control visibility of members of class then we should use access modifier.
- There are 4 access modifiers in Java:
    1. private
    2. package-level private / default
    3. protected
    4. public

	Same Package			Different Package	
Access Modifiers	Same class	Sub class	Non sub cass	Sub class	Non Sub class
private	A	NA	NA	NA	NA
package level private/Default	A	A	A	NA	NA
protected	A	A	A	A	NA
public	A	A	A	A	A

Access Modifier



Class

- Consider following examples:
    1. day, month, year - related to – Date
    2. hour, minute, second - related to – Time
    3. red, green, blue - related to Color
    4. real, imag - related to – Complex
    5. xPosition, yPosition - related to Point
    6. number, type, balance - related to Account
    7. name, id, salary - related to Employee

- If we want to group related data elements together then we should use/define class in Java.

```
class Date{
    int day;        //Field
    int month;      //Field
    int year;       //Field
}
```

```
class Employee{
    String name;    //Field
    int id;          //Field
    float salary;    //Field
}
```

Class

- class is a non primitive/reference type in Java.
- If we want create object/instance of a class then it is mandatory to use new operator.
- If we create instance using new operator then it gets space on heap section.
- Only fields of the get space once per instance according to order of their declaration inside class.

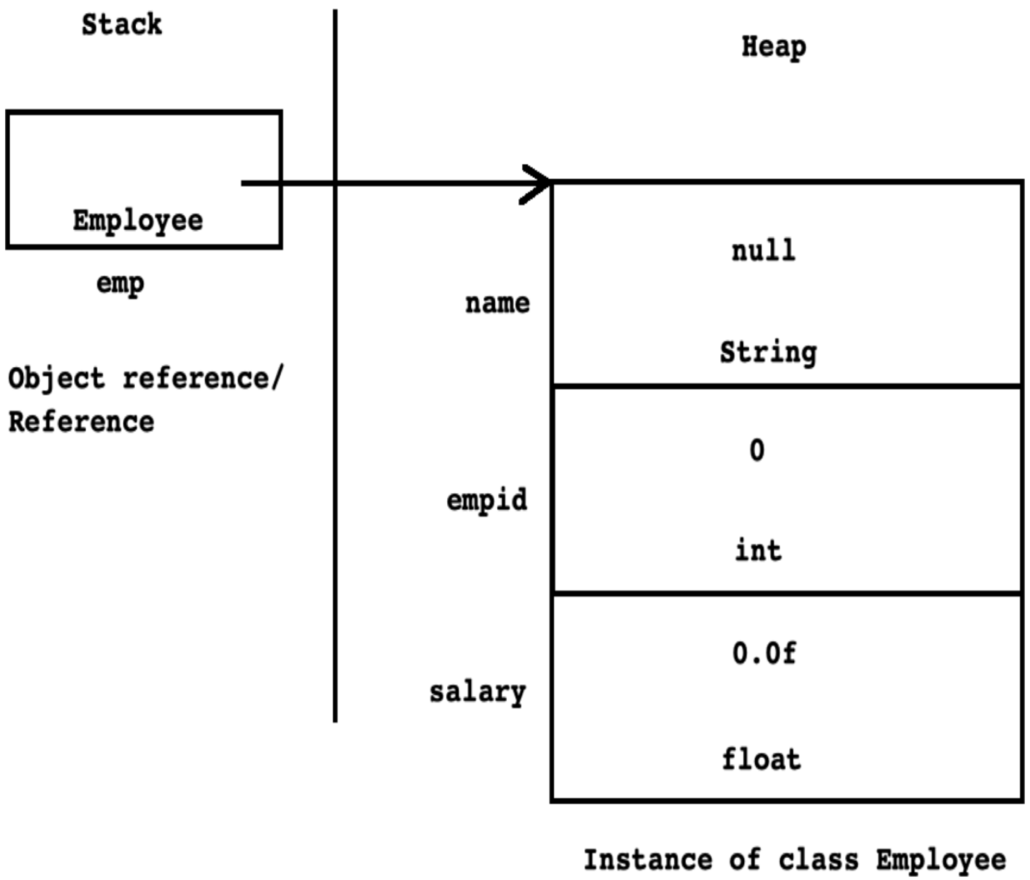
Class

- Field
  - Ø A variable declared inside class / class scope is called a field.
  - Ø Field is also called as attribute or property.
- Method
  - Ø A function implemented inside class/class scope is called as method.
  - Ø Method is also called as operation, behavior or message.
- Class
  - Ø Class is a collection of fields and methods.
  - Ø Class can contain
    1. Nested Type
    2. Field
    3. Constructor
    4. Method
- **Instance**
  - Ø In Java, Object is also called as instance.

Instantiation

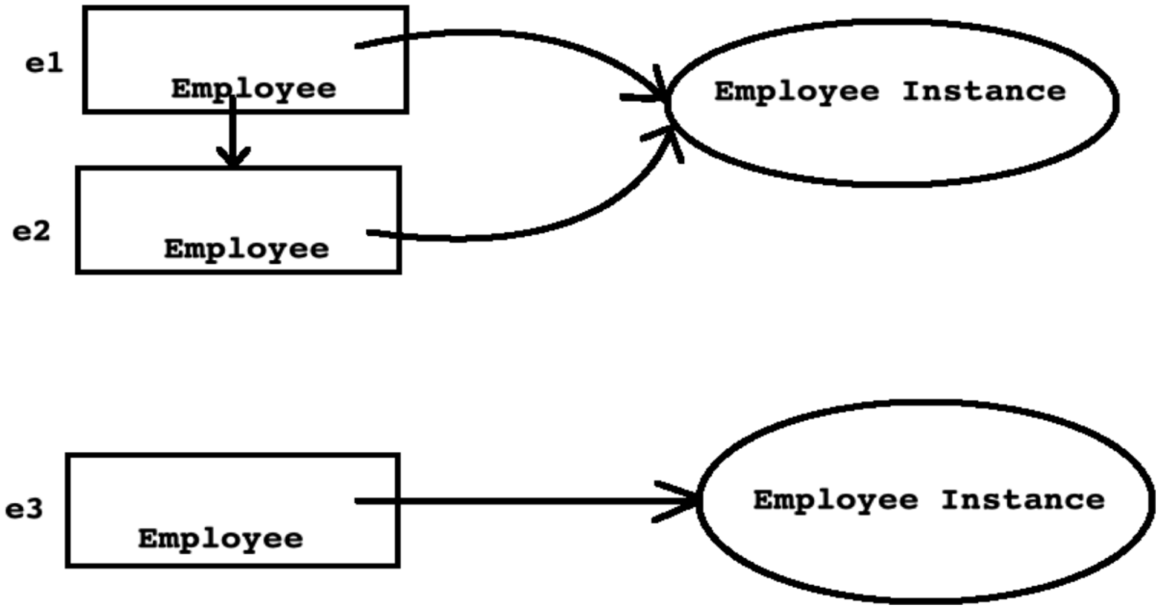
- Process of creating instance/object from a class is called as instantiation.
- In C programming language
  - Ø Syntax : struct StructureName identifier_name; struct
  - Ø Employee emp;
- In C++ programming language
  - Ø Syntax : [class] ClassName identifier_name;
  - Ø Employee emp;
- In Java programming language
  - Ø Syntax : ClassName identifier_name = new ClassName( );
  - Ø Employee emp = new Employee();
- **Every instance on heap section is anonymous.**

Instantiation



For eg :

```
1. Employee e1 = new Employee();
2. Employee e2 = e1;
3. Employee e3 = new Employee();
```



this reference

- If we call non static method on instance(actually object reference) then compiler implicitly pass, reference of current/calling instance as a argument to the method implicitly. To store reference of current/calling instance, compiler implicitly declare one reference as a parameter inside method. It is called this reference.

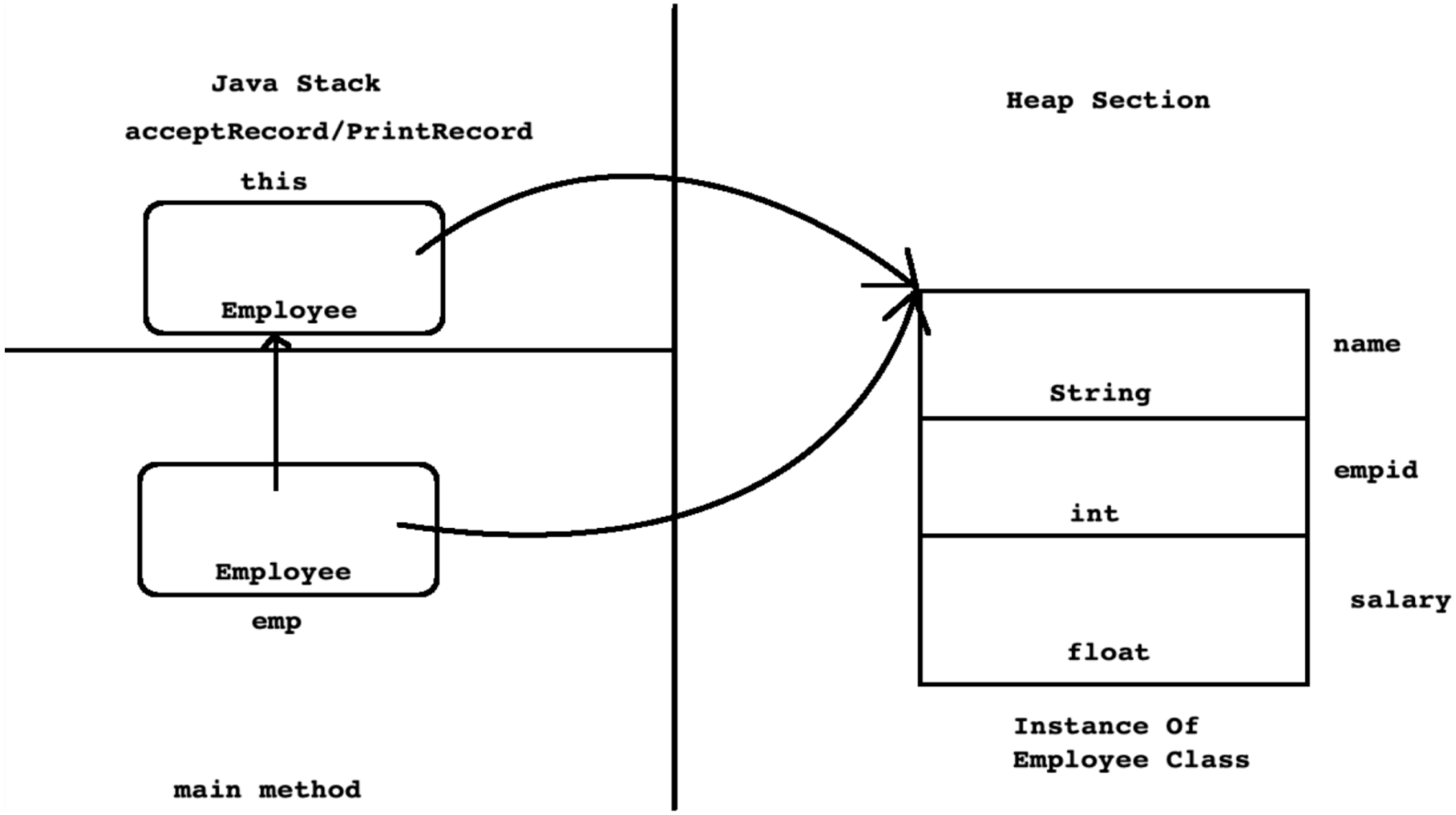
- **this is a keyword** in Java which is designed to store reference of current/calling instance.

- **Using this reference, non static fields and non static methods are communicating with each other. Hence this reference is considered as a link/connection between them.**

- Definition
  - **“this" is implicit reference variable that is available in every non static method of class which is used to store reference of current/calling instance.**

- Inside method, to access members of same class, use this keyword is optional

this reference



this reference

- If name of local variable/parameter and name of field is same then preference is always given to the local variable.

```
class Employee{
    private String name;
    private int empid;
    private float salary;
    public void initEmployee(String name, int empid, float salary ){
        this.name = name;
        this.empid = empid;
        this.salary = salary;
    }
}
```

Constructor

- If we want to initialize instance then we should define constructor inside class.
- Constructor look like method but it is not considered as method.
- It is special because:
  - Its name is same as class name.
  - It doesn't have any return type.
  - It is designed to be called implicitly
  - It is called once per instance.
- We can not call constructor on instance explicitly

  Employee emp = new Employee();
  emp.Employee( ); //Not Ok

- **Types of constructor:**
  1. Parameterless constructor
  2. Parameterized constructor
  3. Default constructor .

Parameterless Constructor

- If we define constructor without parameter then it is called as parameterless constructor.
- It is also called as zero argument / user defined default constructor.
- If we create instance without passing argument then parameterless constructor gets called.

```
public Employee( ){
    //TODO
}
```

```
Employee emp = new Employee( ); //Here on instance parameterless ctor will call.
```

Parameterized Constructor

- If we define constructor with parameter then it is called as parameterized constructor.
- If we create instance by passing argument then parameterized constructor gets called.

```
public Employee( String name, int empid, float salary ){
    //TODO
}
```

```
Employee emp = new Employee( "ABC",123, 8000 ); //Here on instance parameterized ctor will call.
```

Default Constructor

- If we do not define any constructor inside class then compiler generate one constructor for the class by default. It is called default constructor.

- Compiler generated default constructor is parameterless.
- Compiler never generate default parameterized constructor. In other words, if we want to create instance by passing arguments then we must define parameterized constructor inside class.

Constructor Chaining

- We can call constructor from another constructor. It is called constructor chaining.
- For constructor chaining, we should use this statement.
- this statement must be first statement inside constructor body.
- Using constructor chaining, we can reduce developers effort.

```
class Employee{
    //TODO : Field declaration
    public Employee( ){
        this( "None", 0, 8500 );    //Constructor Chaining
    }
    public Employee( String name, int empid, float salary ){
        this.name = name;
        this.empid = empid;
        this.salary = salary;
    }
}
```

Literals

- Consider following literals in Java:
    1. true : boolean
    2. 'A' : char ch;
    3. “Akshita" : String str;
    4. 123 : int num1;
    5. 72.93f : float num2
    6. 3.142 : double num3
    7. null : Used to initialize reference variable.

- null is a literal which is designed to initialize reference variable
    - int num = null ; //invalid
    - Integer num=null; // VALID
    - String str=null; // VALID
    - Employee emp=null; // VALID

null

If reference variable contains null value then it is called null reference variable / null object.

```
class Program{
    public static void main(String[] args) {
      Employee emp; //Object reference / reference
      emp.printRecord(); //error: variable emp might not have been initialized
    }
}
```

```
public static void main(String[] args) {
    Employee emp = null; //null reference varibale / null object
    emp.printRecord();    //NullPointerException
}
```

Value type VS Reference Type

Sr. No.	Value Type	Reference Type
1	primitive type is also calle as value type.	Non primitive type is also called as reference type.
2	boolean, byte, char, short, int, float, double, long are primitive/value type.	Interface, class, type variable and array are non primitive/reference type.
3	Variable of value type contains value.	Variable of reference type contains reference.
4	Variable of value type by default contains 0 value.	Variable of reference type by default contain null reference.
5	We can not create variable of value type using new operator.	It is madatory to use new operator to create instance of reference type.
6	variable of value type get space on Java stack.	Intstance of reference type get space on heap section.
7	We can not store null value inside variable of value type.	We can store null value inside variable reference type.
8	In case of copy, value gets copied.	In case of copy, reference gets copied.

Coding Convention

- **Pascal Case Coding/Naming Convention:**
  - Example
    1. System
    2. StringBuilder
    3. NullPointerException
    4. IndexOutOfBoundsException

  - In this case, including first word, first character of each word must in upper case.

  - We should use this convention for:
    1. Type Name(Interface, class, Enum, Annotation)
    2. File Name

Coding Convention

- **Camel Case Coding/Naming Convention:**
  - Example
    1. main
    2. parseInt
    3. showInputDialog
    4. addNumberOfDays
  - In this case, excluding first word, first character of each word must in upper case.
  - We should use this convention for:
    1. Method Parameter and Local variable
    2. Field
    3. Method
    4. Reference

Coding Convention

- **Naming Convention for package:**
  - We can specify name of the package in uppercase as well as lower-case. But generally it is mentioned in lower case.
  - Example
    1. java.lang
    2. java.lang.reflect
    3. java.util
    4. java.io
    5. java.net
    6. java.sql

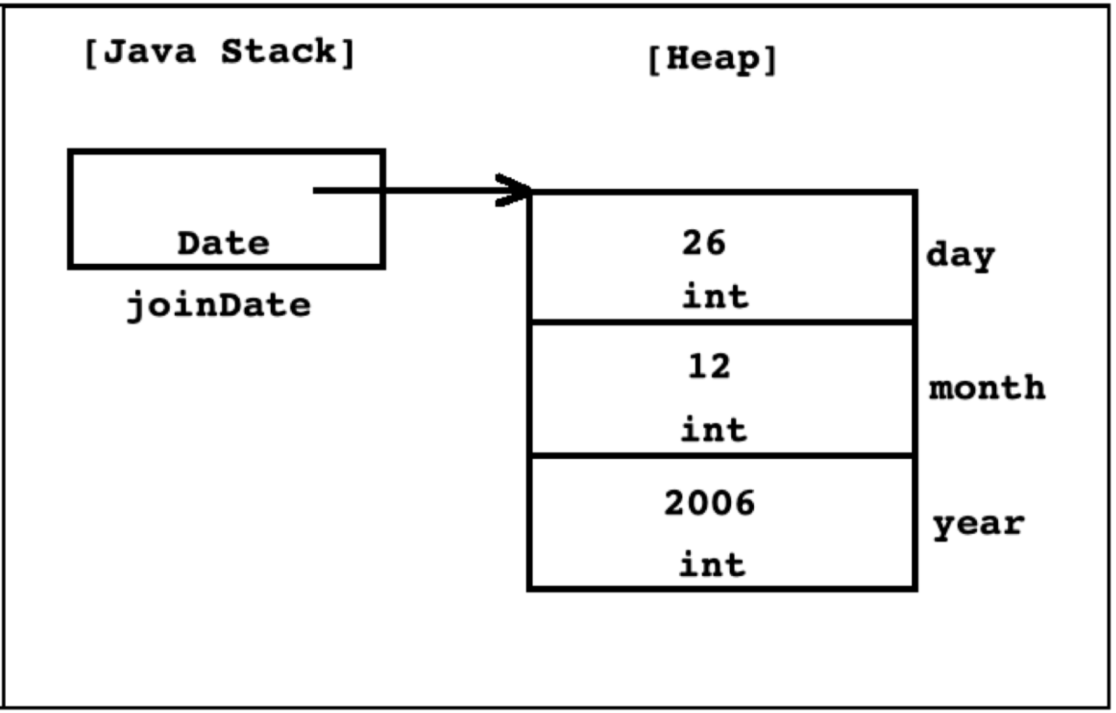
Coding Convention

- **Naming Convention for constant variable and enum constant:**
  - Example
    1. public static final int SIZE;
    2. enum Color{ RED, GREEN, BLUE }
    3. Name of the final variable and name of the enum constant should be in upper case.

Reference

- Local reference variable get space on Java Stack.

```java
class Date{
    private int day;
    private int month;
    private int year;
}
class Program{
    public static void main(String[] args) {
        Date joinDate = new Date( 26,12,2006);
        //joinDate : Method Local Variable
    }
}
```



- In above code joinDate is method local reference variable hence it gets space on Java Stack.

Reference

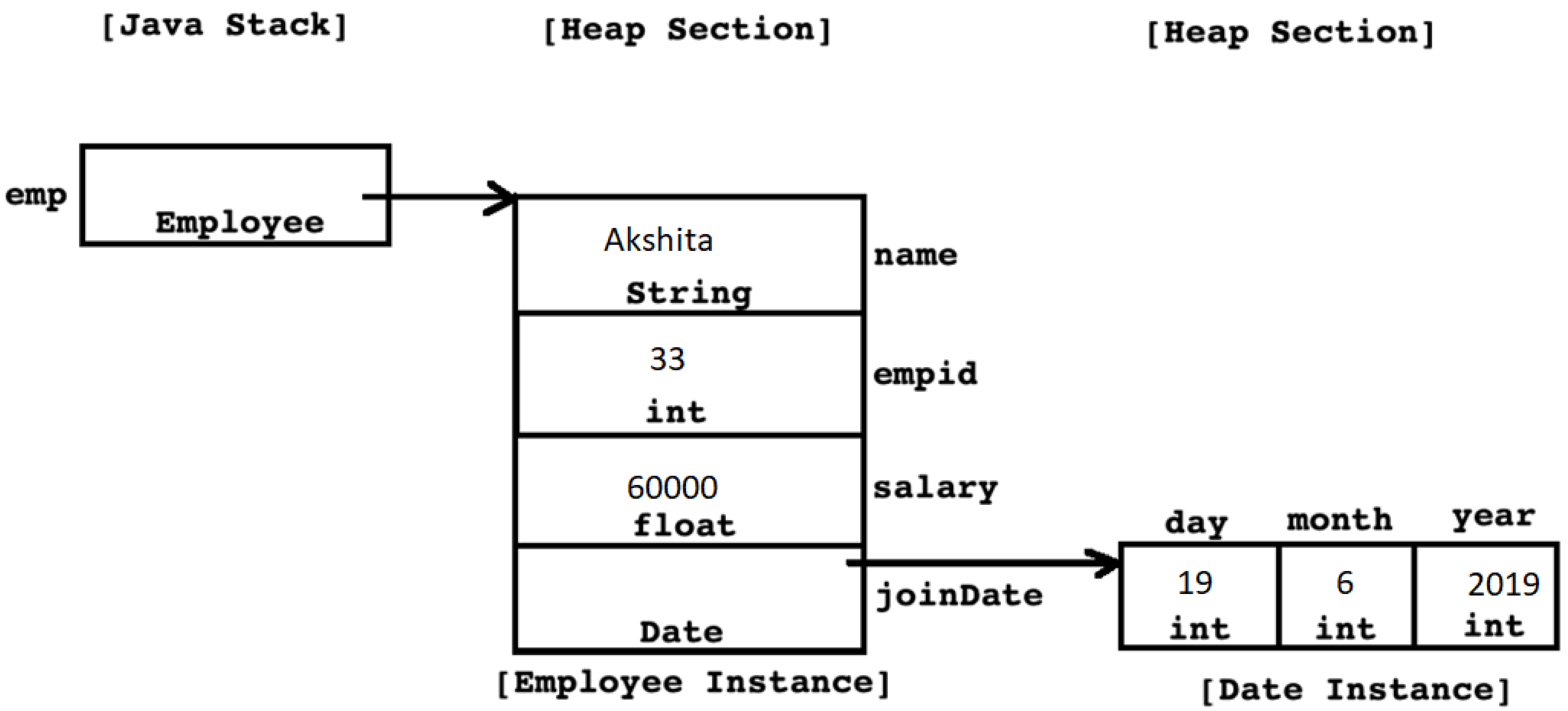
- Class scope reference variable get space on heap.

```java
class Employee{
    private String name;
    private int empid;
    private float salary
    private Date joinDate;  //joinDate : Field
    public Employee( String name, int empid, float salary, Date joinDate ){
        this.name = name;
        this.empid = empid;
        this.salary = salary;
        this.joinDate = joinDate;
    }
}
```

```
Class Program
{
 public static void main(String[] args)
{
    Employee emp = new Employee (“Akshita”,33,60000,new Date(19,06,2019));
}
}
```

- In above code, emp is method local reference variable hence it gets space on Java Stack. But joinDate is field of Employee class hence it will get space inside instance on Heap.

Reference


[Java Stack]
[Heap Section]
[Heap Section]
emp
Employee
Akshita
String
name
33
int
empid
60000
float
salary
Date
joinDate
day
month
year
19
int
6
int
2019
int
[Employee Instance]
[Date Instance]

Contents

- Object class
- toString()
- Static keyword
- Static field
- Static member function
- Static initializer block
- Static import

Object class

- It is a non final and concrete class declared in java.lang package.
- In java all the classes(not interfaces)are directly or indirectly extended from java.lang.Object class.
- In other words, java.lang.Object class is ultimate base class/super cosmic base class/root of Java class hierarchy.
- Object class do not extend any class or implement any interface.
- It doesn’t contain nested type as well as field.
- It contains default constructor.
  - `Object o = new Object(“Hello”);      //Not OK`
  - `Object o = new Object( );            //OK`

- Object class contains 11 methods.

Object class

- Consider the following code:

```
class Person{
}
class Employee extends Person{
}
```

- In above code, java.lang.object is direct super class of class Person.

- In case class Employee, class Person is direct super class and class object is indirect super class.

Methods Of Object class

```
1. public String toString();
2. public boolean equals(Object obj);
3. public native int hashCode( );
4. protected native Object clone( )throws CloneNotSupportedException
5. protected void finalize( void )throws Throwable

6. public final native Class<?> getClass( );
7. public final void wait( )throws InterruptedException
8. public final native void wait( long timeout)throws InterruptedException
9.public  final void wait( long timeout, int nanos)throws InterruptedException
10.public final native void notify( );
11.public final  native void notifyAll( );
```

toString( ) method

- It is a non final method of java.lang.Object class.
- Syntax:
  - **public String toString( );**
- If we want to return state of Java instance in String form then we should use toString() method.
- Consider definition of toString inside Object class:

```
public String toString() {
    return this.getClass().getName() + "@" + Integer.toHexString(this.hashCode());
}
```

toString( ) method

- If we do not define toString() method inside class then super class's toString() method gets call.
- If we do not define toString() method inside any class then object class's toString() method gets call.
- It return String in following form:
  - **F.Q.ClassName@HashCode**
  - **Example : test.Employee@6d06d69c**
- If we want state of instance then we should override toString() method inside class.
- The result in toString method should be a concise but informative that is easy for a person to read.
- It is recommended that all subclasses override this method.

Final variable

- In java we do not get const keyword. But we can use final keyword.
- After storing value, if we don’t want to modify it then we should declare variable final.

```java
public static void main(String[] args) {
    final int number = 10;   //Intialization
    //number = number + 5;     //Not OK
    System.out.println("Number   :    "+number );
}
```

```java
public static void main(String[] args) {
    final int number;
    number = 10;     //Assignment
    //number = number + 5;     //Not OK
    System.out.println("Number   :    "+number );
}
```

Final variable

- We can provide value to the final variable either at compile time or run time.

```
public static void main(String[] args) {
    Scanner sc = new Scanner( System.in);
    System.out.print("Number    :    ");
    final int number = sc.nextInt();    //OK
    //number = number + 5;    //Not OK
    System.out.println("Number  :    "+number );
}
```

Final field

- once initialized, if we don't want to modify state of any field inside any method of the class(including constructor body) then we should declare field final.

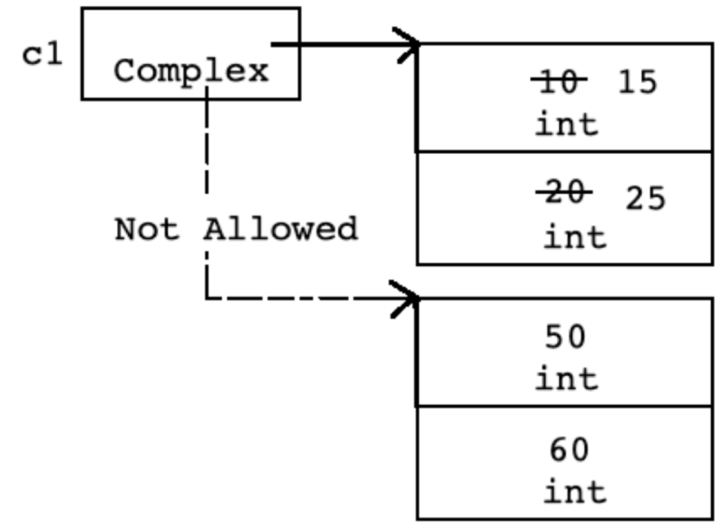
```
class Circle{
    private float area;
    private float radius = 10;
    public static final float PI = 3.142f;
    public void calculateArea( ){
        this.area = PI * this.radius * this.radius;
    }
    public void printRecord( ){
        System.out.println("Area    :   "+this.area);
    }
}
```

- If we want to declare any field final then we should declare it static also.

Final Reference Variable

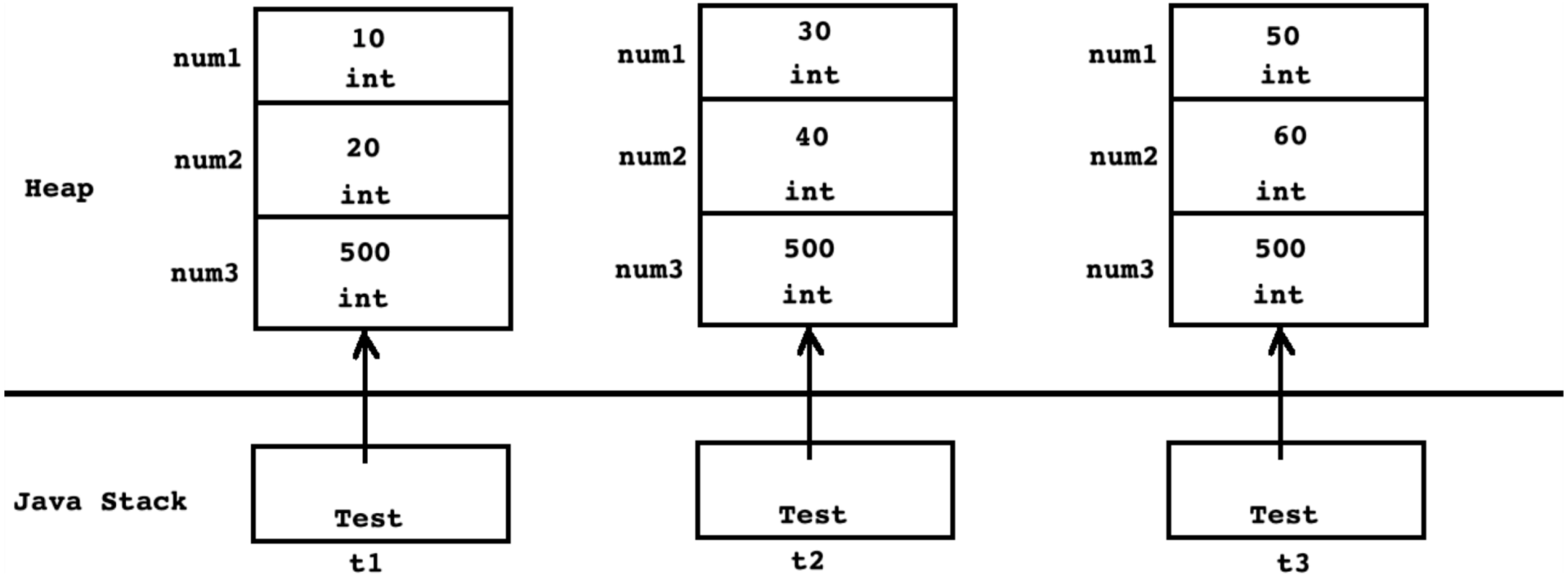
- In Java, we can declare reference final but we can not declare instance final.

```java
public static void main(String[] args) {
    final Complex c1 = new Complex( 10, 20 );
    c1.setReal(15);
    c1.setImag(25);
    //c1 = new Complex(50,60);    //Not OK
    c1.printRecord( );      //15, 25
}
```



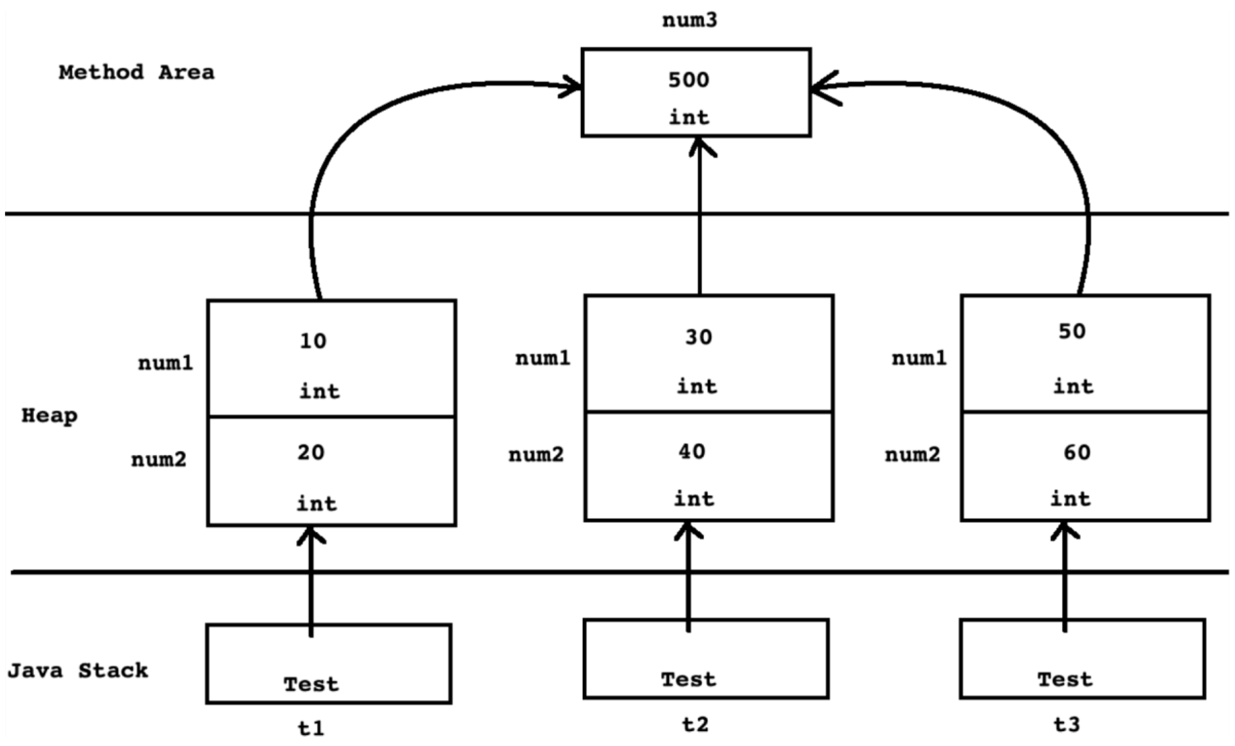
- We can declare method final. It is not allowed to override final method in sub class.
- We can declare class final. It is not allowed to extend final class.

Static Field



Static Field

- If we want to share value of any field inside all the instances of same class then we should declare that field static.



Static Field

- Static field do not get space inside instance rather all the instances of same class share single copy of it.
- Non static Field is also called as instance variable. It gets space once per instance.
- Static Field is also called as class variable. It gets space once per class.
- Static Field gets space once per class during class loading on method area.
- Instance variables are designed to access using object reference.
- Class level variable can be accessed using object reference but it is designed to access using class name and dot operator.

Static Initialization Block

- A *static initialization block* is a normal block of code enclosed in braces, { }, and preceded by the static keyword. Here is an example:

```
static {
    // whatever code is needed for initialization goes here
}
```

- A class can have any number of static initialization blocks, and they can appear anywhere in the class body.
- The runtime system guarantees that static initialization blocks are called in the order that they appear in the source code.
- There is an alternative to static blocks — you can write a private static method:

Instance Initializer Block

- Normally, you would put code to initialize an instance variable in a constructor.
- There are two alternatives to using a constructor to initialize instance variables: initializer blocks and final methods.
- Initializer blocks for instance variables look just like static initializer blocks, but without the static keyword:

```
{
    // whatever code is needed for initialization goes here
}
```

- The Java compiler copies initializer blocks into every constructor. Therefore, this approach can be used to share a block of code between multiple constructors.

Instance Initializer Block

- A *final method* cannot be overridden in a subclass.

```
class Whatever {
    private varType myVar = initializeInstanceVariable();

    protected final varType initializeInstanceVariable() {

        // initialization code goes here
    }
}
```

- This is especially useful if subclasses might want to reuse the initialization method. The method is final because calling non-final methods during instance initialization can cause problems.

Static Method

- To access non static members of the class, we should define non static method inside class.
- Non static method/instance method is designed to call on instance.
- To access static members of the class, we should define static method inside class.
- static method/class level method is designed to call on class name.
- static method do not get this reference:
    1. If we call, non static method on instance then method get this reference.
    2. Static method is designed to call on class name.
    3. Since static method is not designed to call on instance, it doesn't get this reference.

Static Method

- this reference is a link/connection between non static field and non static method.
- Since static method do not get this reference, we can not access non static members inside static method directly. In other words, static method can access static members of the class only.
- Using instance, we can use non static members inside static method.

```
class Program{
    public int num1 = 10;
    public static int num2 = 10;
    public static void main(String[] args) {
        //System.out.println("Num1    :    "+num1);    //Not OK
        Program p = new Program( );
        System.out.println("Num1    :    "+p.num1);    //OK
        System.out.println("Num2    :    "+num2);
    }
}
```

Static Method

- Inside method, If we are going to use this reference then method should be non static otherwise it should be static.

```
class Math{
    public static int power( int base, int index ){
        int result = 1;
        for( int count = 1; count <= index; ++ count ){
            result = result * base;
        }
        return result;
    }
}
```

```
class Program{
    public static void main(String[] args) {
        int result = Math.power(10, 2);
        System.out.println("Result  :   "+result);
    }
}
```

Static Import

- If static members belonging to the same class then use of type name and dot operator is optional.

```
package p1;
public class Program{
    private static int number = 10;
    public static void main(String[] args) {
        System.out.println("Number   :   "+Program.number);  //OK    :   10
        System.out.println("Number   :   "+number);  //OK    :   10
    }
}
```

Static Import

- If static members belonging to the different class then use of type name and dot operator is mandatory.
- PI and pow are static members of java.lang.Math class. To use Math class import statement is not required.
- Consider Following code:

```
package p1;
public class Program{
    public static void main(String[] args) {
        float radius = 10.5f;
        float area = ( float )( Math.PI * Math.pow( radius, 2 );
        System.out.println( "Area    :    "+area );
    }
}
```

Static Import

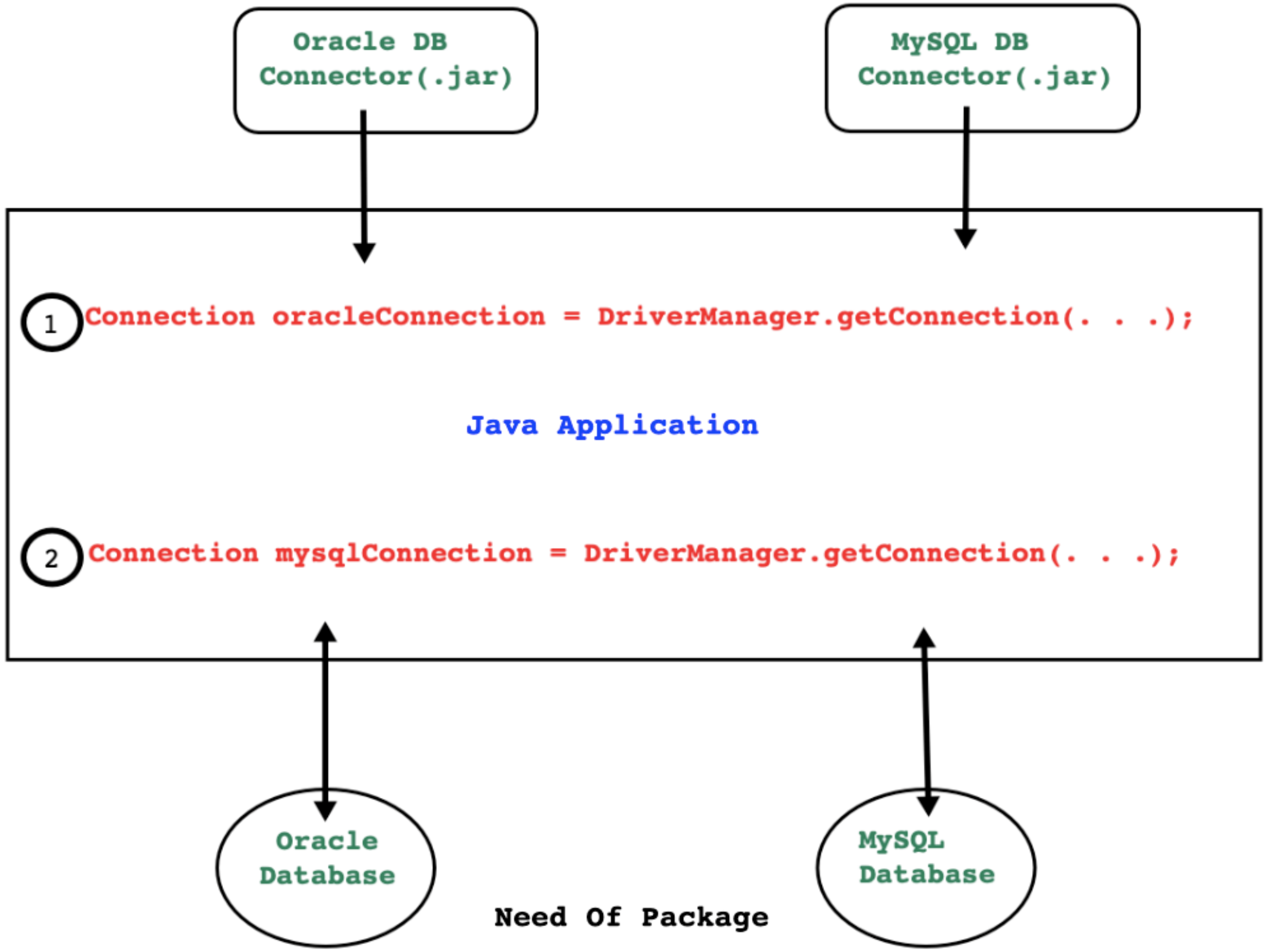
- There are situations where you need frequent access to static final fields (constants) and static methods from one or two classes. Prefixing the name of these classes over and over can result in cluttered code. The static import statement gives you a way to import the constants and static methods that you want to use so that you do not need to prefix the name of their class.
- Consider code:

```java
package p1;
import static java.lang.System.out;
import static java.lang.Math.*;
public class Program{
    public static void main(String[] args) {
        float radius = 10.5f;
        float area = ( float )( PI * pow( radius, 2 );
        out.println( "Area   :   "+area );
    }
}
```

Contents

- Package
- Static import

Package



Need Of Package

Package

- Package is a Java language feature which helps developer to:
    1. To group functionally equivalent or related types together.
    2. To avoid naming clashing/collision/conflict/ambiguity in source code.
    3. To control the access to types.
    4. To make types easier to find(from the perspective of java docs).

- Consider following class:
    - java.lang.Object
        - Here java is main package, lang is sub package and Object is type name.

Package

- Not necessarily but as shown below, package can contain some or types.
    1. Sub package
    2. Interface
    3. Class
    4. Enum
    5. Exception
    6. Error
    7. Annotation Type

Package Creation

- package is a keyword in Java.
- To define type inside package, it is mandatory write package declaration statement inside .java file.
- Package declaration statement must be first statement inside .
- If we define any type inside package then it is called as packaged type otherwise it will be unpackaged type.
- Any type can be member of single package only.

`package p1;   //OK` `class Program{` `    //TODO` `}`	`package p1, p2; //NOT OK` `class Program{` `    //TODO` `}`	`package p1; //OK` `package p2; //NOT OK` `class Program{` `    //TODO` `}` `package p3; //Not OK`

Un-named Package

- If we define any type without package then it is considered as member of unnamed/default package.
- Unnamed packages are provided by the Java SE platform principally for convenience when developing small or temporary applications or when just beginning development.
- An unnamed package cannot have sub packages.
- In following code, class Program is a part of unnamed package.

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

Naming Convention

- For small programs and casual development, a package can be unnamed or have a simple name, but if code is to be widely distributed, unique package names should be chosen using qualified names.
- Generally Package names are written in all lower case to avoid conflict with the names of classes or interfaces.
- Companies use their reserved internet domain name to begin their package names. For example : com.example.mypackage
- Following examples will help you in deciding name of package:
    1. java.lang.reflect.Proxy
    2. oracle.jdbc.driver.OracleDriver
    3. com.mysql.jdbc.cj.Driver
    4. org.cdac.sunbeam.dac.utils.Date

How to use package members in different package?

- If we want to use types declared inside package anywhere outside the package then
    1. Either we should use fully qualified type name or
    2. import statement.
- If we are going to use any type infrequently then we should use fully qualified name.
- Let us see how to use type using package name.

```
class Program{
    public static void main(String[] args) {
        java.util.Scanner sc = new java.util.Scanner( System.in );
    }
}
```

How to use package members in different package?

- If we are going to use any type frequently then we should use import statement.
- Let us see how to import Scanner.

```
import java.util.Scanner;
class Program{
    public static void main(String[] args) {
        Scanner sc = new Scanner( System.in );
    }
}
```

How to use package members in different package?

- There can be be any number of import statements after package declaration statement
- With the help of(*) we can import entire package.

```
import java.util.*;
class Program{
    public static void main(String[] args) {
        Scanner sc = new Scanner( System.in );
    }
}
```

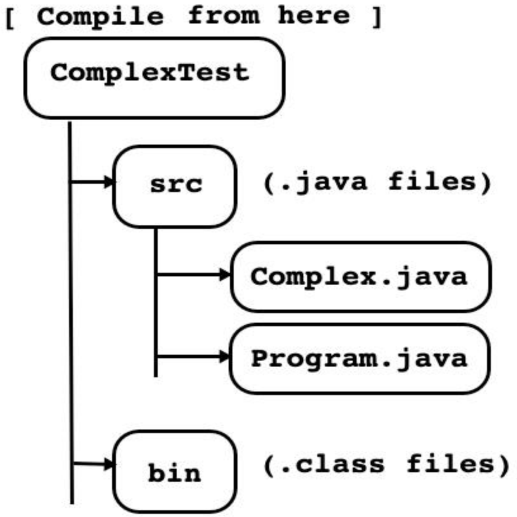
How to use package members in different package?

- Another, less common form of import allows us to import the public nested classes of an enclosing class. Consider following code.

```
import java.lang.Thread.State;
class Program{
    public static void main(String[] args) {
        Thread thread = Thread.currentThread( );
        State state = thread.getState( );
    }
}
```

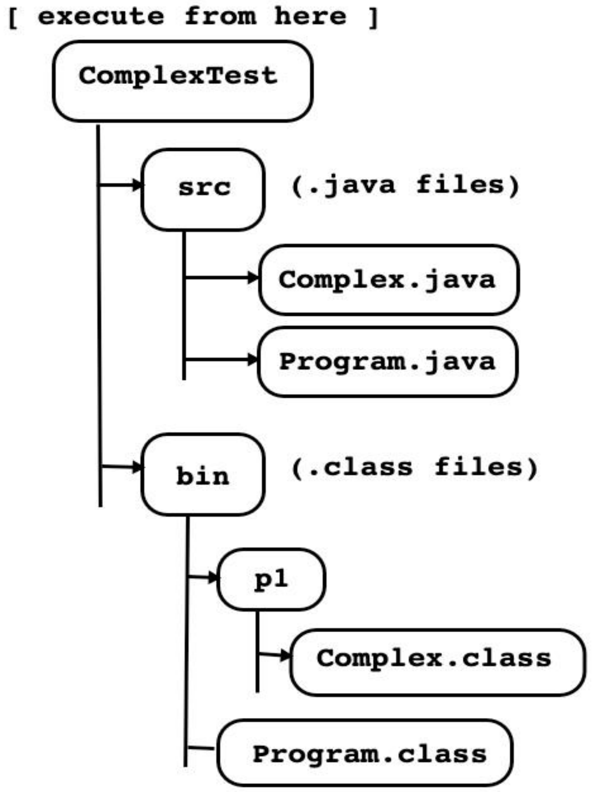
- Note : java.lang package contains fundamental types of core java. This package is by default imported in every .java file hence to use type declared in java.lang package, import statement is optional.

Example 1



[Before Compilation]

1. Set path(if not set)
2. Compile “Complex.java”
3. set classpath
4. Compile “Program.java”
5. execute “Program.class”



[After Compilation]

Example 1

```java
//Location : ./src/Complex.java
package p1;
class TComplex{
    @Override
    public String toString( ){
        return "TComplex.toString()";
    }
}
```

```java
//Location : ./src/Program.java
import p1.TComplex;
class Program{
    public static void main(String[] args) {
        //p1.TComplex c1 = new p1.TComplex( );  //or
        TComplex c1 = new TComplex( );
        System.out.println( c1.toString( ) );
    }
}
```

```
javac -d ./bin ./src/Complex.java   //output : p1/TComplex.class
export CLASSPATH=./bin
javac -d ./bin ./src/Program.java   //Output : Error
//TComplex is not public in p1; can not be accessed from outside package
```

Use export CLASSPATH in case of MAC
and use set CLASSPATH in case of windows.

Example 1

- Package name is physically mapped to the folder.
- Point to Remember : default access modifier of any type is package level private which is also called as default.

```
//location  :   ./src/Complex.java
??? class TComplex{ //here ??? means package level  private / default
    //TODO
}
```

- If we want to use any type inside same package as well as in different package then access modifier of type must be public.
- Access modifier of type(class/interface) can be either package level private/public only. In other words, type can not be private or protected.

```
//location  :   ./src/Complex.java
public class TComplex{
}
```

Example 1

- According to Java Language Specification(JLS), name of public type and name of .java file must be same. It means that, .java file can contain multiple non public types but only one public type.

```
//location  :   ./src/Complex.java
public class Complex{    //Now OK
      @Override
    public String toString( ){
        return "Complex.toString()";
    }
}
```

- Let us recompile above code:
  - javac -d ./bin ./src/Complex.java //output : p1/Complex.class
  - export CLASSPATH=./bin
  - javac -d ./bin ./src/Program.java //Output : Program.class
  - java Program //Output : Complex.toString()
- **Conclusion : It is possible to use packaged type from unpackaged type.**

Example 2

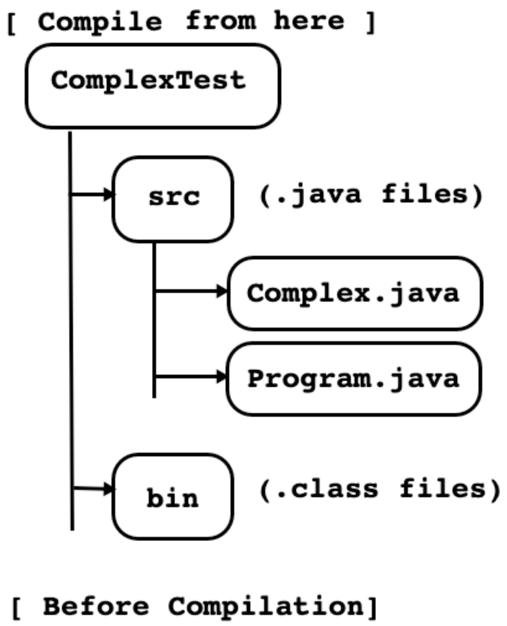
```java
//Location : ./src/Complex.java
public class Complex{ //Unpackaged Type
    @Override
    public String toString( ){
        return "Complex.toString()";
    }
}
```

```java
//Location : ./src/Program.java
package p1;
public class Program{
    public static void main(String[] args) {
        Complex c1 = new Complex( );
        System.out.println( c1.toString( ) );
    }
}
```

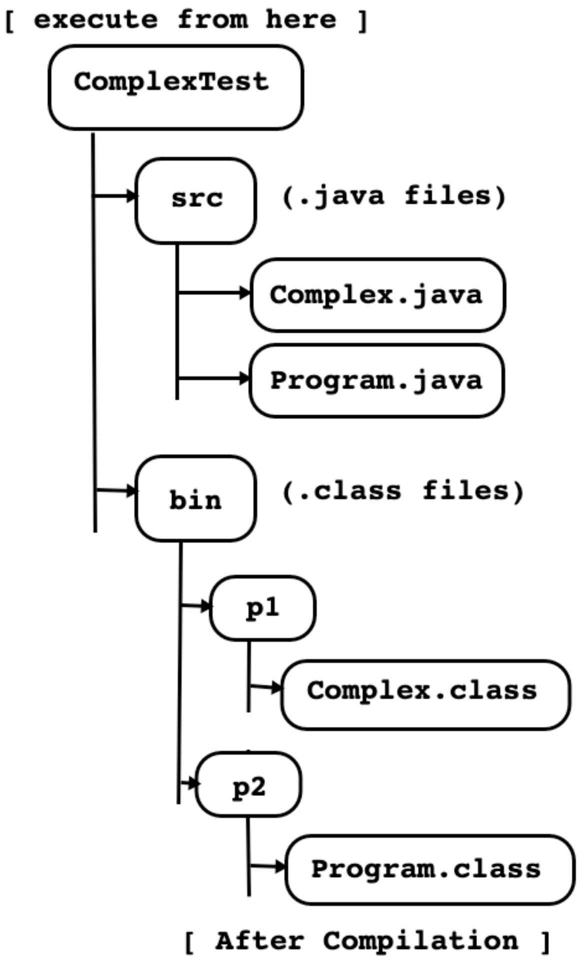
```
javac -d ./bin ./src/Complex.java   //OK:Complex.class
export CLASSPATH=./bin
javac -d ./bin ./src/Program.java   //error : cannot find symbol
```

- If we define any type without package then it is considered as a member of default package.
- Conclusion : Since we can not import default package, it is not possible to use unpackaged type from packaged type.

Example 3



1. Set path(if not set)
2. Compile "Complex.java"
3. set classpath
4. Compile "Program.java"
5. execute "Program.class"



Example 3

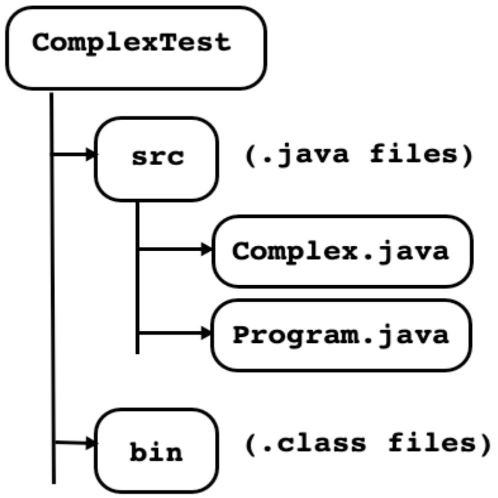
```java
//Location : ./src/Complex.java
package p1;
public class Complex{
    @Override
    public String toString( ){
        return "Complex.toString()";
    }
}
```

```java
//Location : ./src/Program.java
package p2;
import p1.Complex;
public class Program{
    public static void main(String[] args) {
        Complex c1 = new Complex( );
        System.out.println( c1.toString( ) );
    }
}
```

```
javac -d ./bin ./src/Complex.java   //OK:p1/Complex.class
export CLASSPATH=./bin
javac -d ./bin ./src/Program.java   //OK:p2/Program.class
//java Program  //Error
java p2.Program //Complex.toString()
```

Example 4

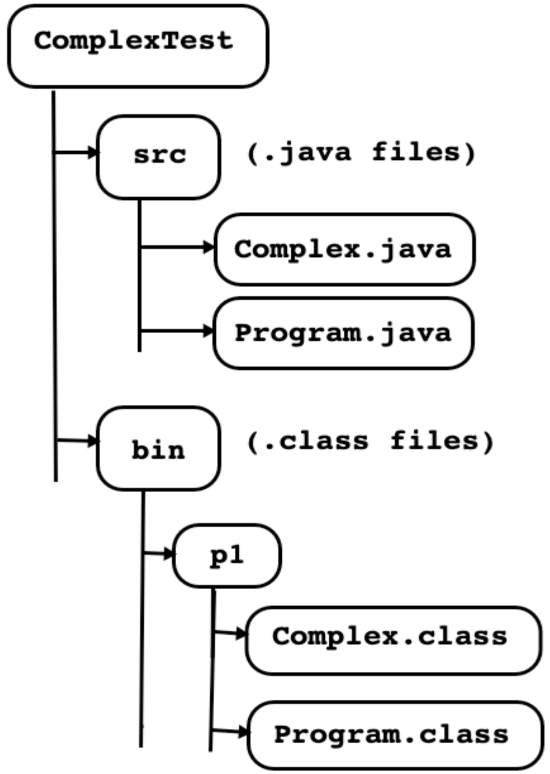
[Compile from here]



[Before Compilation]

1. Set path(if not set)
2. Compile “Complex.java”
3. set classpath
4. Compile “Program.java”
5. execute “Program.class”

[execute from here]



[After Compilation]

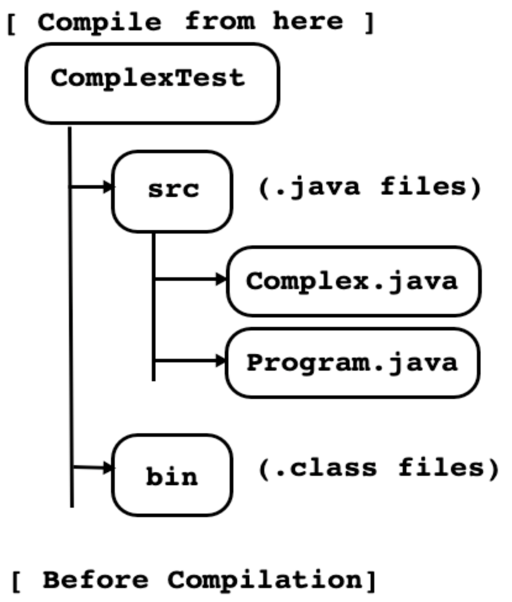
Example 4

```java
//Location : ./src/Complex.java
package p1;
public class Complex{
    @Override
    public String toString( ){
        return "Complex.toString()";
    }
}
```

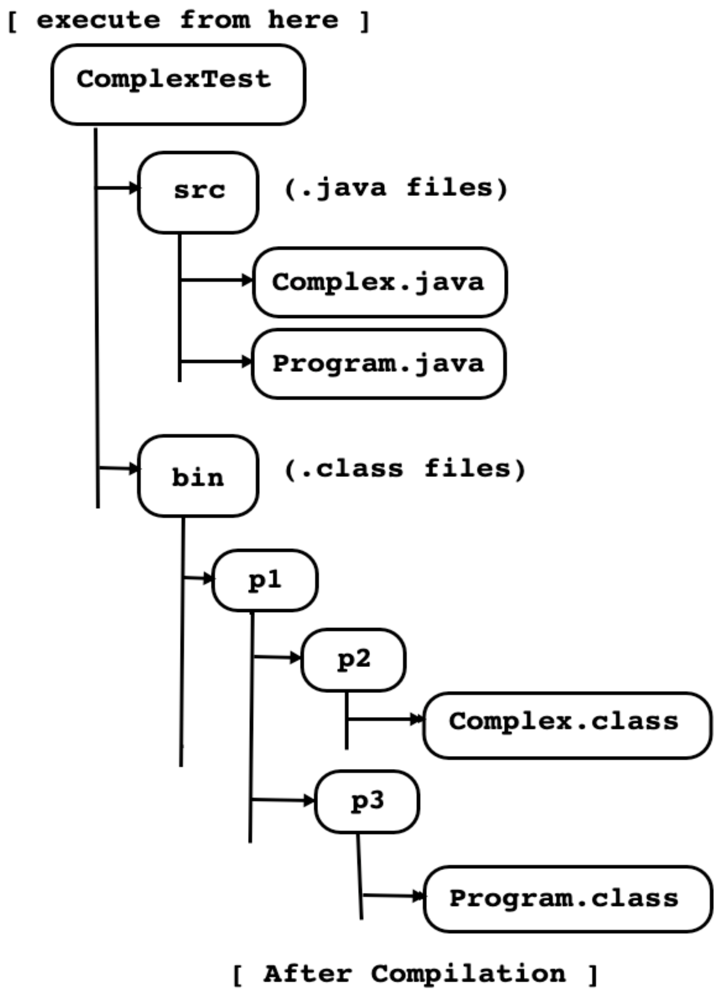
```java
//Location : ./src/Program.java
package p1;
import p1.Complex;  //Optional
public class Program{
    public static void main(String[] args) {
        Complex c1 = new Complex( );
        System.out.println( c1.toString( ) );
    }
}
```

```
javac -d ./bin ./src/Complex.java   //OK:p1/Complex.class
export CLASSPATH=./bin
javac -d ./bin ./src/Program.java   //OK:p1/Program.class
java p1.Program //Complex.toString()
```

Example 5



1. Set path(if not set)
2. Compile “Complex.java”
3. set classpath
4. Compile “Program.java”
5. execute “Program.class”



Example 5

```java
//Location : ./src/Complex.java
package p1.p2;
public class Complex{
    @Override
    public String toString( ){
        return "Complex.toString()";
    }
}
```

```java
//Location : ./src/Program.java
package p1.p3;
import p1.p2.Complex;
public class Program{
    public static void main(String[] args) {
        Complex c1 = new Complex( );
        System.out.println( c1.toString( ) );
    }
}
```

```
javac -d ./bin ./src/Complex.java   //OK:p1/p2/Complex.class
export CLASSPATH=./bin
javac -d ./bin ./src/Program.java   //OK:p1/p3/Program.class
java p1.p3.Program //Complex.toString()
```

Static Import

- If static members belonging to the same class then use of type name and dot operator is optional.

```
package p1;
public class Program{
    private static int number = 10;
    public static void main(String[] args) {
        System.out.println("Number  :   "+Program.number);  //OK    :   10
        System.out.println("Number  :   "+number);  //OK    :   10
    }
}
```

Static Import

- If static members belonging to the different class then use of type name and dot operator is mandatory.
- PI and pow are static members of java.lang.Math class. To use Math class import statement is not required.
- Consider Following code:

```
package p1;
public class Program{
    public static void main(String[] args) {
        float radius = 10.5f;
        float area = ( float )( Math.PI * Math.pow( radius, 2 );
        System.out.println( "Area   :   "+area );
    }
}
```

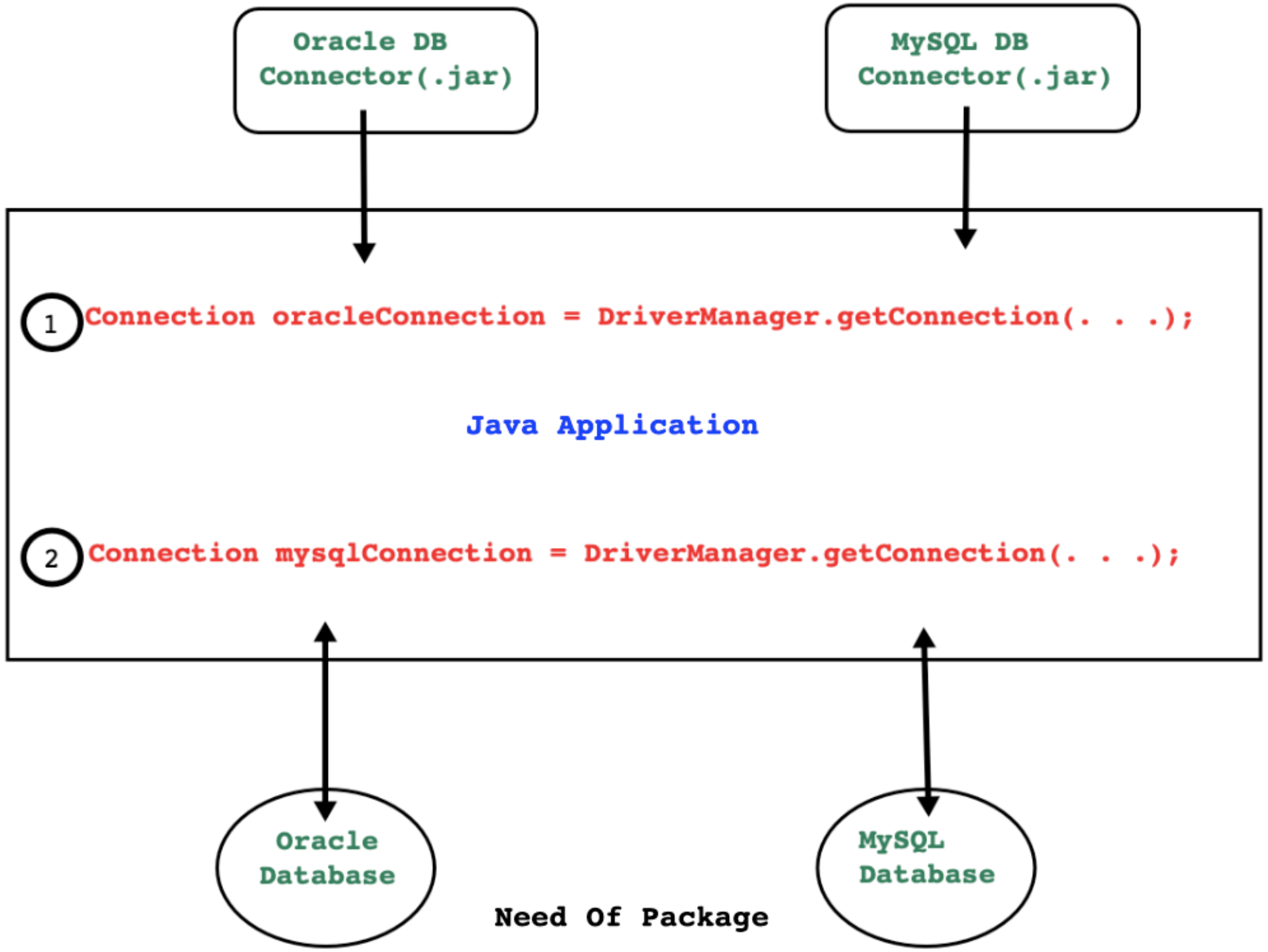
Object Oriented Programming with Java 8

Akshita Chanchlani

Contents

- Package
- Static import
- Array
- Enum

Package



Need Of Package

Package

- Package is a Java language feature which helps developer to:
  1. To group functionally equivalent or related types together.
  2. To avoid naming clashing/collision/conflict/ambiguity in source code.
  3. To control the access to types.
  4. To make types easier to find(from the perspective of java docs).

- Consider following class:
  - java.lang.Object
    - Here java is main package, lang is sub package and Object is type name.

Package

- Not necessarily but as shown below, package can contain some or types.
    1. Sub package
    2. Interface
    3. Class
    4. Enum
    5. Exception
    6. Error
    7. Annotation Type

Package Creation

- package is a keyword in Java.
- To define type inside package, it is mandatory write package declaration statement inside .java file.
- Package declaration statement must be first statement inside .
- If we define any type inside package then it is called as packaged type otherwise it will be unpackaged type.
- Any type can be member of single package only.

`package p1;   //OK` `class Program{` `    //TODO` `}`	`package p1, p2; //NOT OK` `class Program{` `    //TODO` `}`	`package p1; //OK` `package p2; //NOT OK` `class Program{` `    //TODO` `}` `package p3; //Not OK`

Un-named Package

- If we define any type without package then it is considered as member of unnamed/default package.
- Unnamed packages are provided by the Java SE platform principally for convenience when developing small or temporary applications or when just beginning development.
- An unnamed package cannot have sub packages.
- In following code, class Program is a part of unnamed package.

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

Naming Convention

- For small programs and casual development, a package can be unnamed or have a simple name, but if code is to be widely distributed, unique package names should be chosen using qualified names.
- Generally Package names are written in all lower case to avoid conflict with the names of classes or interfaces.
- Companies use their reserved internet domain name to begin their package names. For example : com.example.mypackage
- Following examples will help you in deciding name of package:
    1. java.lang.reflect.Proxy
    2. oracle.jdbc.driver.OracleDriver
    3. com.mysql.jdbc.cj.Driver
    4. org.cdac.sunbeam.dac.utils.Date

How to use package members in different package?

- If we want to use types declared inside package anywhere outside the package then
    1. Either we should use fully qualified type name or
    2. import statement.
- If we are going to use any type infrequently then we should use fully qualified name.
- Let us see how to use type using package name.

```
class Program{
    public static void main(String[] args) {
        java.util.Scanner sc = new java.util.Scanner( System.in );
    }
}
```

How to use package members in different package?

- If we are going to use any type frequently then we should use import statement.
- Let us see how to import Scanner.

```
import java.util.Scanner;
class Program{
    public static void main(String[] args) {
        Scanner sc = new Scanner( System.in );
    }
}
```

How to use package members in different package?

- There can be be any number of import statements after package declaration statement
- With the help of(*) we can import entire package.

```
import java.util.*;
class Program{
    public static void main(String[] args) {
        Scanner sc = new Scanner( System.in );
    }
}
```

How to use package members in different package?

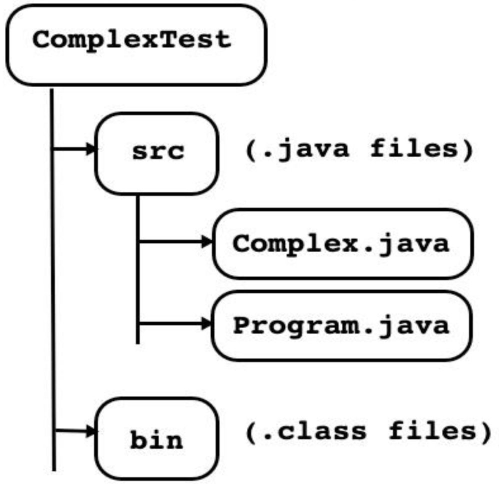
- Another, less common form of import allows us to import the public nested classes of an enclosing class. Consider following code.

```
import java.lang.Thread.State;
class Program{
    public static void main(String[] args) {
        Thread thread = Thread.currentThread( );
        State state = thread.getState( );
    }
}
```

- Note : java.lang package contains fundamental types of core java. This package is by default imported in every .java file hence to use type declared in java.lang package, import statement is optional.

Example 1

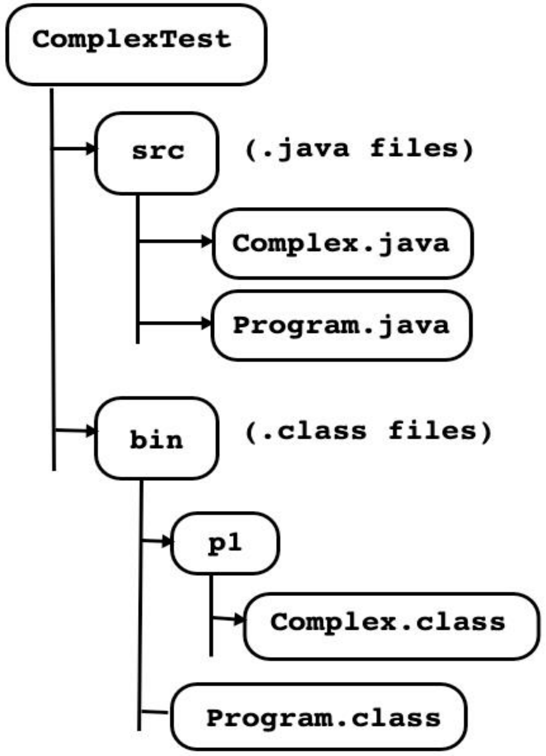
[Compile from here]



[Before Compilation]

1. Set path(if not set)
2. Compile “Complex.java”
3. set classpath
4. Compile “Program.java”
5. execute “Program.class”

[execute from here]



[After Compilation]

Example 1

```java
//Location : ./src/Complex.java
package p1;
class TComplex{
    @Override
    public String toString( ){
        return "TComplex.toString()";
    }
}
```

```java
//Location : ./src/Program.java
import p1.TComplex;
class Program{
    public static void main(String[] args) {
        //p1.TComplex c1 = new p1.TComplex( );  //or
        TComplex c1 = new TComplex( );
        System.out.println( c1.toString( ) );
    }
}
```

```
javac -d ./bin ./src/Complex.java   //output : p1/TComplex.class
export CLASSPATH=./bin
javac -d ./bin ./src/Program.java   //Output : Error
//TComplex is not public in p1; can not be accessed from outside package
```

Use export CLASSPATH in case of MAC
and use set CLASSPATH in case of windows.

Example 1

- Package name is physically mapped to the folder.
- Point to Remember : default access modifier of any type is package level private which is also called as default.

```
//location  :   ./src/Complex.java
??? class TComplex{ //here ??? means package level  private / default
    //TODO
}
```

- If we want to use any type inside same package as well as in different package then access modifier of type must be public.
- Access modifier of type(class/interface) can be either package level private/public only. In other words, type can not be private or protected.

```
//location  :   ./src/Complex.java
public class TComplex{
}
```

Example 1

- According to Java Language Specification(JLS), name of public type and name of .java file must be same. It means that, .java file can contain multiple non public types but only one public type.

```java
//location  :   ./src/Complex.java
public class Complex{    //Now OK
     @Override
    public String toString( ){
        return "Complex.toString()";
    }
}
```

- Let us recompile above code:
    - javac -d ./bin ./src/Complex.java //output : p1/Complex.class
    - export CLASSPATH=./bin
    - javac -d ./bin ./src/Program.java //Output : Program.class
    - java Program //Output : Complex.toString()
- **Conclusion : It is possible to use packaged type from unpackaged type.**

Example 2

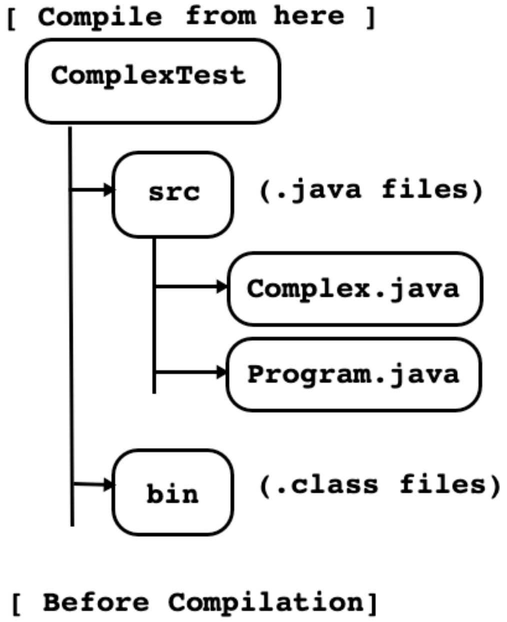
```java
//Location : ./src/Complex.java
public class Complex{ //Unpackaged Type
    @Override
    public String toString( ){
        return "Complex.toString()";
    }
}
```

```java
//Location : ./src/Program.java
package p1;
public class Program{
    public static void main(String[] args) {
        Complex c1 = new Complex( );
        System.out.println( c1.toString( ) );
    }
}
```

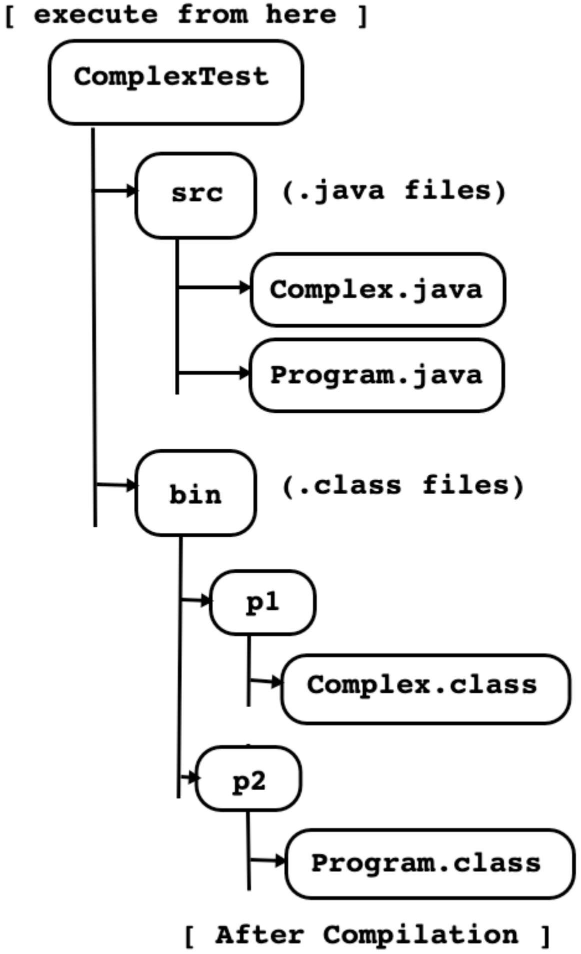
```
javac -d ./bin ./src/Complex.java   //OK:Complex.class
export CLASSPATH=./bin
javac -d ./bin ./src/Program.java   //error : cannot find symbol
```

- If we define any type without package then it is considered as a member of default package.
- Conclusion : Since we can not import default package, it is not possible to use unpackaged type from packaged type.

Example 3



1. Set path(if not set)
2. Compile "Complex.java"
3. set classpath
4. Compile "Program.java"
5. execute "Program.class"



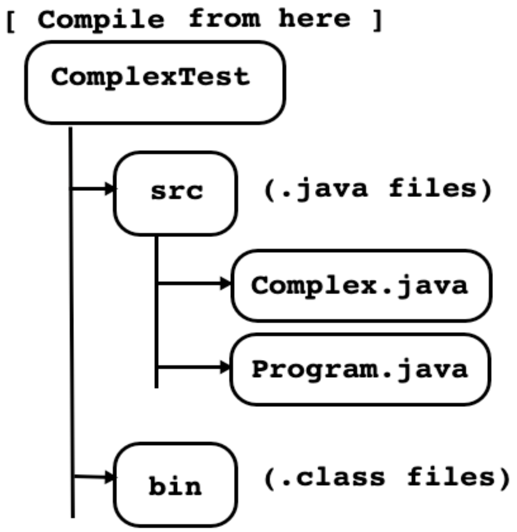
Example 3

```java
//Location : ./src/Complex.java
package p1;
public class Complex{
    @Override
    public String toString( ){
        return "Complex.toString()";
    }
}
```

```java
//Location : ./src/Program.java
package p2;
import p1.Complex;
public class Program{
    public static void main(String[] args) {
        Complex c1 = new Complex( );
        System.out.println( c1.toString( ) );
    }
}
```

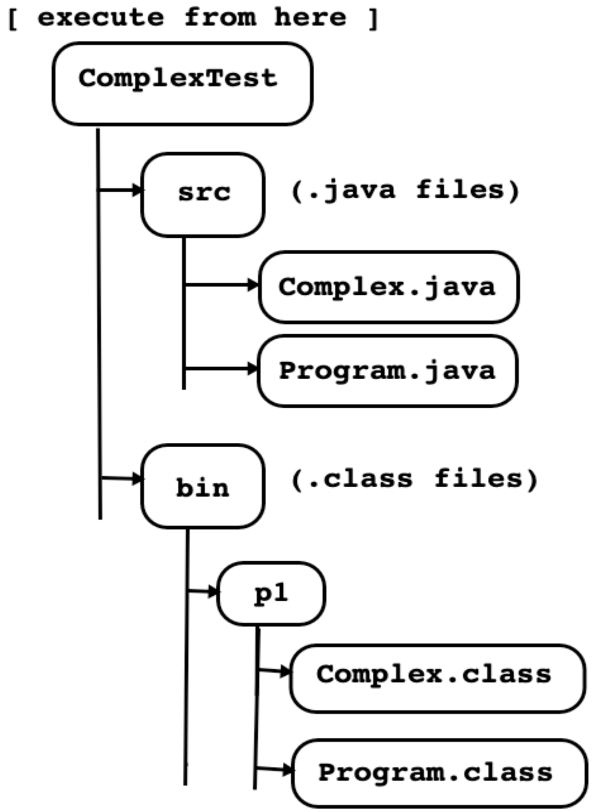
```
javac -d ./bin ./src/Complex.java   //OK:p1/Complex.class
export CLASSPATH=./bin
javac -d ./bin ./src/Program.java   //OK:p2/Program.class
//java Program  //Error
java p2.Program //Complex.toString()
```

Example 4



[Before Compilation]

1. Set path(if not set)
2. Compile “Complex.java”
3. set classpath
4. Compile “Program.java”
5. execute “Program.class”



[After Compilation]

Example 4

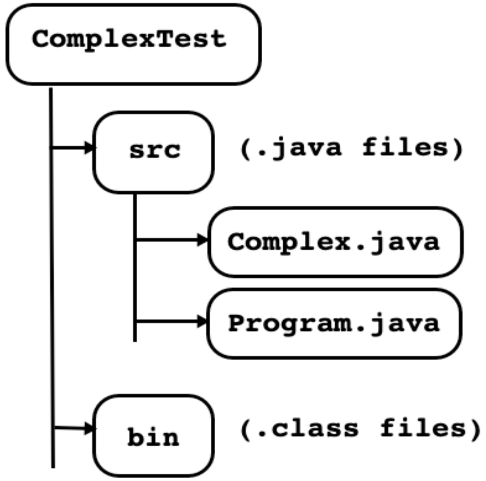
```java
//Location : ./src/Complex.java
package p1;
public class Complex{
    @Override
    public String toString( ){
        return "Complex.toString()";
    }
}
```

```java
//Location : ./src/Program.java
package p1;
import p1.Complex;  //Optional
public class Program{
    public static void main(String[] args) {
        Complex c1 = new Complex( );
        System.out.println( c1.toString( ) );
    }
}
```

```
javac -d ./bin ./src/Complex.java   //OK:p1/Complex.class
export CLASSPATH=./bin
javac -d ./bin ./src/Program.java   //OK:p1/Program.class
java p1.Program //Complex.toString()
```

Example 5

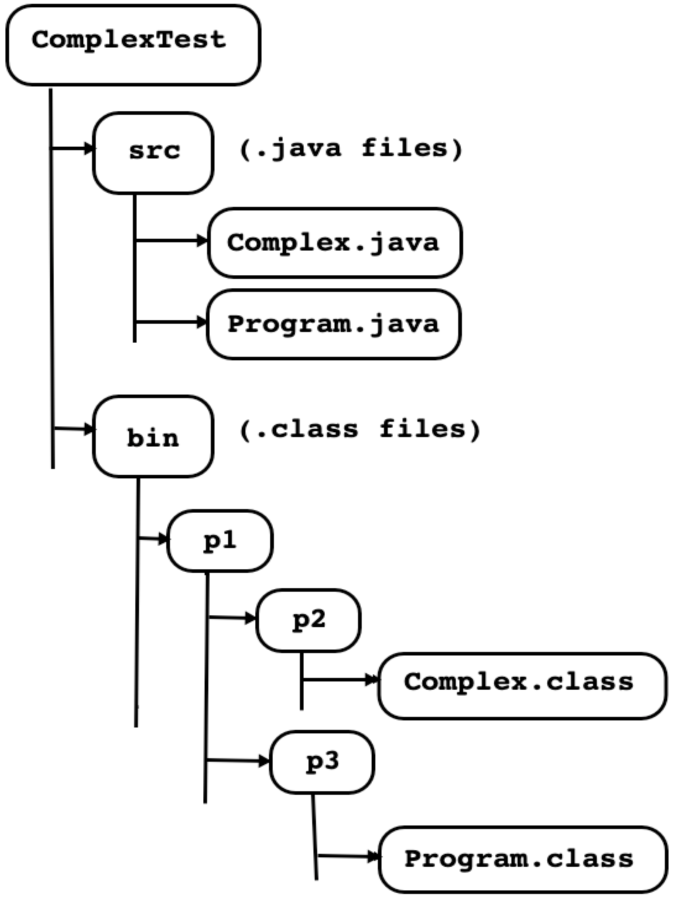
[Compile from here]



[Before Compilation]

1. Set path(if not set)
2. Compile “Complex.java”
3. set classpath
4. Compile “Program.java”
5. execute “Program.class”

[execute from here]



[After Compilation]

Example 5

```java
//Location : ./src/Complex.java
package p1.p2;
public class Complex{
    @Override
    public String toString( ){
        return "Complex.toString()";
    }
}
```

```java
//Location : ./src/Program.java
package p1.p3;
import p1.p2.Complex;
public class Program{
    public static void main(String[] args) {
        Complex c1 = new Complex( );
        System.out.println( c1.toString( ) );
    }
}
```

```
javac -d ./bin ./src/Complex.java   //OK:p1/p2/Complex.class
export CLASSPATH=./bin
javac -d ./bin ./src/Program.java   //OK:p1/p3/Program.class
java p1.p3.Program //Complex.toString()
```

Static Import

- If static members belonging to the same class then use of type name and dot operator is optional.

```
package p1;
public class Program{
    private static int number = 10;
    public static void main(String[] args) {
        System.out.println("Number   :    "+Program.number);  //OK    :   10
        System.out.println("Number   :    "+number);  //OK    :   10
    }
}
```

Static Import

- If static members belonging to the different class then use of type name and dot operator is mandatory.
- PI and pow are static members of java.lang.Math class. To use Math class import statement is not required.
- Consider Following code:

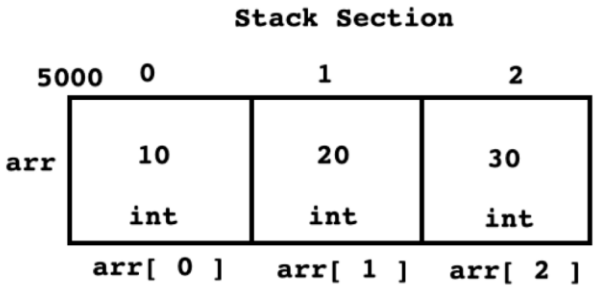
```
package p1;
public class Program{
    public static void main(String[] args) {
        float radius = 10.5f;
        float area = ( float )( Math.PI * Math.pow( radius, 2 );
        System.out.println( "Area   :   "+area );
    }
}
```

Array Introduction

- Array, stack, queue, LinkedList are data structures.
- In Java, data structure is called collection and value stored inside collection is called element.
- Array is a sequential/linear container/collection which is used to store elements of same type in continuous memory location.

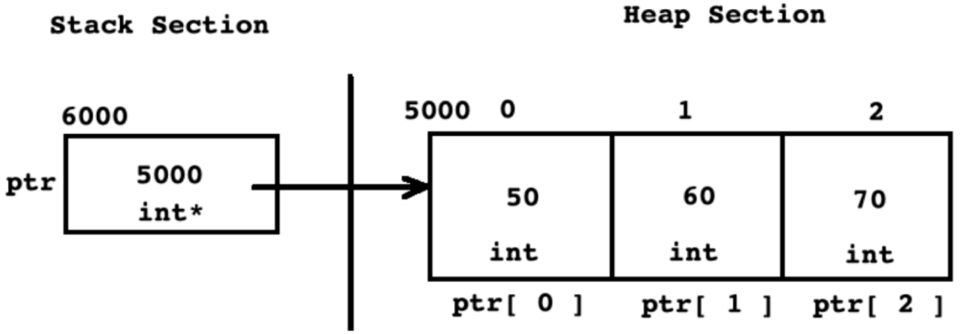
In C/C++	In C/C++
Static Memory allocation for array	**Dynamic Memory allocation for array**
`int arr1[ 3 ];    //OK`	`int *arr = ( int* )malloc( 3 * sizeof( int ));`
	`//or`
`int size = 3;`	`int *arr = ( int* )calloc( 3, sizeof( int ));`
`int arr2[ size ];    //OK`	

Static v/s Dynamic Memory Allocation In C/C++



[Static Memory Allocation]

```
arr[ 0 ]  =>  10
arr[ 1 ]  =>  20
arr[ 2 ]  =>  30
```



[Dynamic Memory Allocation]

```
ptr[ 0 ]  =>  50
ptr[ 1 ]  =>  60
ptr[ 2 ]  =>  70
```

Array Declaration and Initialization In C

- `int arr[ 3 ]; //OK : Declaration`
- `int arr[ 3 ] = { 10, 20, 30 }; //OK : Initialization`
- `int arr[ ] = { 10, 20, 30 }; //OK`
- `int arr[ 3 ] = { 10, 20 }; //OK : Partial Initialization`
- `int arr[ 3 ] = { }; //OK : Partial Initialization`
- `int arr[ 3 ] = { 10, 20, 30, 40, 50 }; //Not recommended`

Accessing Elements Of Array

- If we want to access elements of array then we should use integer index.
- Array index always begins with 0.

```
int arr[ 3 ] = { 10, 20, 30 };
printf("%d\n", arr[ 0 ] );
printf("%d\n", arr[ 1 ] );
printf("%d\n", arr[ 2 ] );
```

```
int arr[ 3 ] = { 10, 20, 30 };
int index;
for( index = 0; index < 3; ++ index )
    printf("%d\n", arr[ index ] );
```

Advantage and Disadvantages Of Array

- **Advantage Of Array**
  1. We can access elements of array randomly.
- Disadvantage Of Array
  1. We can not resize array at runtime.
  2. It requires continuous memory.
  3. Insertion and removal of element from array is a time consuming job.
  4. Using assignment operator, we can not copy array into another array.
  5. Compiler do not check array bounds(min and max index).

Array In Java

- Array is a reference type in Java. In other words, to create instance of array, new operator is required. It means that array instance get space on heap.
- **There are 3 types of array in Java:**
    1. Single dimensional array
    2. Multi dimensional array
    3. Ragged array
- **Types of loop in Java:**
    1. do-while loop
    2. while loop
    3. for loop
    4. for-each loop
- **To perform operations on array we can use following classes:**
    1. java.util.Arrays
    2. org.apache.commons.lang3.ArrayUtils(download .jar file)

Methods Of java.util.Arrays Class

Following are the methods of java.util Arrays class.(try javap java.util.Arrays)

- public static <T> List<T> asList(T... a)
- public static int binarySearch(int[] a, int key) //Overloaded
- public static int binarySearch(Object[] a, Object key)
- public static int[] copyOf(int[] original, int newLength)
- public static <T> T[] copyOf(T[] original, int newLength)
- public static int[] copyOfRange(int[] original, int from, int to)
- public static <T> T[] copyOfRange(T[] original, int from, int to)
- public static void fill(int[] a, int val)
- public static void fill(Object[] a, Object val)
- public static void fill(Object[] a, int fromIndex, int toIndex, Object val)
- public static void sort(int[] a) //Overloaded
- public static void sort(Object[] a)
- public static void parallelSort(int[] a)
- public static <T extends Comparable<? super T>> void parallelSort(T[] a)
- public static String toString(Object[] a) //Overloaded
- public static String deepToString(Object[] a)
- public static IntStream stream(int[] array) //Overloaded
- public static <T> Stream<T> stream(T[] array)

Single Dimensional Array

Reference declaration

```
int arr[ ]; //OK
int [ arr ]; //NOT OK
int[ ] arr; //OK
```

Instantiation

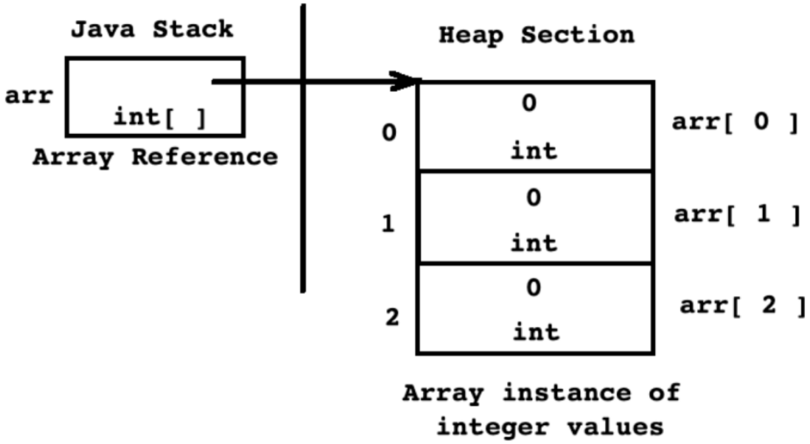
```
int[ ] arr1 = new int[ 3 ];
//or
int size = 3;
int[ ] arr2 = new int[ size ];
```

```
int[] arr1 = new int[ -3 ];  //NegativeArraySizeException
//or
int size = -3;
int[] arr2 = new int[ size ];    //NegativeArraySizeException
```

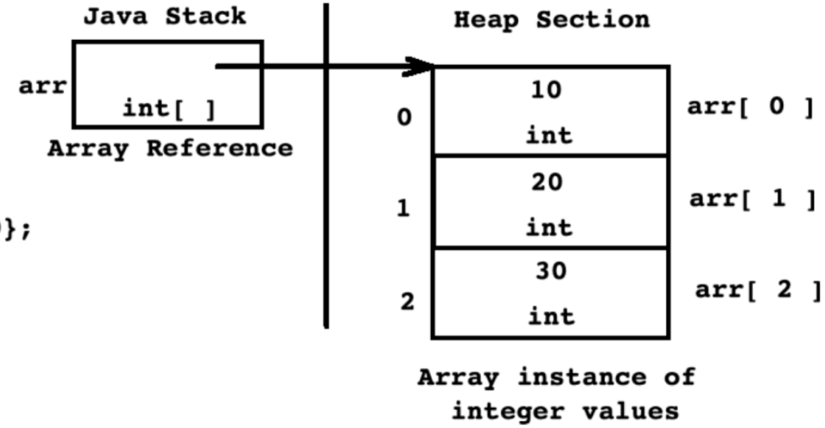
Initialization

```
int[] arr = new int[ size ]{ 10, 20, 30 };  //Not OK
int[] arr = new int[  ]{ 10, 20, 30 };  //OK
int[] arr = { 10, 20, 30 };  //OK
```

Single Dimensional Array




```
int[] arr = new int[3];
```




```
int[] arr = new int[]{10,20,30};
```

Using length Field

```
public class Program {
    public static void printRecord( int[] arr ) {
        for( int index = 0; index < arr.length; ++ index )
            System.out.print( arr[ index ] +"    ");
        System.out.println();
    }
    public static void main(String[] args) {
        int[] arr1 = new int[  ] { 10, 20, 30 };
        Program.printRecord(arr1);

        int[] arr2 = new int[  ] { 10, 20, 30, 40, 50 };
        Program.printRecord(arr2);

        int[] arr3 = new int[  ] { 10, 20, 30, 40, 50, 60, 70  };
        Program.printRecord(arr3);
    }
}
```

Using toString( ) Method

```
public static void main(String[] args) {
    int[] arr = new int[  ] { 10, 20, 30, 40, 50 };
    System.out.println(arr.toString()); //[I@6d06d69c
}
public static void main(String[] args) {
    double[] arr = new double[  ] { 10.1, 20.2, 30.3, 40.4, 50.5 };
    System.out.println(arr.toString()); //[D@6d06d69c
}
//Check the documentation of getName() method of java.lang.Class.
public static void main(String[] args) {
    int[] arr = new int[  ] { 10, 20, 30, 40, 50 };
    System.out.println(Arrays.toString(arr));   //[10, 20, 30, 40, 50]
}
```

ArrayIndexOutOfBoundsException

- Using illegal index, if we try to access elements of array then JVM throws ArrayIndexOutOfBoundsException. Consider following code:

```
public static void main(String[] args) {
    int[] arr = new int[  ] { 10, 20, 30, 40, 50 };
    //int element = arr[ -1 ]; //ArrayIndexOutOfBoundsException
    //int element = arr[ arr.length ]; //ArrayIndexOutOfBoundsException
    //int element = arr[ 7 ]; //ArrayIndexOutOfBoundsException
}
```

ArrayStoreException

- If we try to store incorrect type of object into array then JVM throws ArrayStoreException.
- Consider the following code:

```
public class Program {
    public static void main(String[] args) {
        Object[] arr = new String[ 3 ];
        arr[ 0 ] = new String("DAC");    //OK
        arr[ 1 ] = "DMC";    //OK
        arr[ 2 ] = new Integer(123);     //Not OK : ArrayStoreException
    }
}
```

Sorting Array Elements

```
public class Program {
    public static void main(String[] args) {
        int[] arr = new int[] { 50, 10, 40, 20, 30 };
        System.out.println(Arrays.toString(arr));
        Arrays.sort(arr);   //The sorting algorithm is a Dual-Pivot Quicksort
        System.out.println(Arrays.toString(arr));
    }
}
```

Reference Copy and Instance Copy

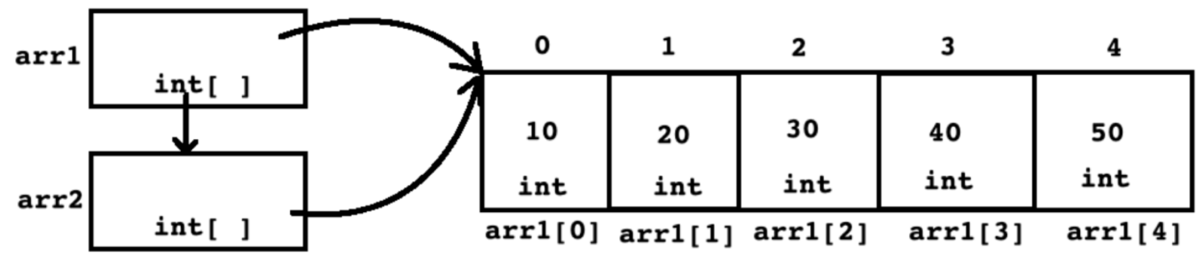
```
Array Reference copy

int[] arr1 = new int[  ] { 10, 20, 30, 40, 50 };
int[] arr2 = arr1;  //Reference Copy
```

```
Array Instance Copy( Using Arrays.copyOf() )

int[] arr1 = new int[  ] { 10, 20, 30, 40, 50 };
int[] arr2 = Arrays.copyOf(arr1, arr1.length);  //Array instance copy
```

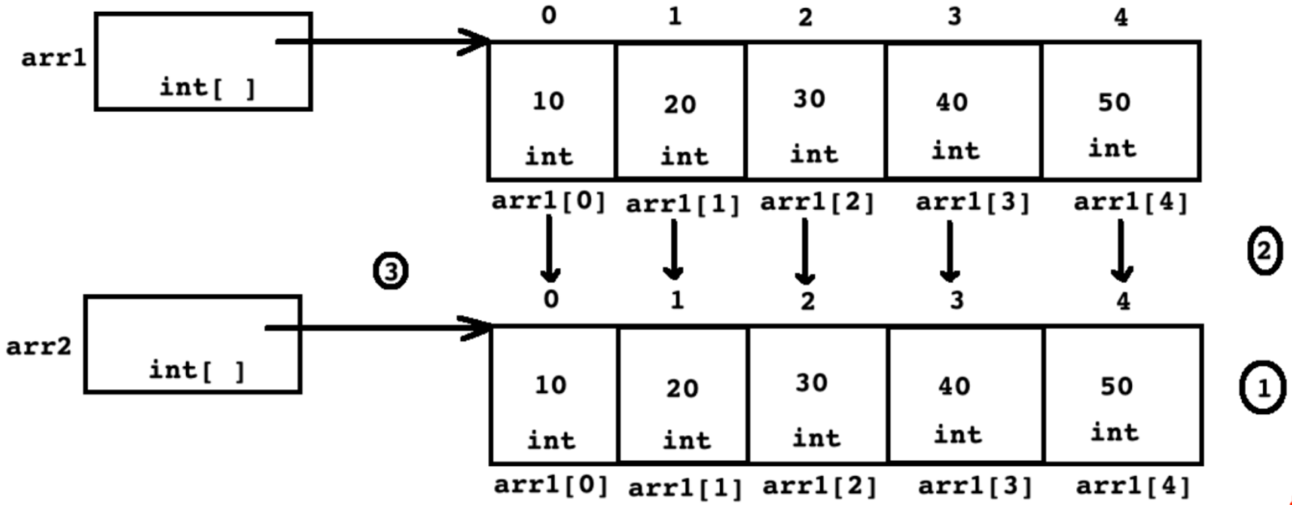
```
Implementation of Arrays.copyOf method:

public static int[] copyOf(int[] original, int newLength) {
    int[] copy = new int[newLength];
    //public static void arraycopy(Object src, int srcPos, Object dest, int destPos, int length);
    System.arraycopy(original, 0, copy, 0, Math.min(original.length, newLength));
    return copy;
}
```

Reference Copy and Instance Copy

```java
int[] arr1 = new int[  ] { 10, 20, 30, 40, 50 };
int[] arr2 = arr1;  //Reference Copy
```



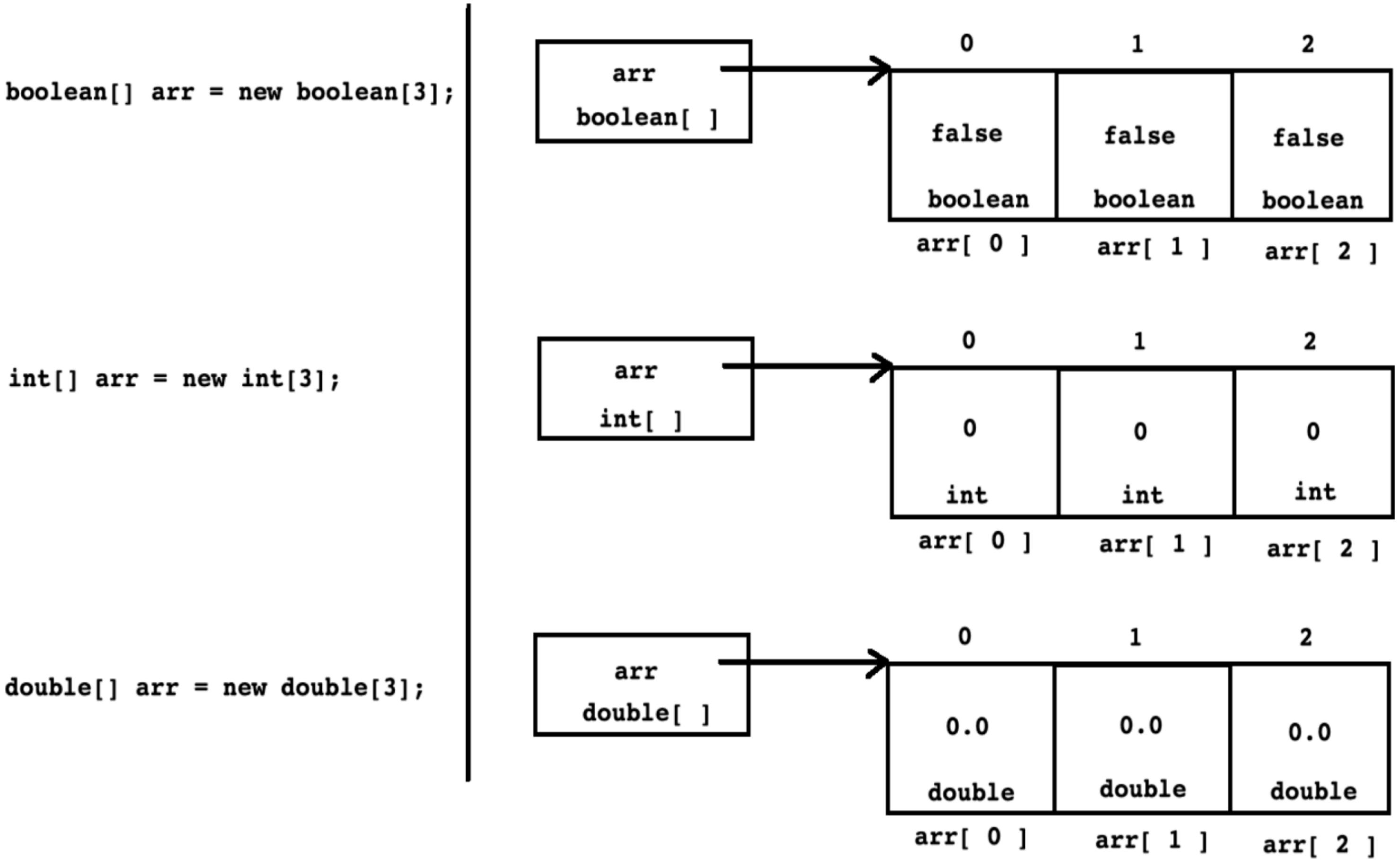

```java
int[] arr1 = new int[  ] { 10, 20, 30, 40, 50 };
int[] arr2 = Arrays.copyOf(arr1, arr1.length);  //Array instance copy
```



Array Of Primitive Values

```
public class Program {
    public static void main(String[] args) {
        boolean[] arr = new boolean[ 3 ];   //contains all false
        int[] arr = new int[ 3 ];   //contains all 0
        double[] arr = new double[ 3 ]; //contains all 0.0
    }
}
```

Array Of Primitive Values



If we create array of primitive values then it's default value depends of default value of data type.

Array Of References

```
public class Program {
    public static void main(String[] args) {
        Date[] arr = new Date[ 3 ]; //Contains all null
    }
}
```

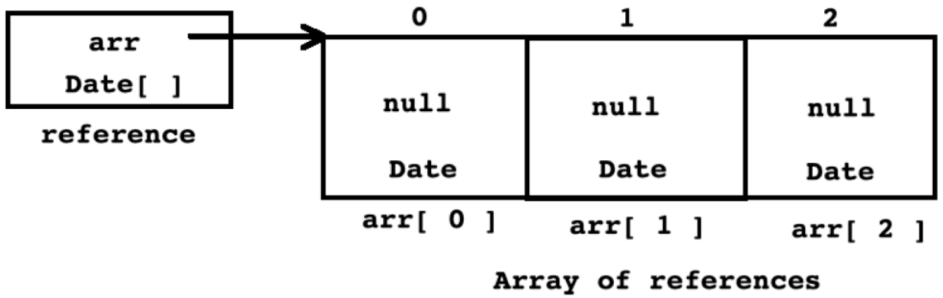
Array Of References and Instances

```
public class Program {
    public static void main(String[] args) {
        Date[] arr = new Date[ 3 ]; //Contains all null
    }
}
```

```
- Let us see how to create array of instances of non primitive type

public class Program {
    public static void main(String[] args) {
        Date[] arr = new Date[ 3 ];
        arr[ 0 ] = new Date( );
        arr[ 1 ] = new Date( );
        arr[ 2 ] = new Date( );
    }
    //or
    public static void main(String[] args) {
        Date[] arr = new Date[ 3 ];
        for( int index = 0; index < arr.length; ++ index )
        arr[ index ] = new Date( );
    }
}
```

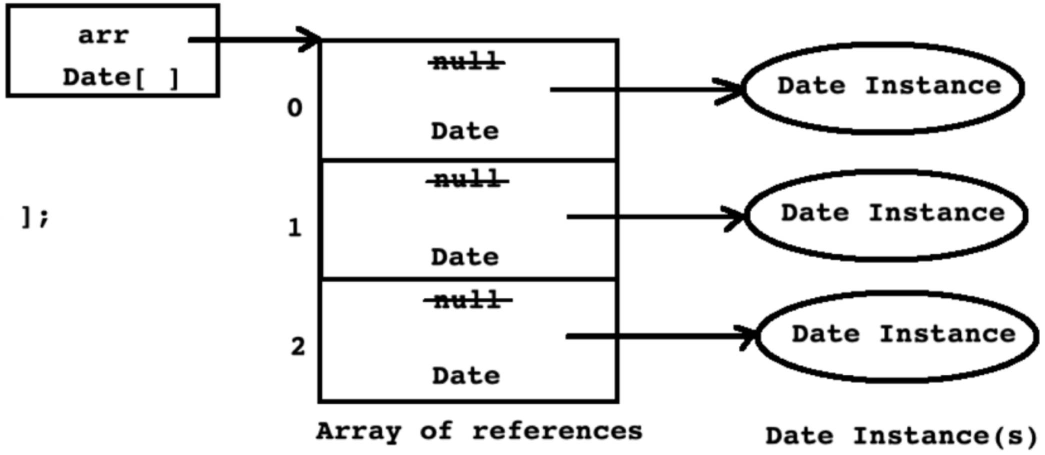
Array Of References and Instances

```
Date[ ] arr = new Date[ 3 ];
```



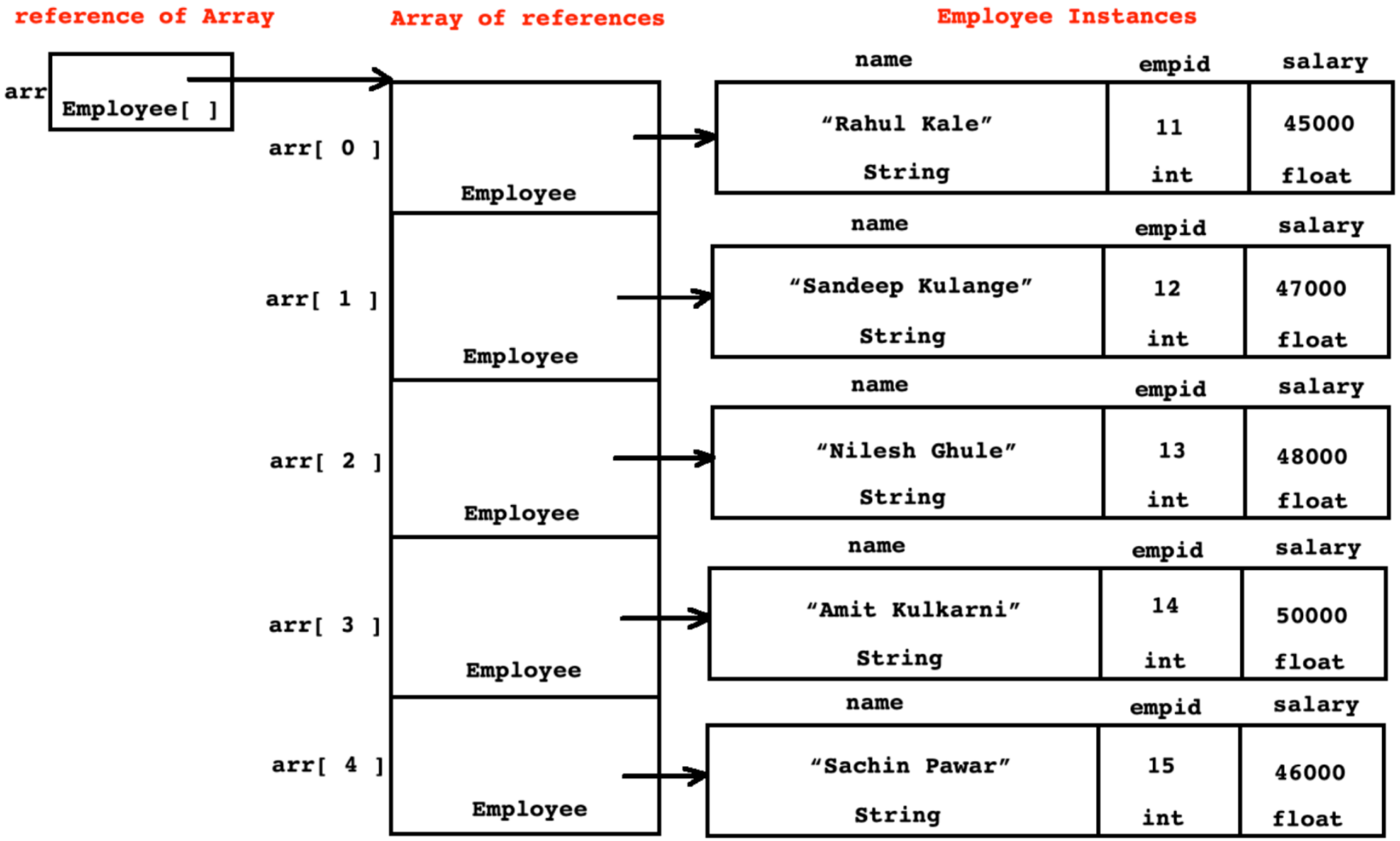
If we create an array of references then by default it contains null.

```
Date[] arr = new Date[ 3 ];
arr[ 0 ] = new Date( );
arr[ 1 ] = new Date( );
arr[ 2 ] = new Date( );
```



[Array Of Instances]

Array Of Instances



Multi Dimensional Array

- Array of elements where each element is array of same column size is called as multi dimensional array.

Reference declaration:

```
int arr[ ][ ];   //OK
int [ ]arr[ ]    //OK
int[ ][ ] arr;   //OK
```

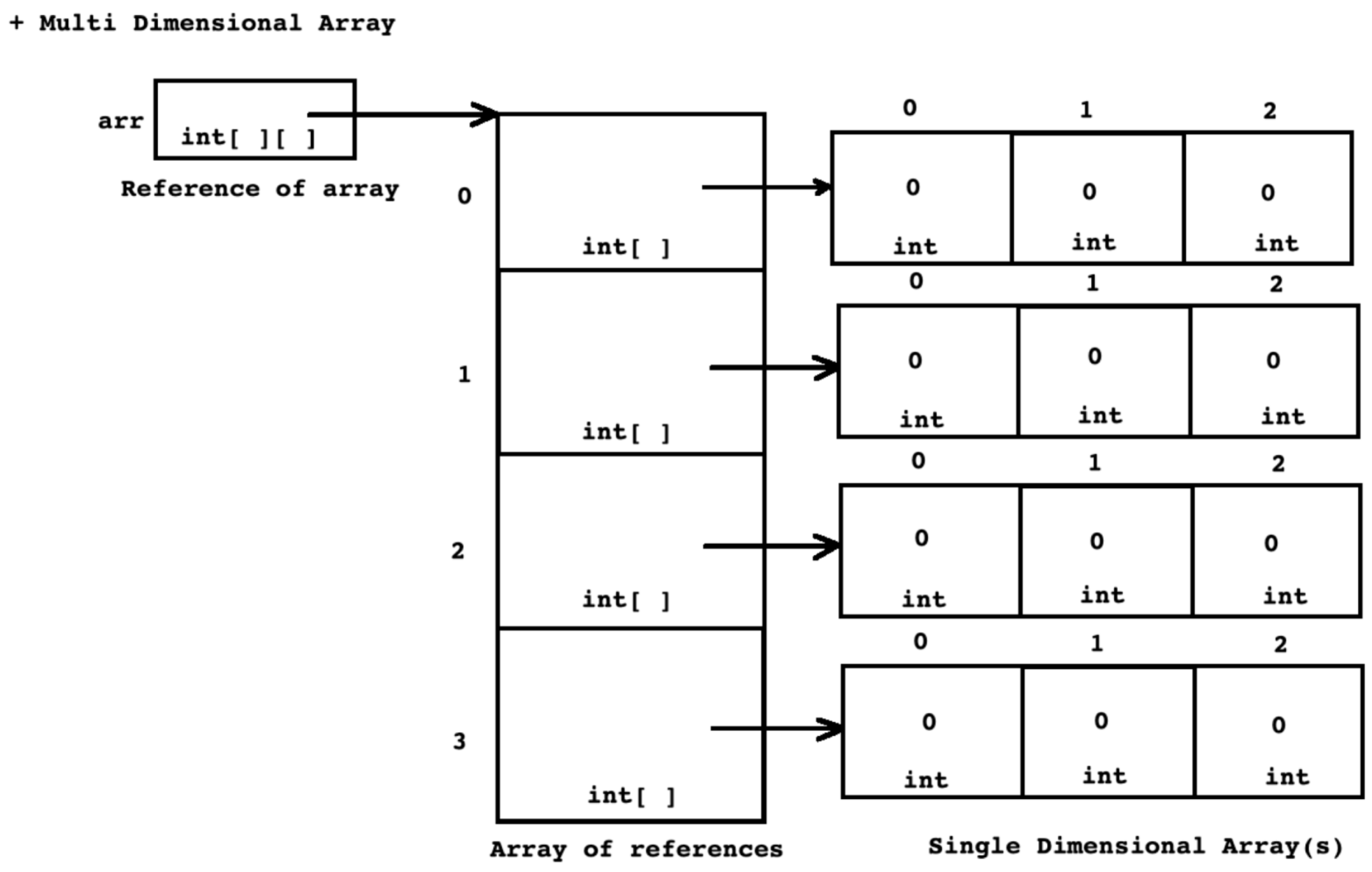
Array Creation:

```
int[][] arr = new int[ 2 ][ 3 ];
```

Initialization

```
int[][] arr = new int[ ][ ]{{10,20,30},{40,50,60}}; //OK
int[][] arr = { {10,20,30}, {40,50,60} };   //OK
```

Multi Dimensional Array



Ragged Array

- A multidimensional array where column size of every array is different.

Reference declaration

```
int arr[][];
int []arr[];
int[][] arr;
```

Array creation

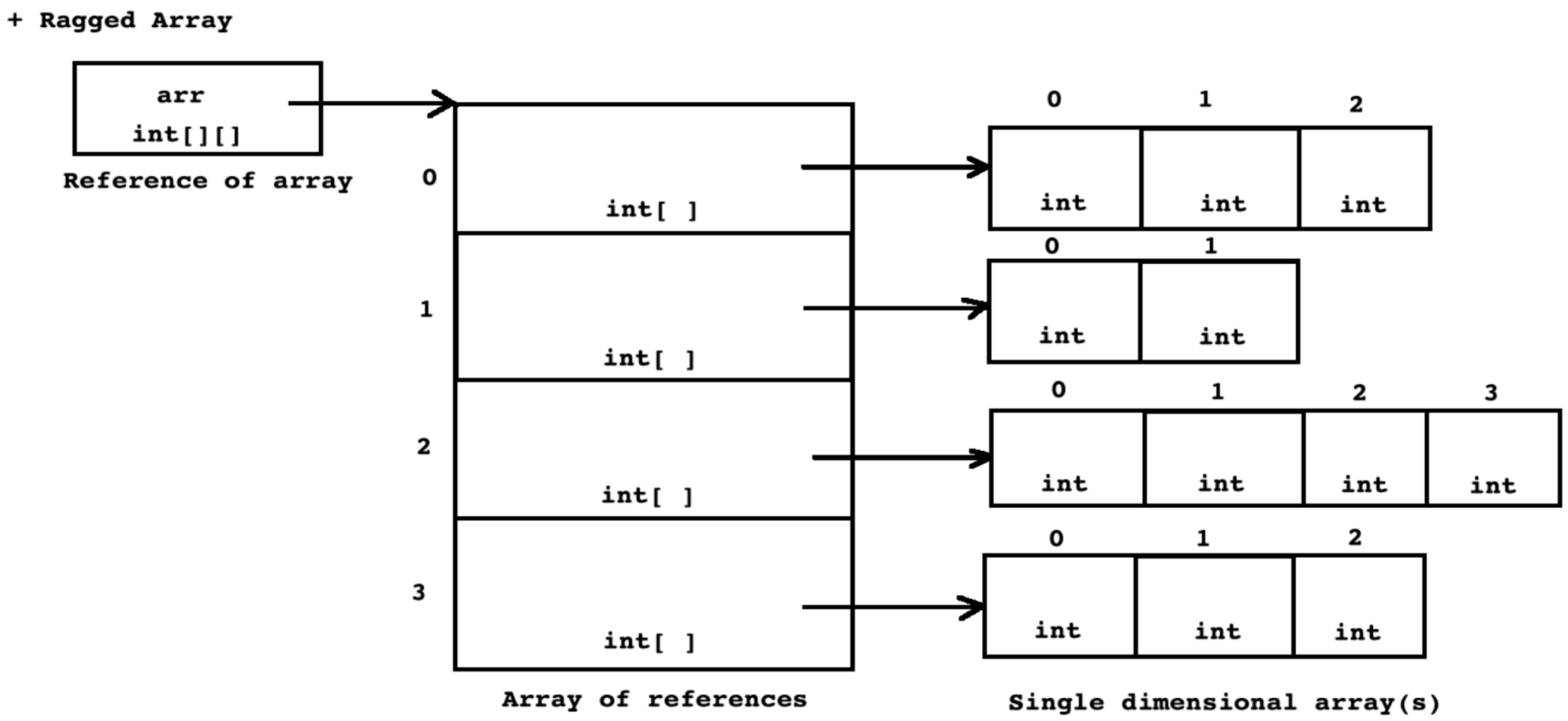
```
int[][] arr = new int[3][];
arr[ 0 ] = new int[ 2 ];
arr[ 1 ] = new int[ 3 ];
arr[ 2 ] = new int[ 5 ];
```

Array Initialization

```
int[][] arr = new int[3][];
arr[ 0 ] = new int[  ]{ 10, 20 };
arr[ 1 ] = new int[  ]{ 10, 20, 30 };
arr[ 2 ] = new int[  ]{ 10, 20, 30, 40, 50 };
```

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

Ragged Array



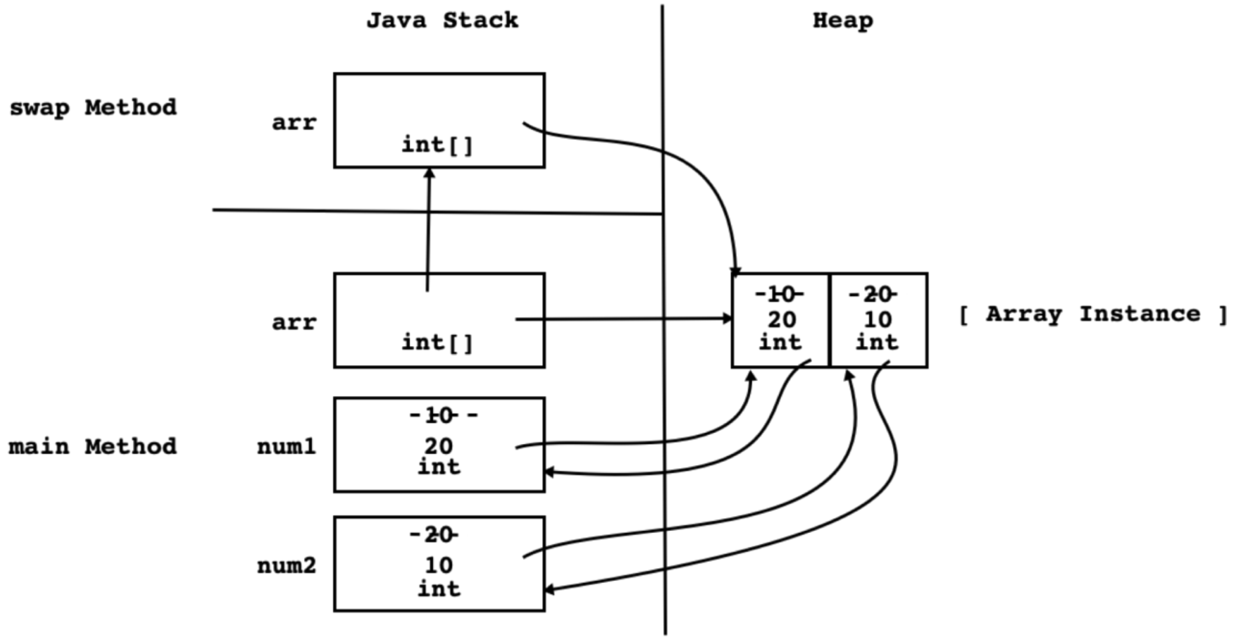
Argument Passing Methods

- In C programming language, we can pass argument to the function using 2 ways:
    1. By value.
    2. By address
- In C++ programming language, we can pass argument to the function using 3 ways:
    1. By value.
    2. By address
    3. By reference
- In Java programming language, we can pass argument to the method using a way:
    1. By value.
    - In other word, every variable of primitive type/non primitive type is pass to the method by value only.

Simulation Of Pass By Reference in Java

```
public class Program {
    private static void swap(int[] arr) {
        int temp = arr[0];
        arr[0] = arr[1];
        arr[1] = temp;
    }

    public static void main(String[] args) {
        int num1 = 10, num2 = 20;
        int[] arr = new int[] { num1, num2 };
        Program.swap(arr);  //passing arr as a argument to the method by value.
        num1 = arr[0];  num2 = arr[1];
        System.out.println("Num1     :    " + num1);  //20
        System.out.println("Num2     :    " + num2);  //10
    }
}
```

Simulation Of Pass By Reference in Java



Variable Arity/Argument Method

```
private static sum( int... arguments ){
    int result = 0;
    for( int element : arguments )
        result = result + element;
    return result;
}
public static void main(String[] args) {
    int result = 0;
    result = Program.sum( );    //OK
    result = Program.sum( 10, 20, 30 );    //OK
    result = Program.sum( 10, 20, 30, 40, 50  );    //OK
    result = Program.sum( 10, 20, 30, 40, 50, 60, 70, 80, 90, 100  );    //OK
}
```

- Consider Examples from Java API:
    1. public PrintStream printf(String format, Object... args);
    2. public static String format(String format, Object... args);
    3. public Object invoke(Object obj, Object... args);

Enum In C/C++ Programming language.

- According ANSI C standard, if we want to assign name to the integer constant then we should use enum.
- Enum helps developer to improve readability of source code.
- enum is keyword in C. Let us consider syntax of enum:

``enum Identifier { //enumerator-list };```	```enum Color { RED, GREEN, BLUE //RED = 0, GREEN = 1, BLUE = 2 };```

```c
enum Identifier
{
    //enumerator-list
};
```

```c
enum Color
{
    RED, GREEN, BLUE
    //RED = 0, GREEN = 1, BLUE = 2
};
```

Enum In C/C++ Programming language.

- By default, the first enumeration-constant is associated with the value 0. The next enumeration-constant in the list is associated with the value of (constant-expression + 1), unless you explicitly associate it with another value.

`enum Channel { FOX = 11, CNN = 25, ESPN = 15, HBO = 22, MAX = 30, NBC = 32 };`	`enum Suit { Diamonds = 1, Hearts, Clubs, Spades };`

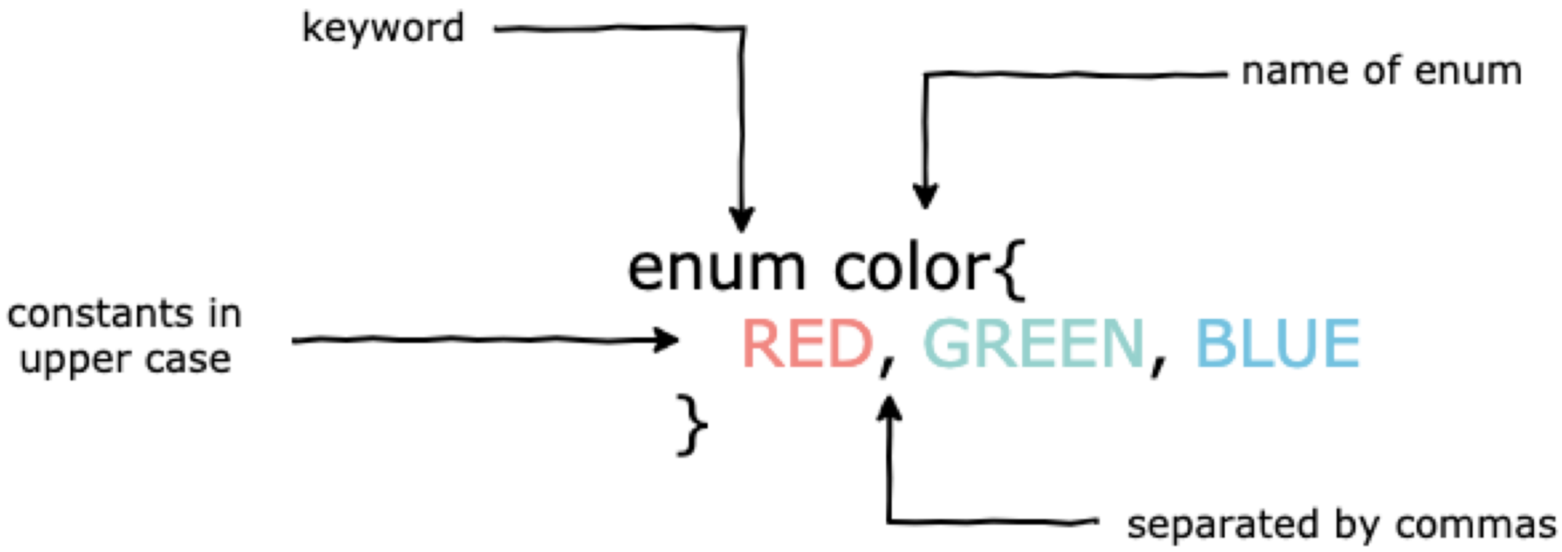
```c
enum Channel
{
    FOX = 11,
    CNN = 25,
    ESPN = 15,
    HBO = 22,
    MAX = 30,
    NBC = 32
};
```

```c
enum Suit { Diamonds = 1, Hearts, Clubs, Spades };
```

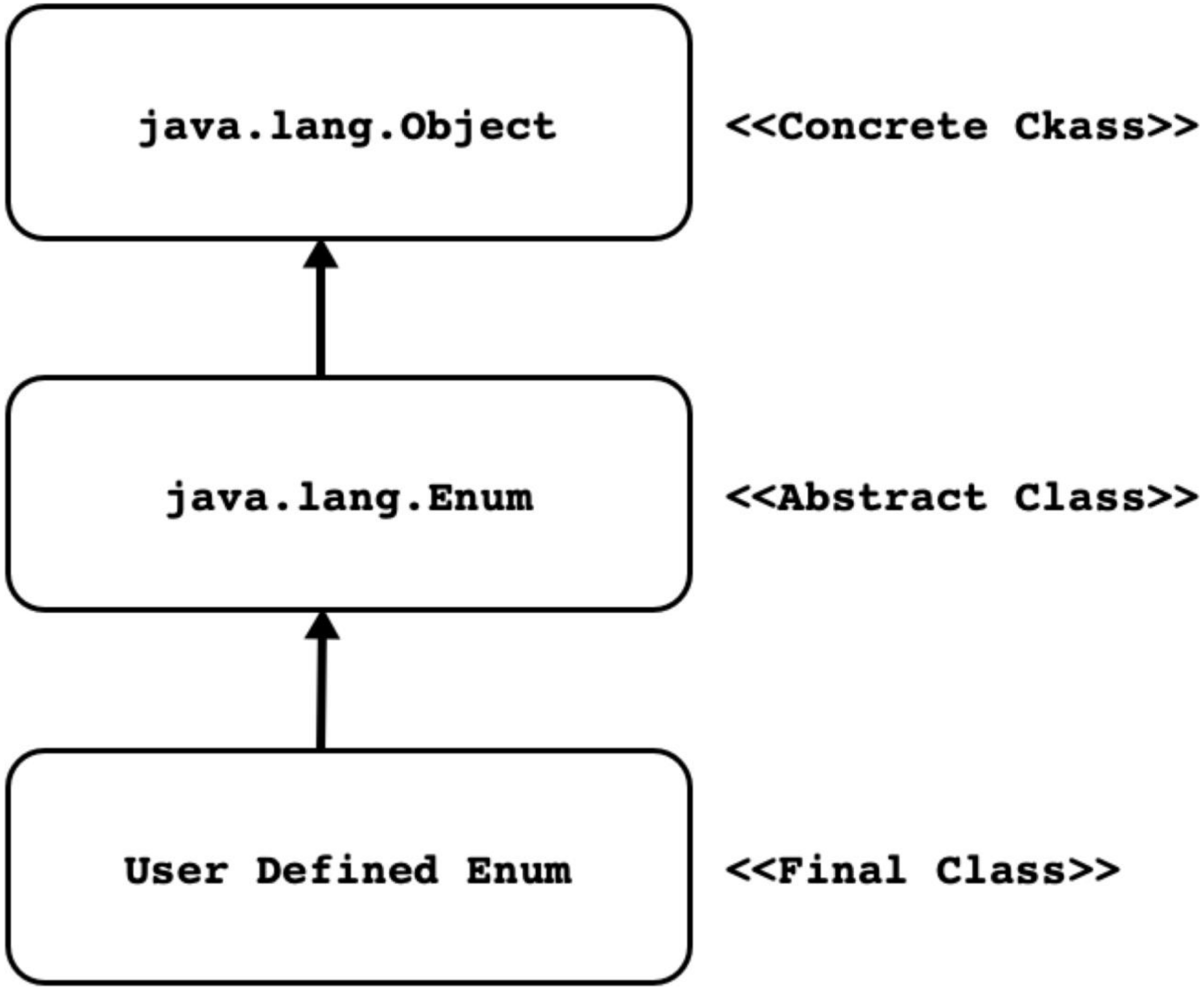
- constant-expression must have int type and can be negative.

Enum In Java Programming language.

- An enum is a class that represents a group of constants.
- **Enum keyword** is used to create an enum. The constants declared inside are separated by a comma and should be in upper case.



Enum Class Hierarchy



Enum API

- **`Following are the methods declared in java.lang.Enum class:`**

String	name()Returns the name of this enum constant, exactly as declared in its enum declaration.
int	ordinal()Returns the ordinal of this enumeration constant (its position in its enum declaration, where the initial constant is assigned an ordinal of zero).
String	toString()Returns the name of this enum constant, as contained in the declaration.
static <T extends Enum<T>> T	valueOf(Class<T> enumType, String name)Returns the enum constant of the specified enum type with the specified name.

Sole constructor : Programmers cannot invoke this constructor. It is for use by code emitted by the compiler in response to enum type declarations.

Enum for the compiler

Java Source Code

```java
enum Color{
    RED, GREEN, BLUE
}
class Program{
    public static void main(String[] args) {
        Color color = Color.GREEN;
    }
}
```

Compiled Code

```java
final class Color extends Enum<Color> {
    public static final Color RED;

    public static final Color GREEN;

    public static final Color BLUE;

    public static Color[] values();

    public static Color valueOf(String name);
}
```

Properties of enum

1. Similar to a class, an enum can have objects and methods. The only difference is that enum constants are public, static and final by default. Since it is final, we can’t extend enums
2. It cannot extend other classes since it already extends the java.lang.Enum class.
3. It can implement interfaces.
4. The enum objects cannot be created explicitly and hence the enum constructor cannot be invoked directly.
5. It can only contain concrete methods and no abstract methods.

Application of enum

1. enum is used for values that are not going to change e.g. names of days, colors in a rainbow, number of cards in a deck etc.
2. enum is commonly used in switch statements and below is an example of it:

```
class Program {
    enum color {
        RED, GREEN, BLUE
    }
    public static void main(String[] args) {
        color x = color.GREEN; // storing value
        switch(x) {
        case RED:
            System.out.println("x has RED color");
            break;
        case GREEN:
            System.out.println("x has GREEN color");
            break;
        case BLUE:
            System.out.println("x has BLUE color");
            break;
        }
    }
}
```

Contents

- Inheritance

Advantages of OOPS

1. To achieve simplicity

2. To achieve data hiding and data security.

3. To minimize the module dependency so that failure in single part should not stop complete system.

4. To achieve reusability so that we can reduce development time/cost/efforts.

5. To reduce maintenance of the system.

6. To fully utilize hardware resources.

7. To maintain state of object on secondary storage so that failure in system should not impact on data.

Major and Minor pillars of oops

- 4 Major pillars
  1. Abstraction
  2. Encapsulation
  3. Modularity
  4. Hierarchy

- 3 Minor Pillars
  1. Typing
  2. Concurrency
  3. Persistence

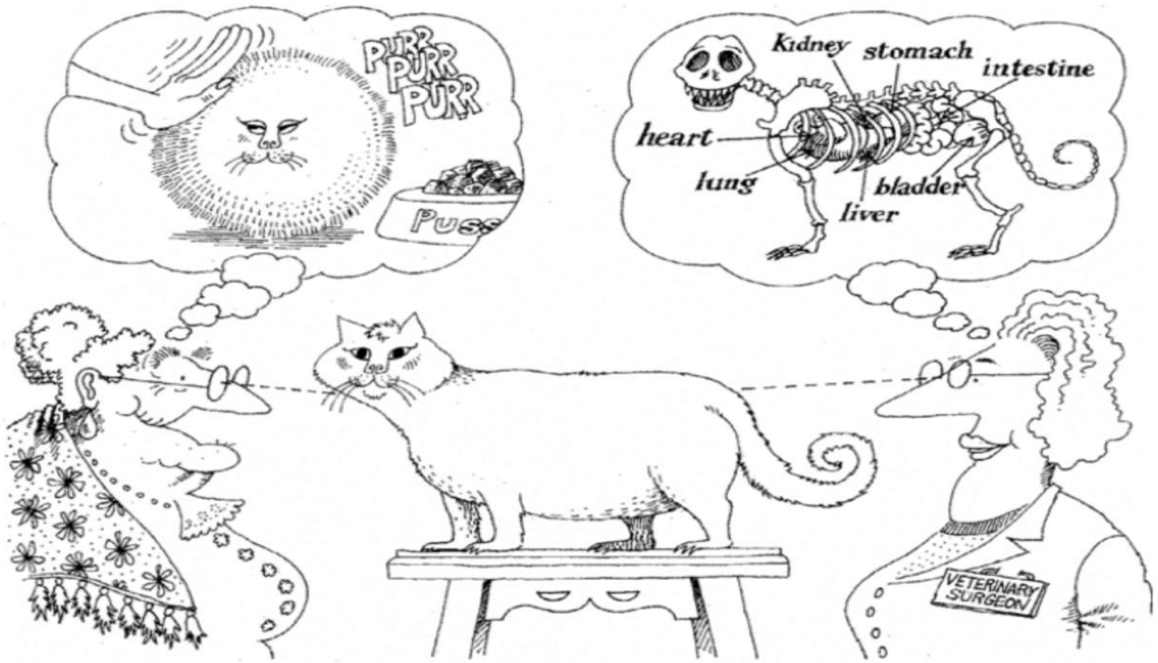
Abstraction

- It is a major pillar of oops.
- **It is a process of getting essential things from object.**
- It describes outer behaviour of the object.
- Abstraction focuses on some essential characteristics of object relative to the perspective of viewer. In other words, abstraction changes from user to user.
- **Using abstraction, we can achieve simplicity.**
- Abstraction in Java

```
Complex c1 = new Complex( );
c1.acceptRecord( );
c1.printRecord( );
```

Abstraction

Abstraction



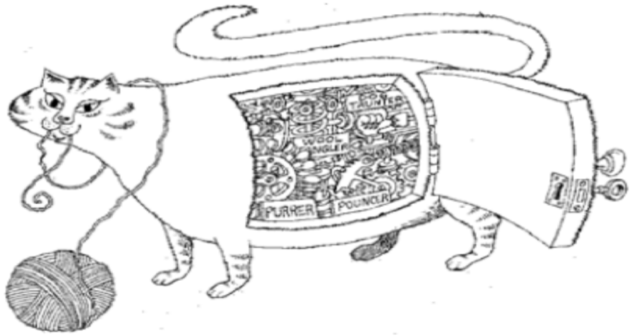
Abstraction focuses on the essential characteristics of some object, relative to the perspective of the viewer.

Encapsulation

- It is a major pillar of oops.
- Definition:
    1. **Binding of data and code together is called encapsulation.**
    2. To achieve abstraction, we should provide some implementation. It is called encapsulation.
- Encapsulation represents, internal behaviour of the object.
- **Using encapsulation we can achieve data hiding.**
- Abstraction and encapsulation are complementary concepts: **Abstraction focuses on the observable behaviour** of an object, whereas **encapsulation focuses on the implementation** that gives rise to this behaviour.

Encapsulation

Encapsulation



Encapsulation hides the details of the implementation of an object.

Abstraction and encapsulation are complementary concepts: Abstraction focuses on the observable behavior of an object, whereas encapsulation focuses on the implementation that gives rise to this behavior.

Modularity

- It is a major pillar of oops.
- It is the process of developing complex system using small parts.
- **Using modularity, we can reduce module dependency.**
- We can implement modularity by creating library files.
  - .lib/.a, .dll / .so files
  - .jar/.war/.ear in java

Hierarchy

- It is a major pillar of oops.
- **Level / order / ranking of abstraction is called hierarchy.**
- Main purpose of hierarchy is **to achieve reusability.**
- Advantages of code reusability
    1. We can reduce development time.
    2. We can reduce development cost.
    3. We can reduce developers effort.

- Types of hierarchy:
    1. **Has-a** / Part-of => Association
    2. **Is-a** / Kind-of => Inheritance / Generalization
    3. **Use-a** => Dependency
    4. **Creates-a** => Instantiation

Typing

- It is a minor pillar of oops.
- Typing is also called as polymorphism.
- Polymorphism is a Greek word. Polymorphism = Poly(many) + morphism(forms).
- **An ability of object to take multiple forms is called polymorphism.**
- **Using polymorphism, we can reduce maintenance of the system.**
- Types of polymorphism:
    - **Compile time polymorphism**
        - It is also calling static polymorphism / **Early binding** / Weak Typing / False polymorphism.
        - We can achieve it using:
            1. **Method Overloading**
    - **Run time polymorphism**
        - It is also calling dynamic polymorphism / **Late binding** / Strong Typing / True polymorphism.
        - We can achieve it using:
            1. **Method Overriding.**

Concurrency

- It is a minor pillar of oops.
- In context of operating system, it is called as multitasking.
- It is the process of executing multiple task simultaneously.
- Main purpose of concurrency is to utilise CPU efficiently.
- In Java, we can achieve concurrency using thread.

Persistence

- It is a minor pillar of oops.
- It is process of maintaining state of object on secondary storage.
- In Java, we can achieve Persistence using file and database.

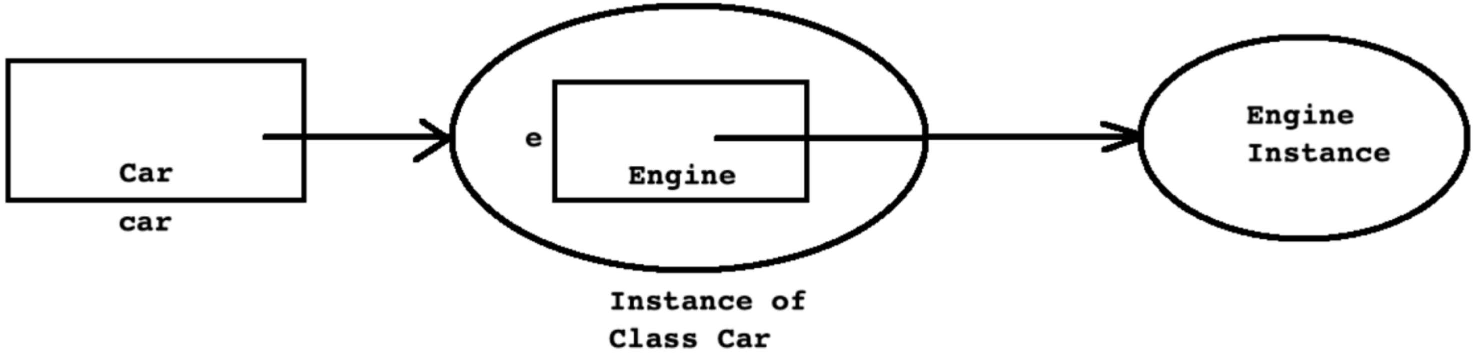
Association

- If has-a relationship is exist between the types then we should use association.
- Example
    1. Car has a engine
    2. Room has a chair
- Let us consider example of car and engine:
    1. Car has a engine
    2. Engine is part of Car.
- If object/instance is a part/component of another instance then it is called as association.
- To implement association, we should declare instance of a class as a field inside another class.

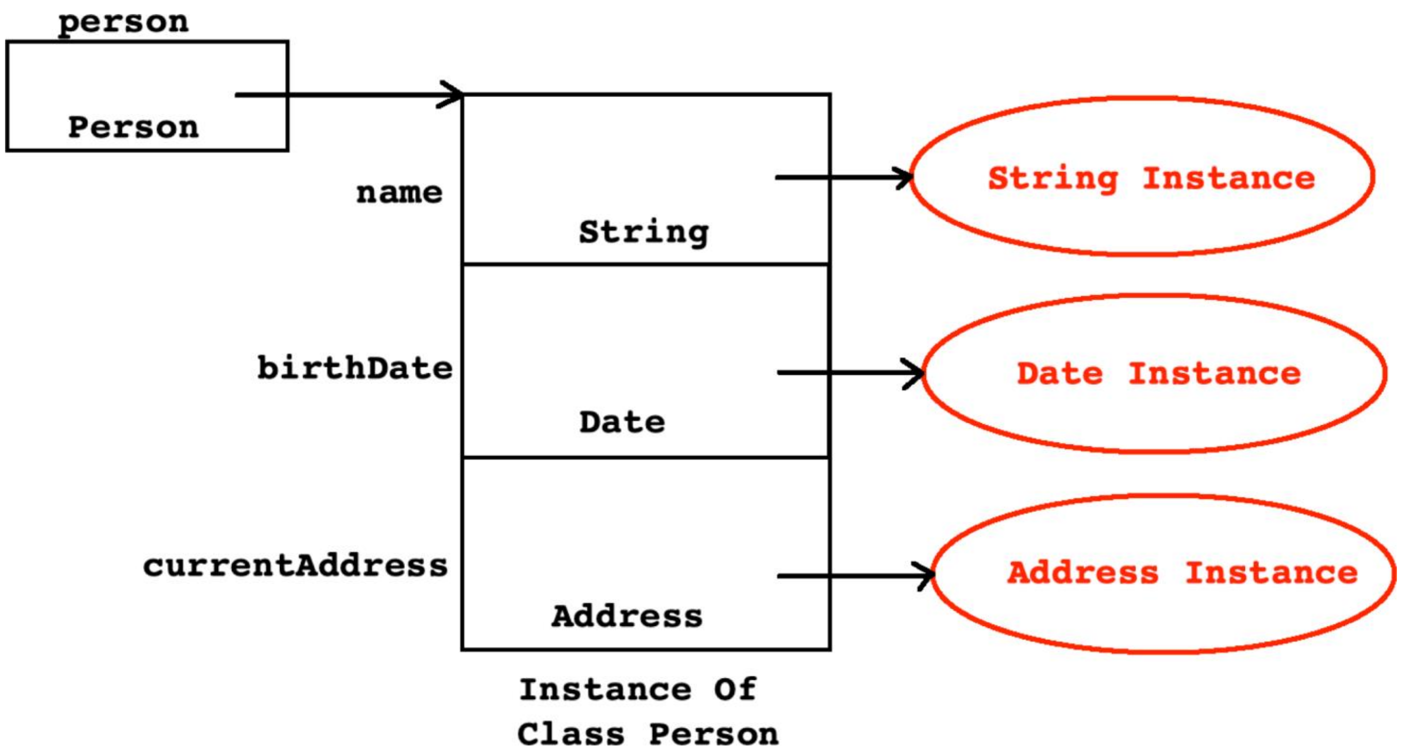
Association In Java

- Engine is part of Car

```
class Engine{
  //TODO
}
class Car{
  Engine e = new Engine( ); //Association
}
Car c = new Car( );
```



Association In Java



Inheritance

- If "is-a" relationship is exist between the types then we should use inheritance.
- Inheritance is also called as generalization.
- Example
    1. Manager is a employee
    2. Book is a product
    3. Triangle is a shape
    4. SavingAccount is a account.

```
class Employee{ //Parent class
    //TODO
}
class Manager extends Employee{ //Child class
    //TODO
}
//Here class Manager is extended from class Employee.
```

Inheritance

- If we want to implement inheritance then we should use extends keyword.
- In Java, parent class is called as super class and child class is called as sub class.
- Java do not support private and protected mode of inheritance
- If Java, class can extend only one class. In other words, multiple class inheritance is not allowed.
- Consider following code:

```
class A{     }
class B{     }
class C extends A, B{    //Not OK
}
```

Inheritance

- During inheritance, if super type and sub type is class, then it is called as implementation inheritance.

Single implementation Inheritance `class A{ }` `class B extends A{ } //OK`	Hierarchical implementation Inheritance `class A{ }` `class B extends A{ } //OK` `class C extends A{ } //OK`
Multiple implementation Inheritance `class A{ }` `class B{ }` `class C extends A, B{ } //Not OK`	Multilevel implementation inheritance `class A{ }` `class B extends A{ } //OK` `class C extends B{ } //OK`

Multiple Inheritance In Java

```
class A{    }
class B{    }
class C extends A, B{   //Not OK : Multiple implementation inheritance
    //TODO
}
```

```
interface A{    }
interface B{    }
interface C extends A, B{   //OK : Multiple interface inheritance
    //TODO
}
```

```
interface A{    }
interface B{    }
class C implements A, B{   //OK : Multiple interface implementation inheritance
    //TODO
}
```

Inheritance

- If we create instance of sub class then all the non static fields declared in super class and sub class get space inside it. In other words, non static fields of super class inherit into sub class.
- Static field do not get space inside instance. It is designed to share among all the instances of same class.
- Using sub class, we can access static fields declared in super class. In other words, static fields of super class inherit into sub class.
- All the fields of super class inherit into sub class but only non static fields gets space inside instance of sub class.
- Fields of sub class, do not inherit into super class. Hence if we create instance of super class then only non static fields declared in super class get space inside it.
- If we declare field in super class static then, all the instances of super class and sub class share single copy of static field declared in super class.

Inheritance

- We can call/invoke, non static method of super class on instance of sub class. In other words, non static method inherit into sub class.

- We can call static method of super class on sub class. In other words, static method inherit into sub class.

- Except constructor, all the methods of super class inherit into sub class.

Inheritance

- If we create instance of super class then only super class constructor gets called. But if we create instance of sub class then JVM first give call to the super class constructor and then sub class constructor.
- From any constructor of sub class, by default, super class's parameterless constructor gets called.
- Using super statement, we can call any constructor of super class from constructor of sub class.
- Super statement, must be first statement inside constructor body.

Inheritance

- According to client's requirement, if implementation of super class is logically incomplete / partially complete then we should extend the class. In other words we should use inheritance.
- According to client's requirement, if implementation of super class method is logically incomplete / partially complete then we should redefine method inside sub class.
- Process of redefining method of super class inside sub class is called as method overriding.

Regarding this and super

this(...) implies invoking constructor from the same class.
super(...) implies invoking constructor from the immediate super class

1. Only a constr can use this() or super()
2. Has to be 1st statement in the constructor
3. Any constructor can never have both ie. this() & super()
4. super & this (w/o brackets) are used to access (visible) members of super class or the same class.

Contents

- String
- String Buffer

java.lang.Character

- It is a final class declared in java.lang package.
- The Character class wraps a value of the primitive type char in an object.
- This class provides a large number of static methods for determining a character's category (lowercase letter, digit, etc.) and for converting characters from uppercase to lowercase and vice versa.
- The fields and methods of class Character are defined in terms of character information from the Unicode Standard.
- The char data type are based on the original Unicode specification, which defined characters as fixed-width 16-bit entities.

java.lang.Character

- The range of legal *code points* is now U+0000 to U+10FFFF, known as *Unicode scalar value*.
- The set of characters from U+0000 to U+FFFF is sometimes referred to as the *Basic Multilingual Plane (BMP)*.
- Characters whose code points are greater than U+FFFF are called *supplementary characters*.
- The Java platform uses the UTF-16 representation in char arrays and in the String and StringBuffer classes.
- A char value, therefore, represents Basic Multilingual Plane (BMP) code point

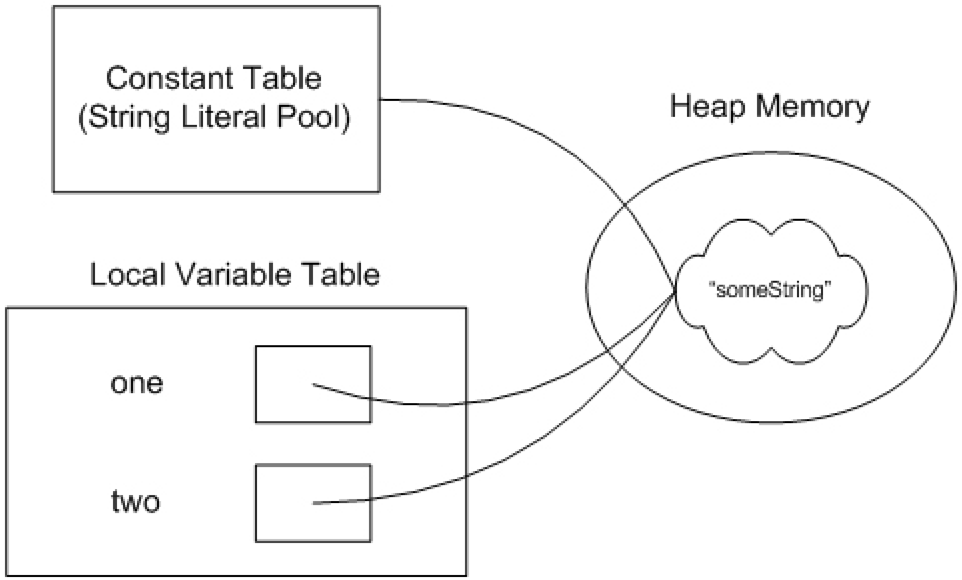
String Introduction

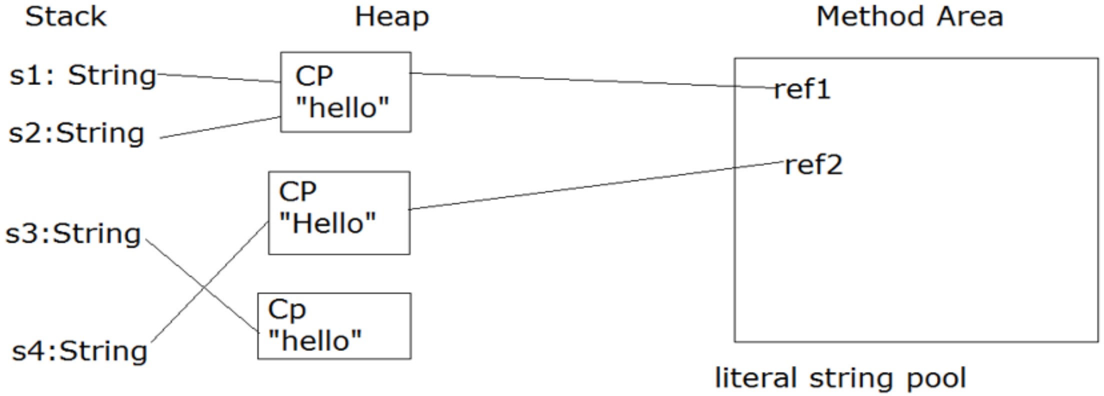
- Strings, which are widely used in Java programming, are a sequence of characters.

- In the Java programming language, strings are objects.
- We can use following classes to manipulate string
    1. **java.lang.String : immutable character sequence**
    2. **java.lang.StringBuffer : mutable**
    3. **java.lang.StringBuilder : mutable character sequence**
    4. java.util.StringTokenizer
    5. java.util.regex.Pattern
    6. java.util.regex.Matcher

Literal Vs Non Literal

Two ways to create a String in Java which are String Literal and String Object. The main difference between String Literal and String Object is that String Literal is a String created using double quotes while String Object is a String created using the new() operator.





Eg. String s1="hello"; // Literal
String s2="hello"; // Literal
String s3=new String(s1); // Non Literal
String s4="hello"; // Literal

Note: JVM Class loader will scan the literal string @class loading and create string objects on heap and its reference in literal/constant string pool (Memory allocated to method area).
Pool : Sharing of resources, so multiple references for the same content string will not be kept.

Example Literal Vs Non Literal

Literal

String s1 = “Hello World”;
Here, the s1 is referring to “Hello World” in the String pool.
If there is another statement as follows.
String s2 = “Hello World”;
As “Hello World” already exists in the String pool, the s2 reference variable will also point to the already existing “Hello World” in the String pool. In other words, now both s1 and s2 refer to the same “Hello World” in the String pool. Therefore, if the programmer writes a statement as follows, it will display true.
System.out.println(s1==s2);

Non Literal

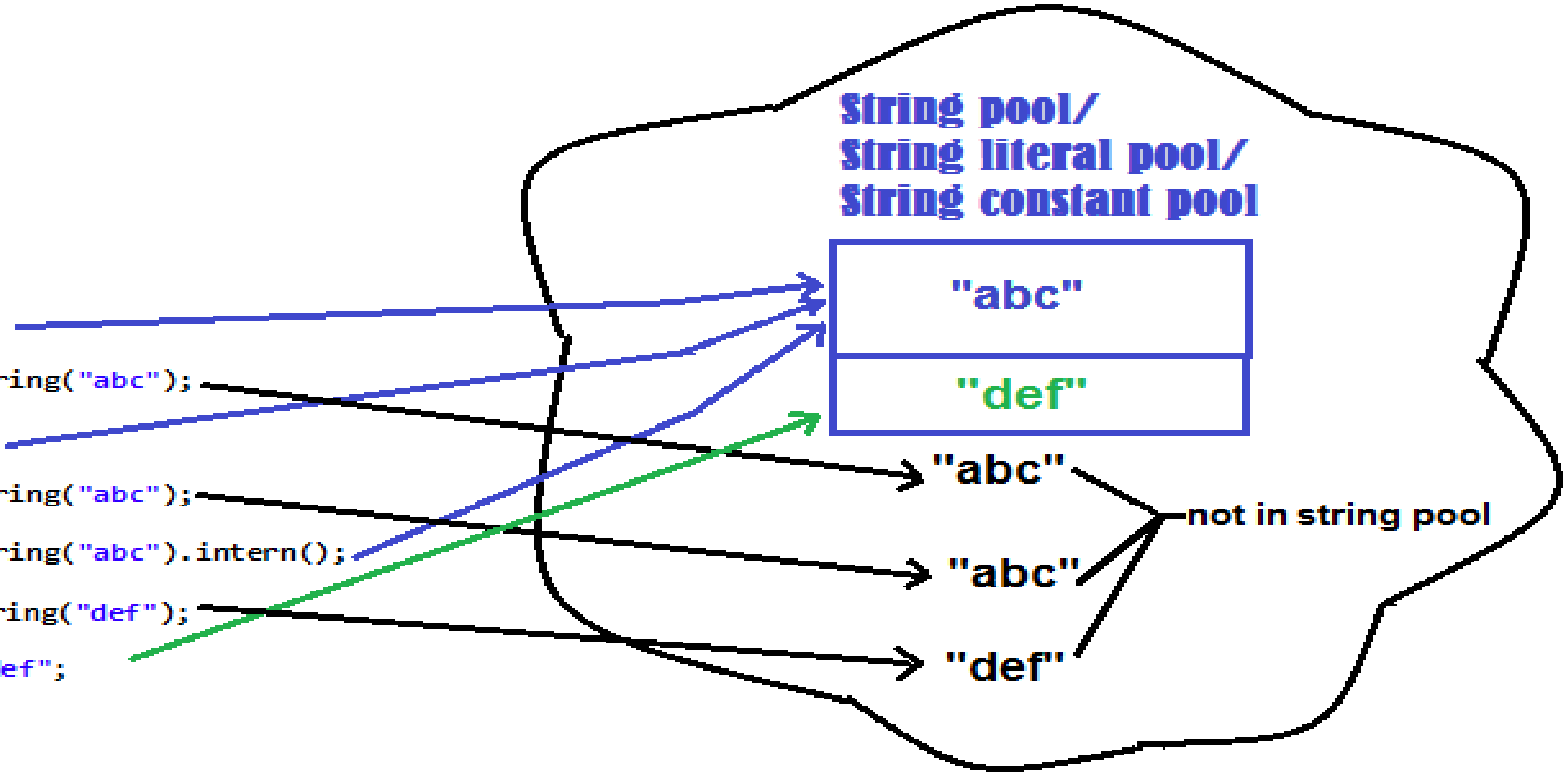
String s1 = new (“Hello World”);
String s2 = new (“Hello World”);
Unlike with String literals, in this case, there are two separate objects. In other words, s1 refers to one “Hello World” while s2 refers to another “Hello World”. Here, the s1 and s2 are reference variables that refer to separate String objects. Therefore, if the programmer writes a statement as follows, it will display false.
System.out.println(s1==s2);

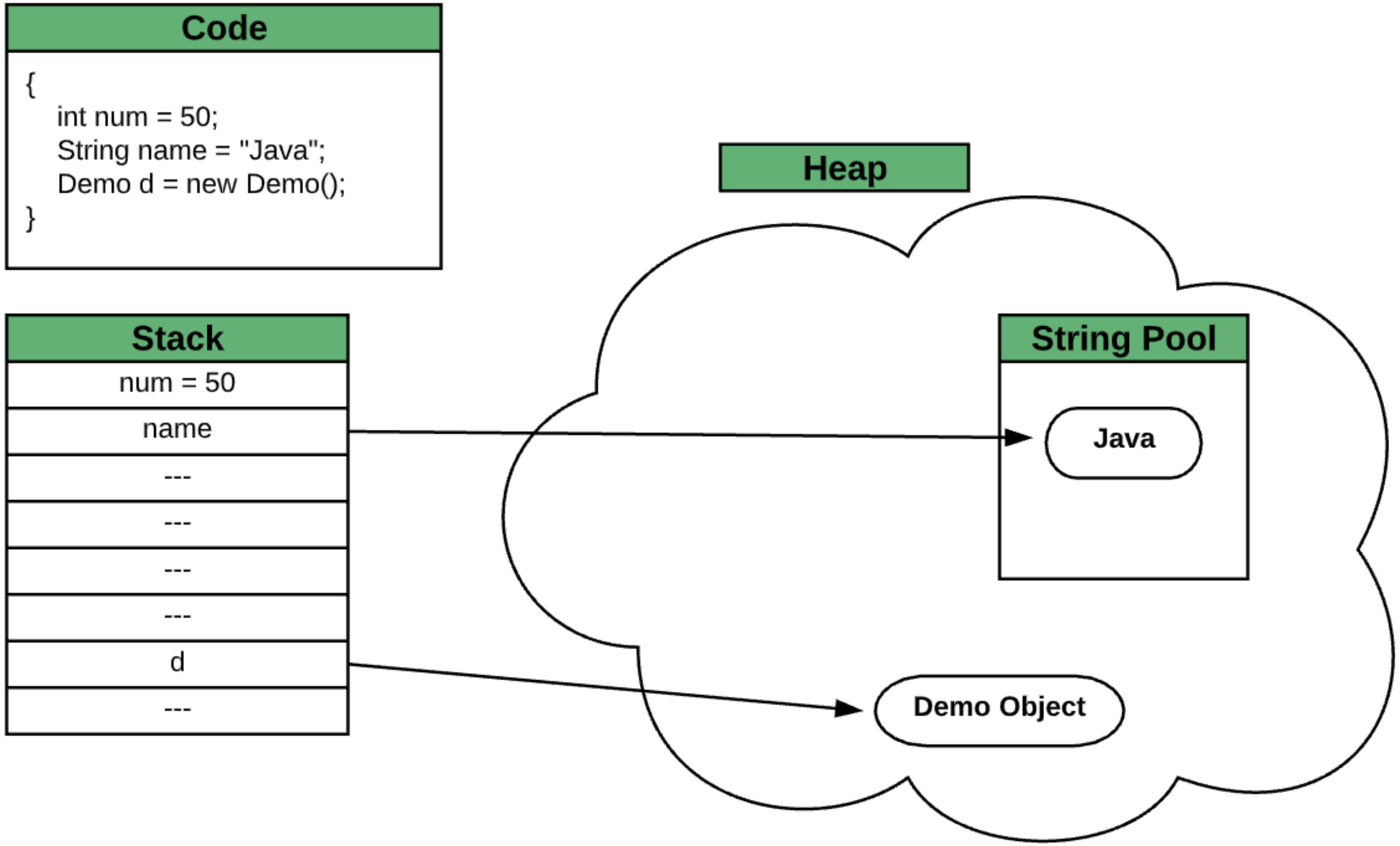
When you create a String object using the new() operator, it always creates a new object in heap memory.

if you create an object using String literal it may return an existing object from String pool (a cache of String object in which is now moved to heap space in recent Java release).

JAVA HEAP MEMORY

```
String s1 = "abc";
String s2 = new String("abc");
String s3 = "abc";
String s4 = new String("abc");
String s5 = new String("abc").intern();
String a1 = new String("def");
    String a2 = "def";
```




Code
{
int num = 50;
String name = "Java";
Demo d = new Demo();
}
Stack
num = 50
name

---
d

Heap
String Pool
Java
Demo Object

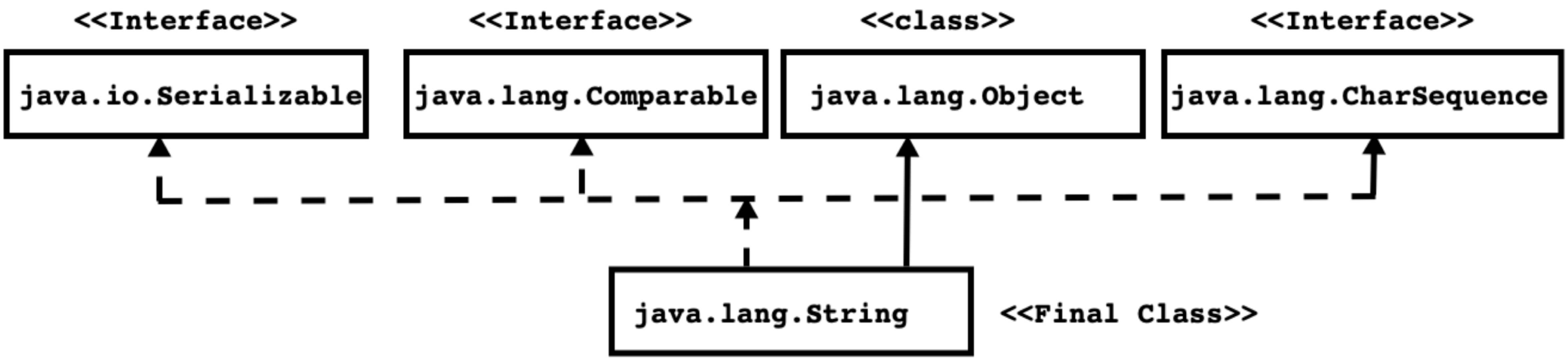
Literal Vs Non Literal example

```
String s="Hello";//literal string
s.toUpperCase();//non literal object
s.concat("12345");//non literal object ---> Hello12345 , literal string obj : "12345"
sop(s);//Hello
String s1="testing strings";//literal string
String s2=new String(s1);//non literal s2 ----> heap ("testing strings")
sop(s1==s2);//false
sop(s1.equals(s2));//true
String s3="He"+"llo";//literal strings : He , llo : two strings , s3 is a literal string
String s4="He".concat("llo");//s4 ---> non literal
String s5="hello";//adds new literal string s5----> literal string
sop(s==s3);//true
sop(s==s4);//false
sop(s==s5);//false
```

Literal Vs Non Literal example

```
String s1="hello";//s1 --> literal
String s2="hello";//nothing
String s3=new String(s1);//non literal
String s4=s3.intern();//won't add any new literal string : since "hello" alrdy exists
String s5="he"+"llo";//won't add any new literal string : since "hello" alrdy exists
String s6="he".concat("llo");//new non literal
System.out.println(s1==s2);//t
System.out.println(s1==s3);//f
System.out.println(s1==s4);//t
System.out.println(s1==s5);//t
System.out.println(s1==s6);//f
String s7=new String("Hello");//how many string objects are created in this line? : 2
String s8=new String("hello");//how many string objects are created in this line? : 1
```

String Class Hierarchy



String Introduction

- Serializable is a Marker interface declared in java.io package.
- Comparable is Functional interface declared in java.lang package.
  1. int compareTo(T other)
- CharSequence is interface declared in java.lang package.
  1. char charAt(int index)
  2. int length()
  3. CharSequence subSequence(int start, int end)
  4. default IntStream chars()
  5. default IntStream codePoints( )
- Object is non final, concrete class declared in java.lang package.
  1. It is having 11 methods(5 Non final + 6 final)
- String is a final class declared in java.lang package.

String Introduction

- String is not a built-in or primitive type. It is a class, hence considered as non primitive/reference type.

- We can create instance of String with and W/o new operator.
  - String str = new String(“Akshita”);   //String Instance
  - String str = “SunBeam”;

- String str = “SunBeam”, is equivalent to:
- char[] data = new char[ ]{‘S’,’u’,’n’,’B’,’e’,’a’,’m’};
- String str = new String(data);

String concatenation

- If we want to concatenate Strings then we should use concat() method:
  - "public String concat(String str)"

- Consider following Example:

```
String s1 = "SunBeam";
String s2  =  "Pune/Karad";
String s3 = s1.concat( s2 );
```

- The Java language provides special support for the string concatenation operator (+), and for conversion of other objects to strings.

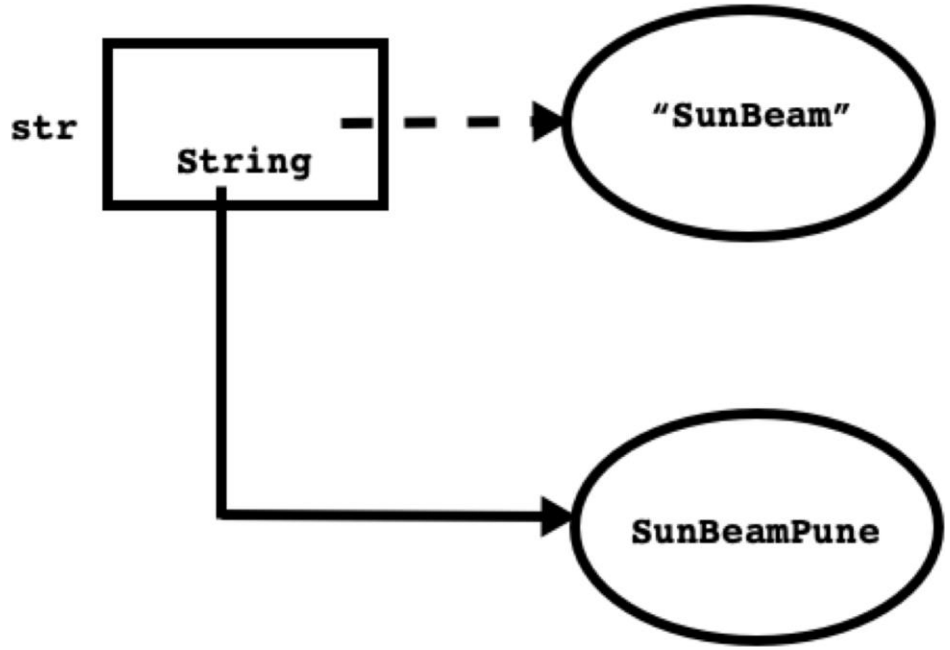
```
String s1 = "SunBeam";
String s2 = s1 +" Pune/Karad";
```

-
- `int pinCode = 411057;`
- `String str = "Pune,"+pinCode;`

Immutable Strings

- Strings are constant; their values cannot be changed after they are created.
- Because String objects are immutable they can be shared.

```
String str = "SunBeam";

str = str + "Pune";
```



A Strategy for Defining Immutable Objects

1. Don't provide "setter" methods — methods that modify fields or objects referred to by fields.

2. Make all fields final and private.

3. Don't allow subclasses to override methods. The simplest way to do this is to declare the class as final. A more sophisticated approach is to make the constructor private and construct instances in factory methods.

4. If the instance fields include references to mutable objects, don't allow those objects to be changed:

   - Don't provide methods that modify the mutable objects.
   - Don't share references to the mutable objects. Never store references to external, mutable objects passed to the constructor; if necessary, create copies, and store references to the copies. Similarly, create copies of your internal mutable objects when necessary to avoid returning the originals in your methods.

String Class Constructors

```
1. public String()

2. public String(byte[] bytes)

3. public String(char[] value)

4. public String(String original)

5. public String(StringBuffer buffer)

6. public String(StringBuilder builder)
```

String Class Methods

1. public char charAt(int index)
2. public int compareTo(String anotherString)
3. public String concat(String str)
4. public boolean equalsIgnoreCase(String anotherString)
5. public boolean startsWith(String prefix)
6. public boolean endsWith(String suffix)
7. public static String format(String format, Object... args)
8. public byte[] getBytes()
9. public int indexOf(int ch)
10. public int indexOf(String str)
11. public String intern( )
12. public boolean isEmpty()
13. public int length()
14. public boolean matches(String regex)

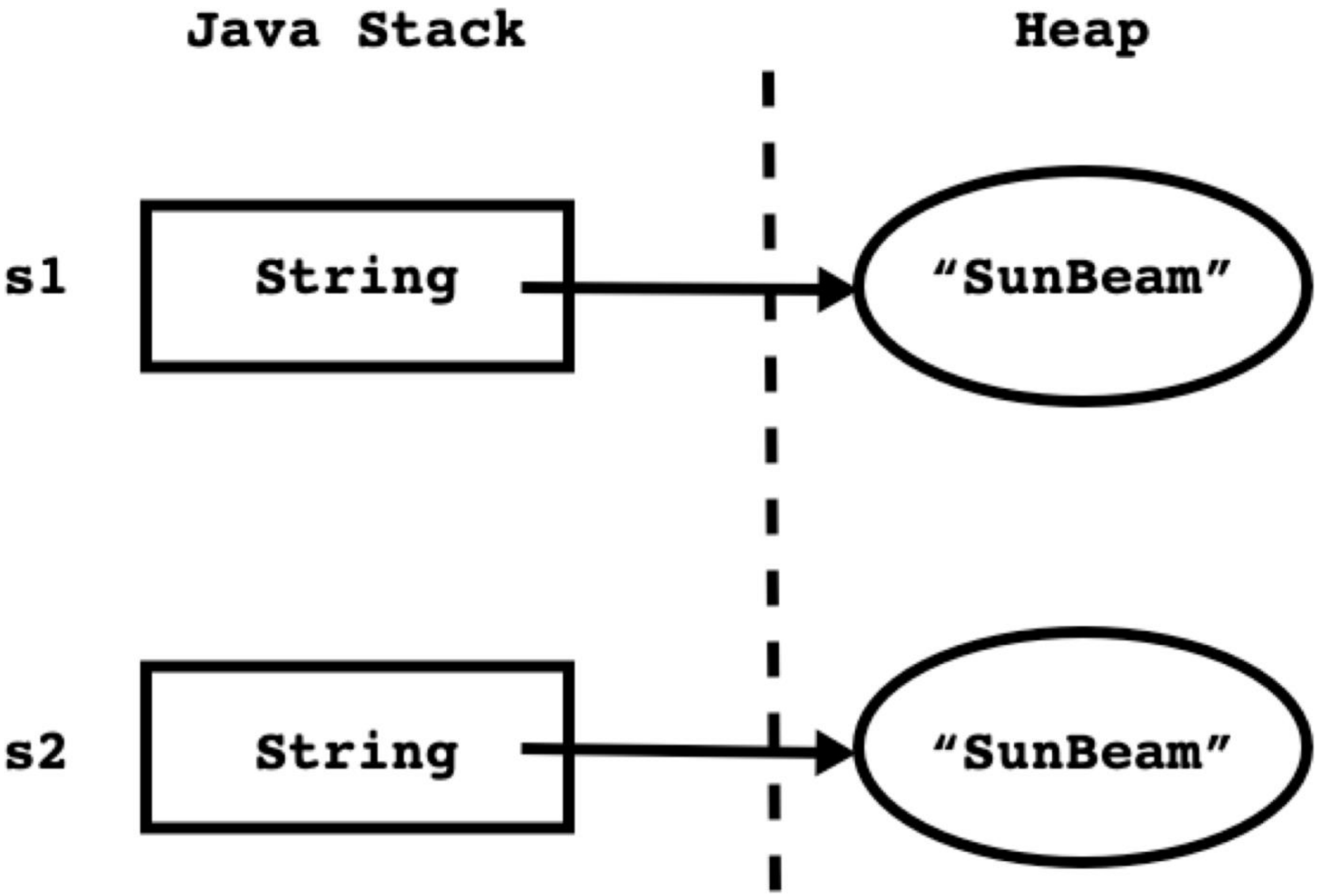
String Class Methods

15. public String[] split(String regex)
16. public String substring(int beginIndex)
17. public String substring(int beginIndex, int endIndex)
18. public char[] toCharArray()
19. public String toLowerCase()
20. public String toUpperCase()
21. public String trim()
22. public static String valueOf(Object obj)

String Twister

```
public class Program {
   public static void main(String[] args) {
      String s1 = new String("SunBeam");
      String s2 = new String("SunBeam");
      if( s1 == s2 )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Not Equal
   }
}
```

String Twister



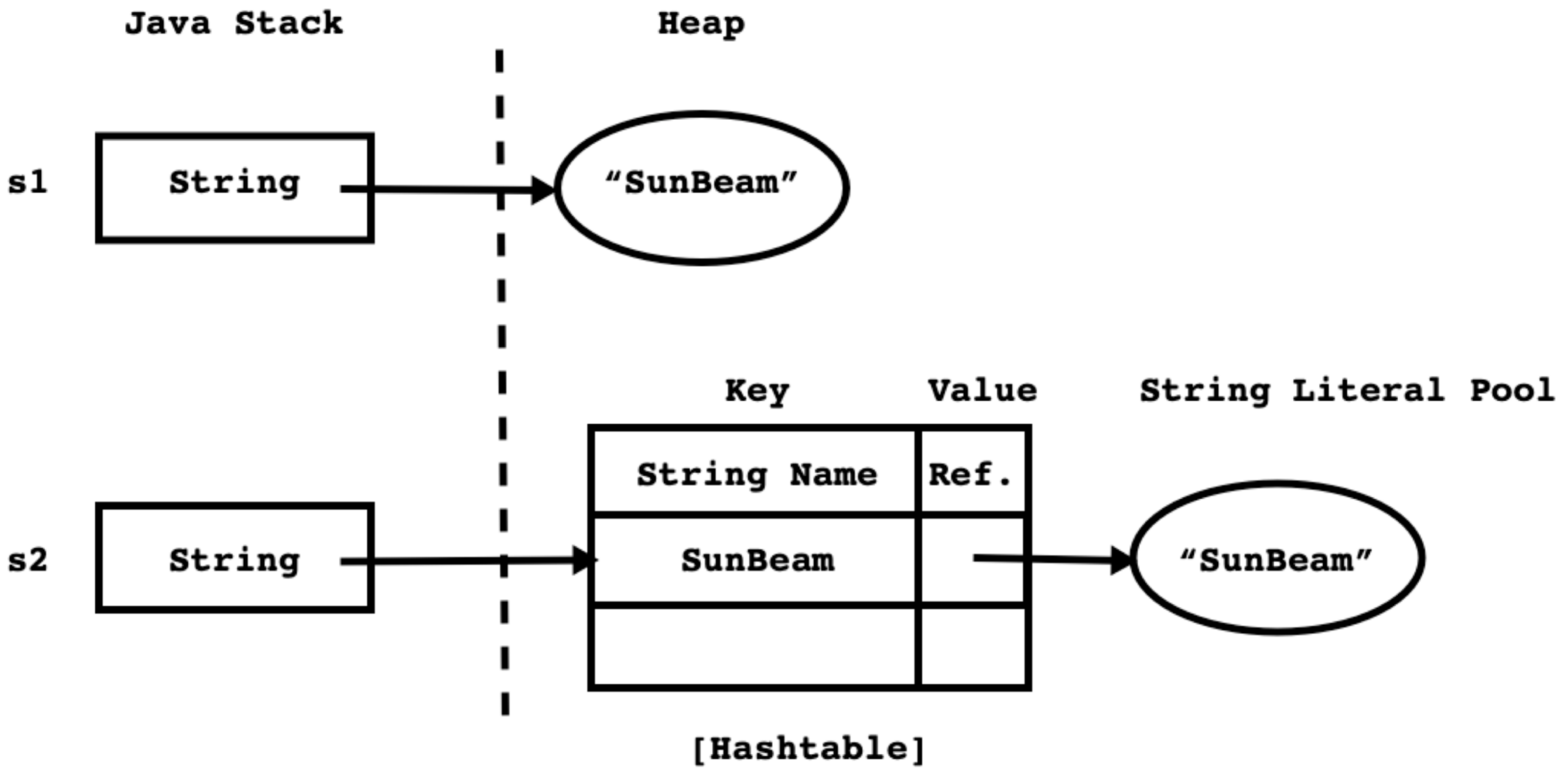
String Twister

```java
public class Program {
   public static void main(String[] args) {
      String s1 = new String("SunBeam");
      String s2 = new String("SunBeam");
      if( s1.equals(s2) )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Equal
   }
}
```

String Twister

```
public class Program {
   public static void main(String[] args) {
      String s1 = new String("SunBeam");
      String s2 = "SunBeam";
      if( s1 == s2 )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Not Equal
   }
}
```

String Twister



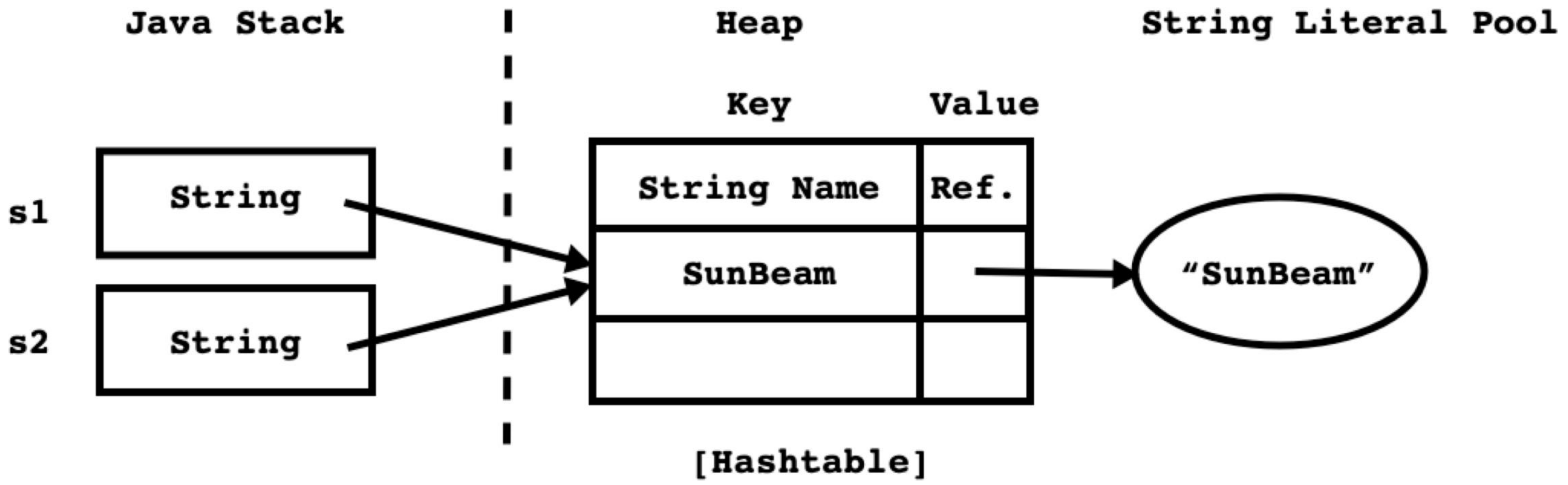
String Twister

```
public class Program {
   public static void main(String[] args) {
      String s1 = new String("SunBeam");
      String s2 = "SunBeam";
      if( s1.equals(s2) )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Equal
   }
}
```

String Twister

```java
public class Program {
    public static void main(String[] args) {
        String s1 = "SunBeam";
        String s2 = "SunBeam";
        if( s1 == s2 )
            System.out.println("Equal");
        else
            System.out.println("Not Equal");
        //Output : Equal
    }
}
```

String Twister



String Twister

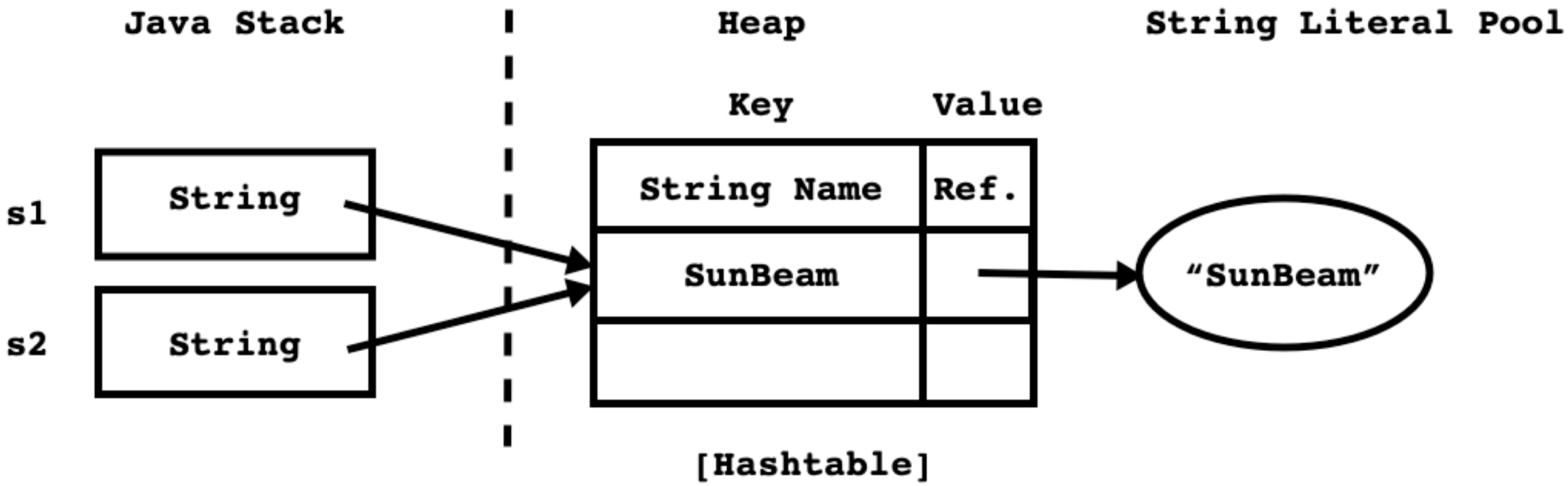
```java
public class Program {
   public static void main(String[] args) {
      String s1 = "SunBeam";
      String s2 = "SunBeam";
      if( s1.equals(s2) )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Equal
   }
}
```

String Twister

```java
public class Program {
   public static void main(String[] args) {
      String s1 = "SunBeam";
      String s2 = "Sun"+"Beam";
      if( s1 == s2 )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Equal
   }
}
```

String Twister

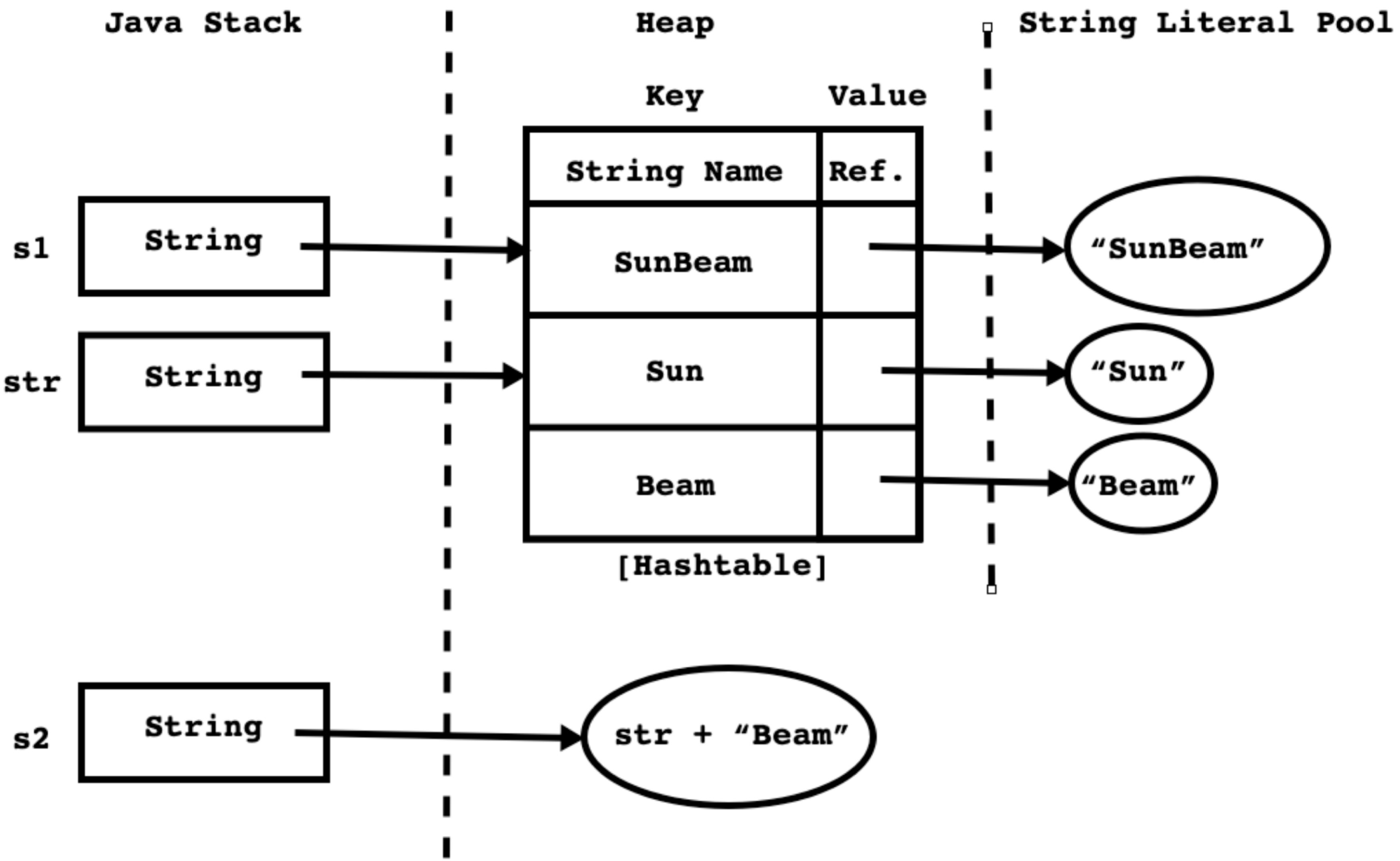
- Constant expression gets evaluated at compile time.
  - "int result = 2 + 3;" becomes "int result = 5;" at compile time
  - "String s2 = "Sun"+"Beam";" becomes "String s2="SunBeam";" at compile time.



String Twister

```java
public class Program {
   public static void main(String[] args) {
      String s1 = "SunBeam";
      String str = "Sun";
      String s2 = str + "Beam";
      if( s1 == s2 )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Not Equal
   }
}
```

String Twister



String Twister

```
public class Program {
    public static void main(String[] args) {
        String s1 = "SunBeam";
        String str = "Sun";
        String s2 = ( str + "Beam" ).intern();
        if( s1 == s2 )
            System.out.println("Equal");
        else
            System.out.println("Not Equal");
        //Output : Equal
    }
}
```

String Twister

```java
package p1;
public class A {
    public static final String str = "Hello";
}
```

```java
package test;
class B {
    public static final String str = "Hello";
}
```

```java
package test;
public class Program {
    public static final String str = "Hello";
    public static void main(String[] args) {
        String str = "Hello";
    }
}
```

String Twister

```
public class Program {
   public static final String str = "Hello";
   public static void main(String[] args) {
      String str = "Hello";
      System.out.println(A.str == B.str);          //true
      System.out.println(A.str == Program.str);  //true
      System.out.println(A.str == str);         //true
      System.out.println(B.str == Program.str);  //true
      System.out.println(B.str == str);         //true
      System.out.println(Program.str == str);    //true
   }
}
```

String Twister

```
public class Program {
   public static void main(String[] args) {
      String str = "SunBeam";
      //char ch = str.charAt( 0 );   //S
      //char ch = str.charAt( 6 );   //m
      //char ch = str.charAt(-1); //StringIndexOutOfBoundsException
      char ch = str.charAt( str.length() ); //StringIndexOutOfBoundsException
      System.out.println(ch);
   }
}
```

StringBuffer versus StringBuilder

- StringBuffer and StringBuilder are final classes.
- It is declared in java.lang package.
- It is used create to mutable string instance.
- equals() and hashCode() method is not overridden inside it.
- We can create instances of these classes using new operator only.
- Instances get space on Heap.
- **StringBuffer implementation is thread safe whereas StringBuilder is not.**
- **StringBuffer is introduced in JDK1.0and StringBuilder is introduced in JDK 1.5.**

StringBuffer Twister

```
public class Program {
   public static void main(String[] args) {
      StringBuffer s1 = new StringBuffer("SunBeam");
      StringBuffer s2 = new StringBuffer("SunBeam");
      if( s1 == s2 )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Not Equal
   }
}
```

StringBuffer Twister

```java
public class Program {
   public static void main(String[] args) {
      StringBuffer s1 = new StringBuffer("SunBeam");
      StringBuffer s2 = new StringBuffer("SunBeam");
      if( s1.equals(s2) )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Not Equal
   }
}
```

StringBuffer Twister

```
public class Program {
   public static void main(String[] args) {
      String s1 = new String("SunBeam");
      StringBuffer s2 = new StringBuffer("SunBeam");
      if( s1 == s2 )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Compiler Error
   }
}
```

StringBuffer Twister

```java
public class Program {
   public static void main(String[] args) {
      String s1 = new String("SunBeam");
      StringBuffer s2 = new StringBuffer("SunBeam");
      if( s1.equals(s2) )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Not Equal
   }
}
```

StringBuffer Twister

```
public class Program {
   public static void main(String[] args) {
      StringBuffer s1 = new StringBuffer("SunBeam");
      String s2 = new String("SunBeam");
      if( s1.equals(s2) )
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Not Equal
   }
}
```

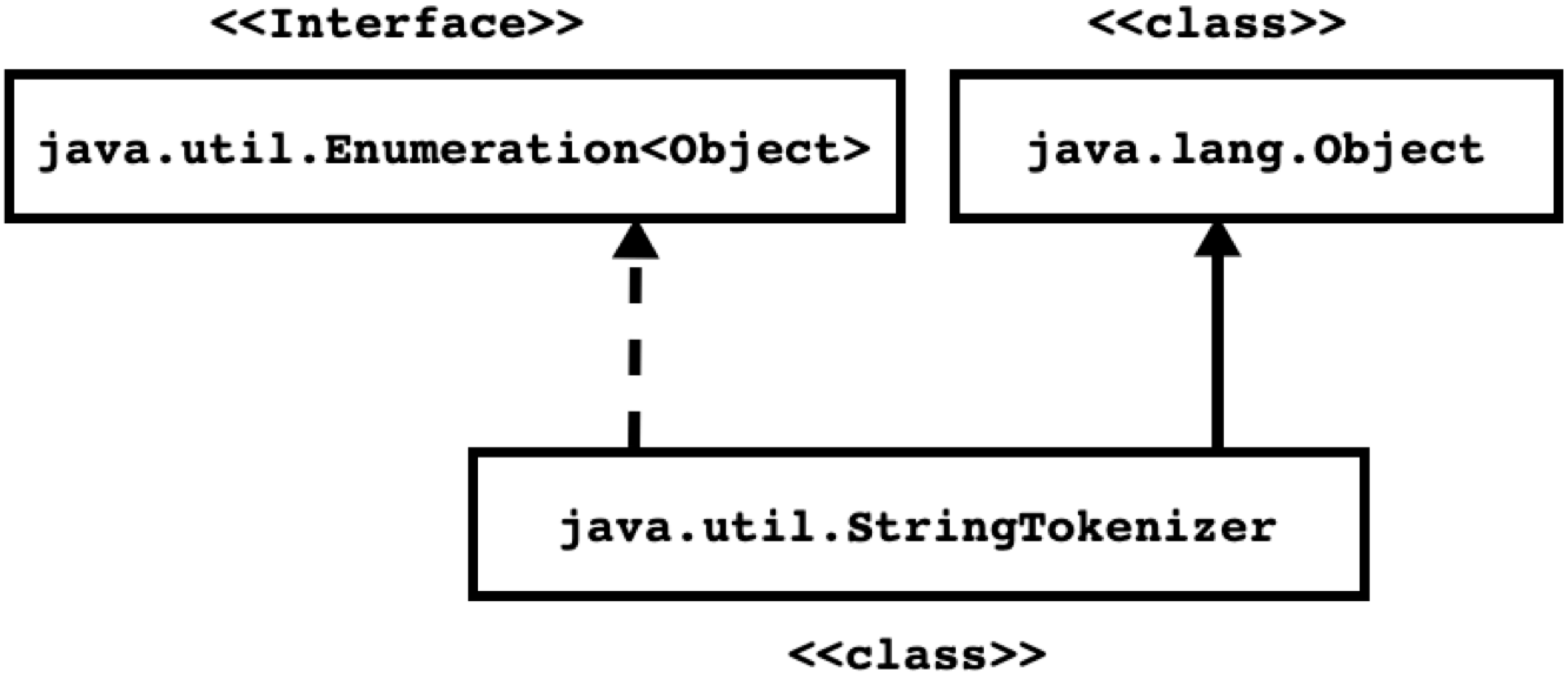
StringBuilder Twister

```java
public class Program {
   public static void main(String[] args) {
      StringBuilder s1 = new StringBuilder("SunBeam");
      StringBuilder s2 = new StringBuilder("SunBeam");
      if( s1 ==  s2)
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Not Equal
   }
}
```

StringBuilder Twister

```java
public class Program {
   public static void main(String[] args) {
      StringBuilder s1 = new StringBuilder("SunBeam");
      StringBuilder s2 = new StringBuilder("SunBeam");
      if( s1.equals(s2))
         System.out.println("Equal");
      else
         System.out.println("Not Equal");
      //Output : Not Equal
   }
}
```

StringTokenizer



StringTokenizer

- The string tokenizer class allows an application to break a string into tokens.
- Methods of java.util.Enumeration<E> interface
    1. boolean hasMoreElements( )
    2. E nextElement()
- Methods of java.util.StringTokenizer class
    1. public int countTokens()
    2. public boolean hasMoreTokens()
    3. public String nextToken()
    4. public String nextToken(String delim)

StringTokenizer

```
public class Program {
    public static void main(String[] args) {
        String str = "SunBeam Infotech Pune";
        StringTokenizer stk = new StringTokenizer(str);
        String token = null;
        while( stk.hasMoreTokens()) {
            token = stk.nextToken();
            System.out.println(token);
        }
    }
}
```

```
Output
________
SunBeam
Infotech
Pune
```

StringTokenizer

```
public class Program {
   public static void main(String[] args) {
      String str = "www.sunbeaminfo.com";
      String delim = ".";
      StringTokenizer stk = new StringTokenizer(str, delim);
      String token = null;
      while( stk.hasMoreTokens()) {
         token = stk.nextToken();
         System.out.println(token);
      }
   }
```

```
Output
-------------
www
sunbeaminfo
com
```

StringTokenizer

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

public class Day6_5
{
    static Scanner sc = new Scanner(System.in);
    public static void main(String[] args)
    {
        String str = "https://admission.sunbeaminfo.com/aspx/RegistrationForm.aspx?BatchID=J8BwSw7MbJHgHVtHZgIUlA==";

        String delim = "/:-=.//#";
        StringTokenizer stk = new StringTokenizer(str, delim, true);

        String token  = null;
        while( stk.hasMoreTokens()) {
            token = stk.nextToken();
            System.out.println(token);
    }
}
}
```

OUTPUT

https
:
/
/
admission
.
sunbeaminfo
.
com
/
aspx
/
RegistrationForm
.
aspx?BatchID
=
J8BwSw7MbJHgHVtHZgIUlA
=
=

Pattern and Matcher

- Java.util.regex.Pattern and Matcher Classes are used for matching character sequences against patterns specified by regular expressions.
- An instance of the Pattern class represents a regular expression that is specified in string form in a syntax similar to that used by Perl.
- Instances of the Matcher class are used to match character sequences against a given pattern.

```
Pattern p = Pattern.compile( regex );
Matcher m = p.matcher( input );
boolean b = m.matches();

//or

boolean b = Pattern.matches(regex, input);
```

Upcasting

When the reference variable of super class refers to the object of subclass, it is known as widening or **upcasting in java**.

when subclass object type is converted into superclass type, it is called widening or upcasting.

Superclass s = new SubClass();

Up casting : *Assigning child class object to parent class reference .*
Syntax for up casting : **Parent p = new Child();**
Here **p** is a parent class reference but point to the child object. *This reference p can access all the methods and variables of parent class but only overridden methods in child class.*

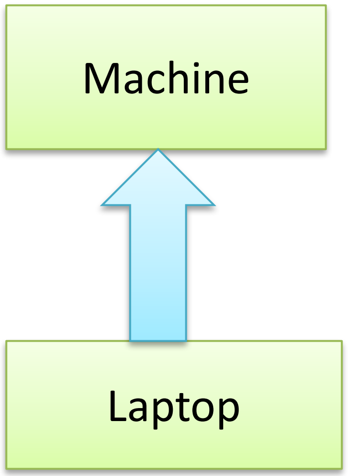
Upcasting gives us the flexibility to access the parent class members, but it is not possible to access all the child class members using this feature. Instead of all the members, we can access some specified members of the child class. For instance, we can only access the overridden methods in the child class.

Downcasting

Down casting : *Assigning parent class reference (which is pointing to child class object) to child class reference .*

Syntax for down casting : **Child c = (Child)p;**

Here **p** is pointing to the object of child class as we saw earlier and now we cast this parent reference **p** to child class reference **c**. *Now this child class reference **c** can access all the methods and variables of child class as well as parent class.*



*For example, if we have two classes, **Machine** and **Laptop** which extends **Machine** class. Now for upcasting, every laptop will be a machine but for downcasting, every machine may not be a laptop because there may be some machines which can be **Printer**, **Mobile,** etc.*

Downcasting is not always safe, and we explicitly write the class names before doing downcasting. So that it won't give an error at compile time but it may throw **ClassCastExcpetion** at run time, if the parent class reference is not pointing to the appropriate child class.

Explanation

```
Machine machine = new Machine ();

Laptop laptop = (Laptop)machine;//this won't give an error while compiling

//laptop is a reference of type Laptop and machine is a reference of type Machine and points to Machine
class Object .So logically assigning machine to laptop is invalid because these two classes have different
object strucure.And hence throws ClassCastException at run time .
```

To remove ClassCastException we can use instanceof operator to check right type of class reference in case of down casting .

```
if(machine instanceof Laptop)
{
Laptop laptop = machine;     //here machine must be pointing to Laptop class object .
}
```

Polymorphisim

- The ability to have many different forms
- An object always has only one form
- A reference variable can refer to objects of different forms

Method Binding

Static Binding

- Static binding
- Compile time
- early binding
- Resolved by java compiler
- Achieved via method overloading

Example :

In class Test :

```
void test(int i,int j){...}
void test(int i) {..}
void test(double i){..}
void test(int i,double j,boolean flag){...}
int test(int a,int b){...}   //javac error
```

Dynamic Binding

- Dynamic binding
- Run time / Late binding
- Resolved by java runtime environment
- Achieved by method overriding (Dynamic method dispatch)
- Method Overriding is a Means of achieving run-time polymorphism

All java methods can be overridden : if they are not marked as private or static or final

Super-class form of method is called as overridden method

sub-class form of method is called as overriding form of the method

Example :

```
class A {
   A getInstance()
            {
              return new A();
            }
   }
```

```
class B extends A
{
   B getInstance()
            {
              return new B();
            }
}
```

Run time polymorphism or Dynamic method dispatch

- Super -class ref. can directly refer to sub-class object(direct=w/o type casting) as its the example of up-casting(similar to widening auto. conversion) .

- When such a super class ref is used to invoke the overriding method then the method to send for execution that decision is taken by JRE & not by compiler.
- In such case overriding form of the method(sub-class version) will be dispatched for exec.
- Javac resolves the method binding by the type of the reference & JVM resolves the method binding by type of the object it's referring to.
- Super class reference can directly refer to sub-class instance BUT it can only access the members declared in super-class directly.
- eg : A ref=new B();

  ref.show(); // this will invoke the sub-class: overriding form of the show () method

Java compiler resolves method binding by type of the reference & JVM resolves it by the type of the object, reference is referring to.

Annotation

- From JDK 1.5 onwards : Annoations are available , it is metadata meant for Compiler or JRE.(Java tools)

- Java Annotation is a tag that represents the metadata i.e. attached with class, interface, methods or fields to indicate some additional information which can be used by java compiler and JVM.

- Annotations in java are used to provide additional information, so it is an alternative option for XML.

- eg @Override,@Deprecated,@SuppressWarnings,@FunctionalInterface

- @Override
- It is an annotation meant for javac.
- It's Method level annotation ,that appears in a sub class
- It's Optional BUT recommended.
- While overriding the method if you want to inform the compiler that : following is the overriding form of the method use :
- @Override
- method declaration {...}

Nested Class

- In Java, we can define class inside scope of another class. It is called nested class.
- Nested class represents encapsulation.

```
//Top-Level class
class Outer{    //Outer.class
    //Nested class
    class Inner{    //Outer$Inner.class
      //TODO
    }
}
```

- Access modifier of top level class can be either package level private or public only.
- We can use any access modifier on nested class.
- Types of nested class:
    1. Non static nested class / Inner class
    2. Static nested class

Non Static Nested Class

- Non static nested class is also called as inner class.
- If implementation of nested class depends on implementation of top level class then nested class should be non static.
- **Implementation Hint** : For the simplicity, consider non static nested class as non static method of class.

`class Outer{` `    public class Inner{` `        //TODO` `    }` `}`	Instantiation of top level class: `Outer out = new Outer( );`
* Instantiation of top level class: - method 1 `Outer out = new Outer( );` `Outer.Inner in = out.new Inner( );`	- method 2 `Outer.Inner in = new Outer( ).new Inner( );`

Non Static Nested Class

- Top level class can contain static as well as non static members.
- Inside non static nested class we can not declare static members.
- If we want to declare any field static then it must be final.
- Using instance, we can access members of non static nested class inside method of top level class.
- Without instance, we can use all the members of top level class inside method of non static nested class.
- But if we want refer member of top level class, inside method of non static nested class then we should use "TopLevelClassName.this" syntax.

Non Static Nested Class

```
class Outer{
    private int num1 = 10;

    public class Inner{
        private int num1 = 20;

        public void print( ) {
            int num1 = 30;
            System.out.println("Num1     :    "+Outer.this.num1); //10
            System.out.println("Num1     :    "+this.num1);    //20
            System.out.println("Num1     :    "+num1);    //30
        }
    }
}
public class Program {
    public static void main(String[] args) {
        Outer.Inner in = new Outer().new Inner();
        in.print();
    }
}
```

Static Nested Class

- If we declare nested class static then it is simply called as static nested class.
- We can declare nested class static but we can not declare top level class static.
- If implementation of nested class do not depends on implementation of top level class then we should declare nested class static.
- **Implementation hint:** For simplicity consider static nested class as a static method of a class.

```
class Outer{
    public static class Inner{
        //TODO
    }
}
```

```
* Instantiation of top level class:
Outer out = new Outer( );

* Instantiation of static nested class:
Outer.Inner in = new Outer.Inner();
```

Static Nested Class

- Static nested class can contain static members.

- Using instance, we can access all the members of static nested class inside method of top level class.

- If we want to use non static members of top level class inside method of static nested class then it is mandatory to create instance of top level class.

Nested Class

```
class LinkedList implements Iterable<Integer>{
    static class Node{
        //TODO
    }
    //TODO
    class LinkedListIterator implements Iterator<Integer>{
        //TODO
    }
}
```

Local Class

- In Java, we can define class inside scope of another method. It is called local class / method local class.

- Types of local class:
    1. Method local inner class
    2. Method local anonymous inner class.

Method Local Inner Class

- In Java, we can not declare local variable /class static hence local class is also called as local inner class.
- We can not use reference/instance of method local class outside method.

```
public class Program {  //Program.class
    public static void main(String[] args) {
        class Complex{  //Program$1Complex.class
            private int real = 10;
            private int imag = 20;
            public void print( ) {
                System.out.println("Real Number :   "+this.real);
                System.out.println("Imag Number :   "+this.imag);
            }
        }
        Complex c1 = new Complex();
        c1.print();
    }
}
```

Method local anonymous innerclass.

- In java, we can create instance without reference. It is called anonymous instance.
- Example:
- `new Object( );`
- We can define a class without name. It is called anonymous class.
- If we want to define anonymous class then we should use new operator.
- We can create anonymous class inside method only hence it is also called as method local anonymous class.
- We can not declare local class static hence it is also called as method local anonymous inner class.
- To define anonymous class, we need to take help of existing interface / abstract class / concrete class.

Method local anonymous inner class.

- Consider anonymous inner class using concrete class.

```
public static void main(String[] args) {
    //Object obj;   //obj => reference
    //new Object( );    // new Object( ) => Anonymous instance
    //Object obj = new Object( );//Instance with reference
    Object obj = new Object( ) {     //Program$1.class
        private String message = "Hello";
        @Override
        public String toString() {
            return this.message;
        }
    };
    String str = obj.toString();
    System.out.println(str);
}
```

Method local anonymous inner class.

- Consider anonymous inner class using abstract class:

```java
abstract class Shape{
    protected double area;
    public abstract void calculateArea( );
    public double getArea() {
        return area;
    }
}
```

```java
public class Program {
    public static void main(String[] args) {
        Shape sh = new Shape() {
            private double radius = 10;
            @Override
            public void calculateArea() {
                this.area = Math.PI * Math.pow(this.radius, 2);
            }
        };

        sh.calculateArea();
        System.out.println("Area    :    "+sh.getArea());
    }
}
```

Method local anonymous inner class.

- Consider anonymous inner class using interface.

```
interface Printable{
    void print( );
}
```

```
public class Program {
    public static void main(String[] args) {
        Printable p = new Printable() {
            @Override
            public void print() {
                System.out.println("Hello");
            }
        };
        p.print();
    }
}
```

Interface

Interface

- In Java, an **interface** is a blueprint or template of a class. It is much similar to the Java class but the only difference is that it has abstract methods and static constants.
- An interface provides specifications of what a class should do or not and how it should do. An interface in Java basically has a set of methods that class may or may not apply.
- It also has capabilities to perform a function. The methods in interfaces do not contain any body.
- An interface in Java is a mechanism which we mainly use to achieve abstraction and multiple inheritances in Java.
- An interface provides a set of specifications that other classes must implement.
- We can implement multiple Java Interfaces by a Java class. All methods of an interface are implicitly public and abstract. The word abstract means these methods have no method body, only method signature.
- Java Interface also represents the IS-A relationship of inheritance between two classes.
- An interface can inherit or extend multiple interfaces.
- We can implement more than one interface in our class.

Interface Vs Class

- Unlike a class, you cannot instantiate or create an object of an interface.
- All the methods in an interface should be declared as abstract.
- An interface does not contain any constructors, but a class can.
- An interface cannot contain instance fields. It can only contain the fields that are declared as both static and final.
- An interface can not be extended or inherited by a class; it is implemented by a class.
- An interface cannot implement any class or another interface.

Syntax Interface

```
interface interface-name
{
//abstract methods
}
```

```
Interface Printable
{
int MIN = 5;
void print();
}
```

Compiler

```
Interface Printable
{
public static final int MIN = 5;
public abstract void print();
}
```

Interface

- Set of rules are called specification/standard.
- It is a contract between service consumer and service provider.
- If we want to define specification for the sub classes then we should define interface.
- Interface is non primitive type which helps developer:
    1. To build/develop trust between service provider and service consumer.
    2. To minimize vendor dependency.
- interface is a keyword in Java.

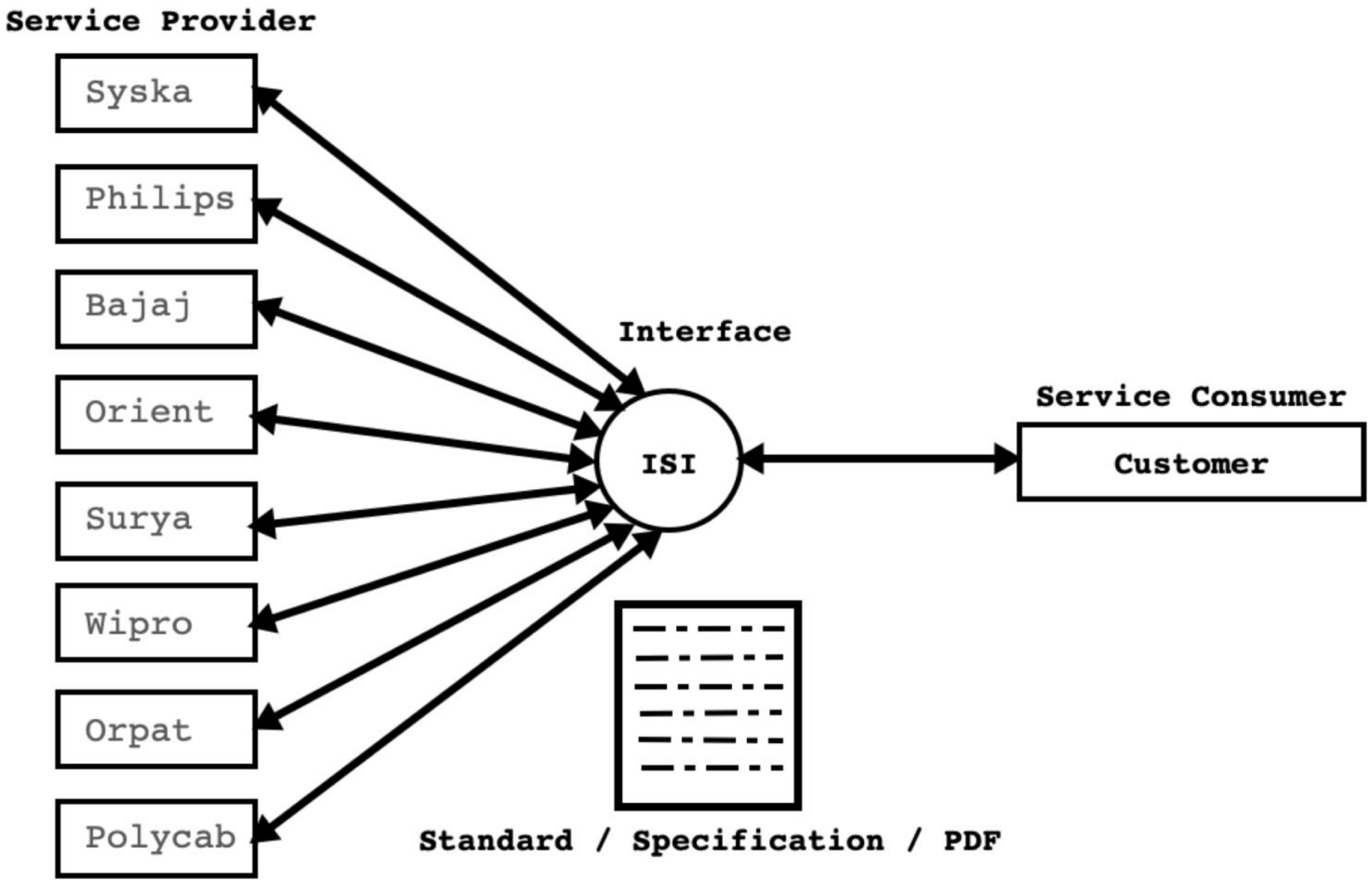
```java
interface Printable{
    //TODO
}
```

Interface

- Interface can contain:
  1. Nested interface
  2. Field
  3. Abstract method
  4. Default method
  5. Static method
- Interfaces cannot have constructors.
- We can create reference of interface but we can not create instance of interface.
- We can declare fields inside interface. Interface fields are by default public static and final.
- We can write methods inside interface. Interface methods are by default considered as public and abstract.

```
interface Printable{
    int number = 10; //public static final int number = 10;
    void print( ) ; //public abstract void print( ) ;
}
```

Interface



Service Provider
Syska
Philips
Bajaj
Orient
Surya
Wipro
Orpat
Polycab
Interface
ISI
Service Consumer
Customer
Standard / Specification / PDF

Interface

- If we want to implement rules of interface then we should use implements keyword.
- It is mandatory to override, all the abstract methods of interface otherwise sub class can be considered as abstract.

```
interface Printable{
    int number = 10;
    void print( );
}
```

```
* Solution 1
abstract class Test implements Printable{
}
```

```
* Solution 2
class Test implements Printable{
    @Override
    public void print( ){
        //TODO
    }
}
```

Interface Implementation Inheritance

```
interface Printable{
    int number = 10;
    //public static final int number = 10;
    void print( ) ;
    //public abstract void print( ) ;
}
class Test implements Printable{
    @Override
    public void print() {
        System.out.println("Number   :    "+Printable.number);
    }
}
public class Program {
    public static void main(String[] args) {
        Printable p = new Test( );  //Upcasting
        p.print();  //Dynamic Method Dispatch
    }
}
```

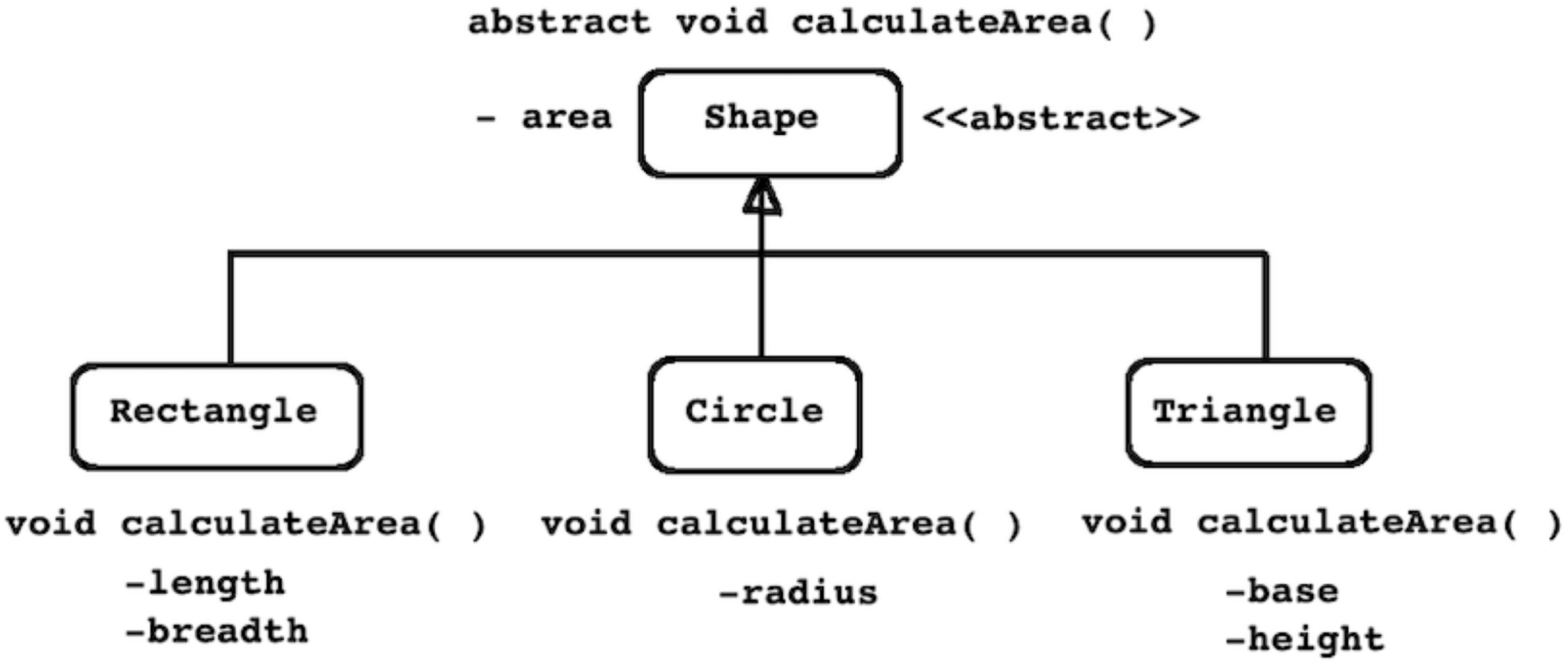
Interface Syntax

```
Interfaces     :   I1, I2, I3
Classes        :   C1, C2, C3
1. I2 implements I1                        //Not OK
2. I2 extends I1                           //OK : Interface Inheritance
3. I3 extends I1, I2                       //OK : Multiple Interface Inheritance
4. I1 extends C1                           //Not OK
5. I1 implements C1                        //Not OK
6. C1 extends I1                           //Not OK
7. C1 implements I1                        //OK : Interface implementation Inherita
8. C1 implements I1, I2                    //OK : Multiple Interface implementatio  ritance
9. C2 implements C1                        //Not OK
10. C2 extends C1                          //OK : Implementation inheritance
11. C3 extends C1, C2                      //NOT OK : Multiple Implementation inhe    e
12. C2 implements I1 extends C1            //NOT OK
13. C2 extends C1 implements I1            //OK
14. C2 extends C1 implements I1, I2, I3    //OK
```

Types of inheritance

- **Interface Inheritance**
  - During inheritance if super type and sub type is interface then it is called interface inheritance.
    1. Single Inheritance(Valid in Java)
    2. Multiple Inheritance(Valid in Java)
    3. Hierarchical Inheritance(Valid in Java)
    4. Multilevel Inheritance(Valid in Java)
- **Implementation Inheritance**
  - During inheritance if super type and sub type is class then it is called implementation inheritance.
    1. Single Inheritance(Valid in Java)
    2. Multiple Inheritance(Invalid in Java)
    3. Hierarchical Inheritance(Valid in Java)
    4. Multilevel Inheritance(Valid in Java)

Abstract Class



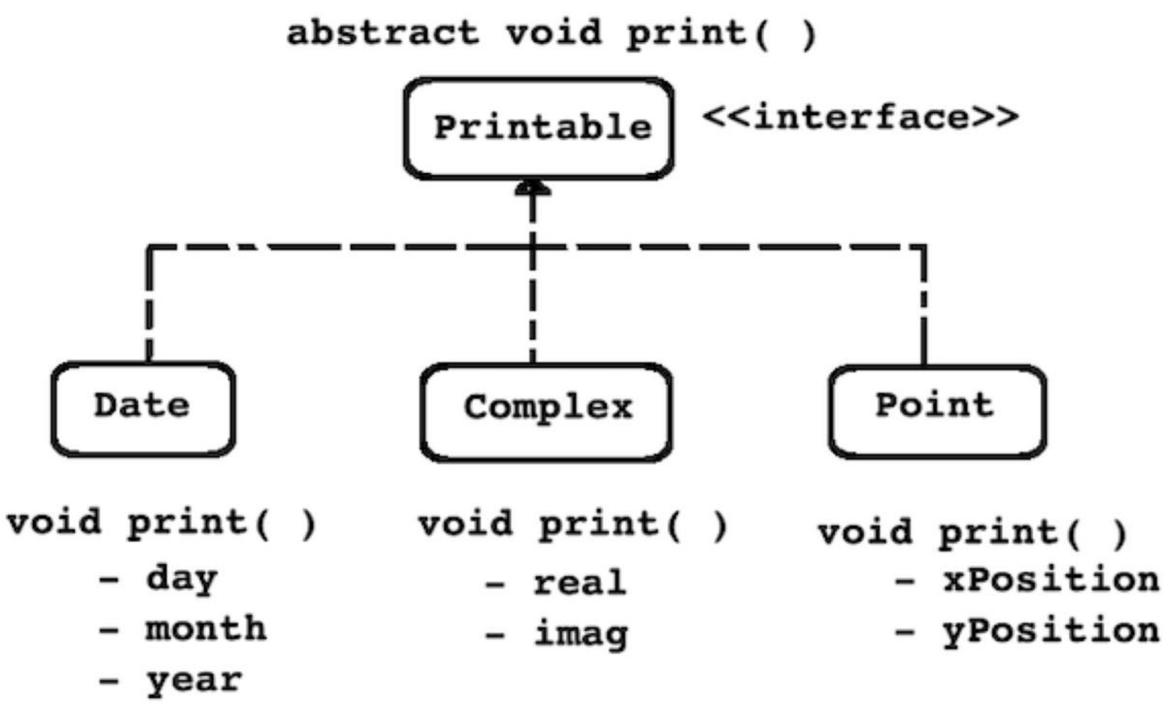

```
Shape[] arr = new Shape[ 3 ];
arr[ 0 ] = new Rectangle( ); //Upcasting
arr[ 1 ] = new Circle( ); //Upcasting
arr[ 2 ] = new Triangle( ); //Upcasting
```

Abstract Class

1. If "is-a" relationship is exist between super type and sub type and if we want same method design in all the sub types then super type must be abstract.
2. Using abstract class, we can group instances of related type together
3. Abstract class can extend only one abstract/concrete class.
4. We can define constructor inside abstract class.
5. Abstract class may or may not contain abstract method.

- **Hint** : In case of inheritance if state is involved in super type then it should be abstract.

Interface




```
Printable[] arr = new Printable[ 3 ];
arr[ 0 ] = new Date( ); //Upcasting
arr[ 1 ] = new Complex( ); //Upcasting
arr[ 2 ] = new Point( ); //Upcasting
```

Interface

1. If "is-a" relationship is not exist between super type and sub type and if we want same method design in all the sub types then super type must be interface.

2. Using interface, we can group instances of unrelated type together.

3. Interface can extend more than one interfaces.

4. We can not define constructor inside interface.

5. By default methods of interface are abstract.

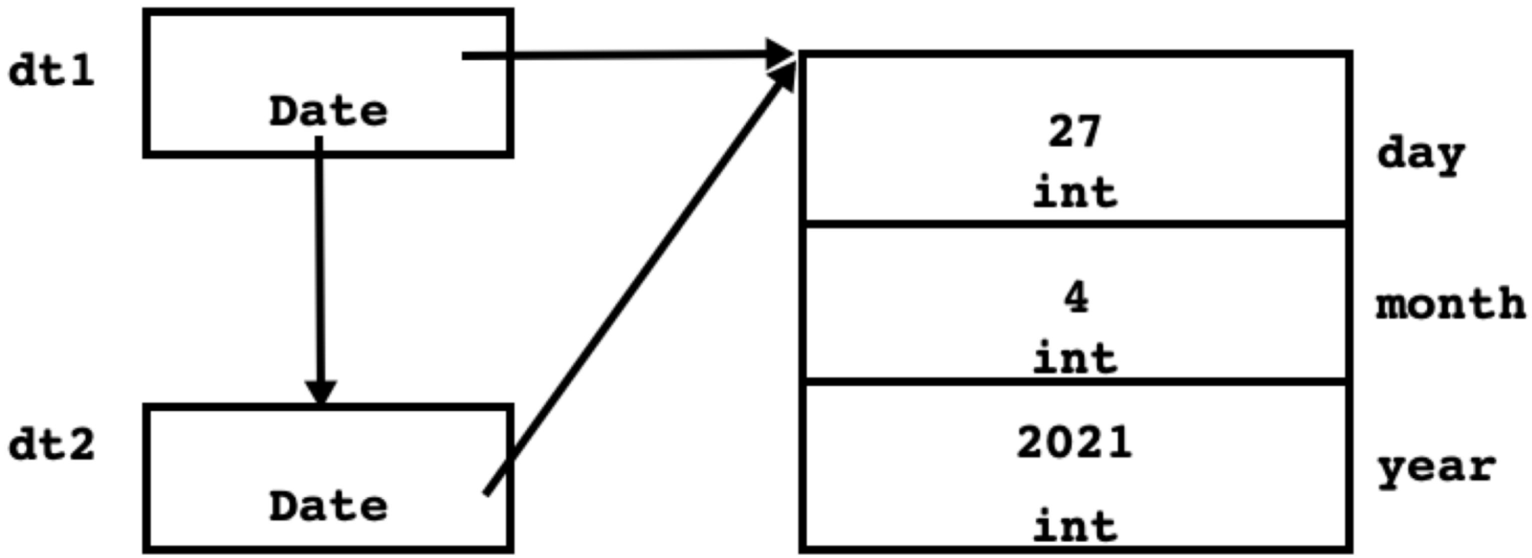
- **Hint** : In case of inheritance if state is not involved in super type then it should be interface.

Commonly Used Interfaces

1. java.lang.AutoCloseable
2. java.io.Closeable
3. java.lang.Cloneable
4. java.lang.Comparable
5. java.util.Comparator
6. java.lang.Iterable
7. java.util.Iterator
8. java.io.Serializable

Cloneable Interface Implementation

- `Date dt1 = new Date( 27, 4, 2021 );`
- `Date dt2 = dt1;  //Shallow Copy Of References`



Cloneable Interface Implementation

- If we want to create new instance from existing instance then we should use clone method.

- clone( ) is non final native method of java.lang.Object class.

- Syntax:
  - **protected native Object clone( ) throws CloneNotSupportedException**

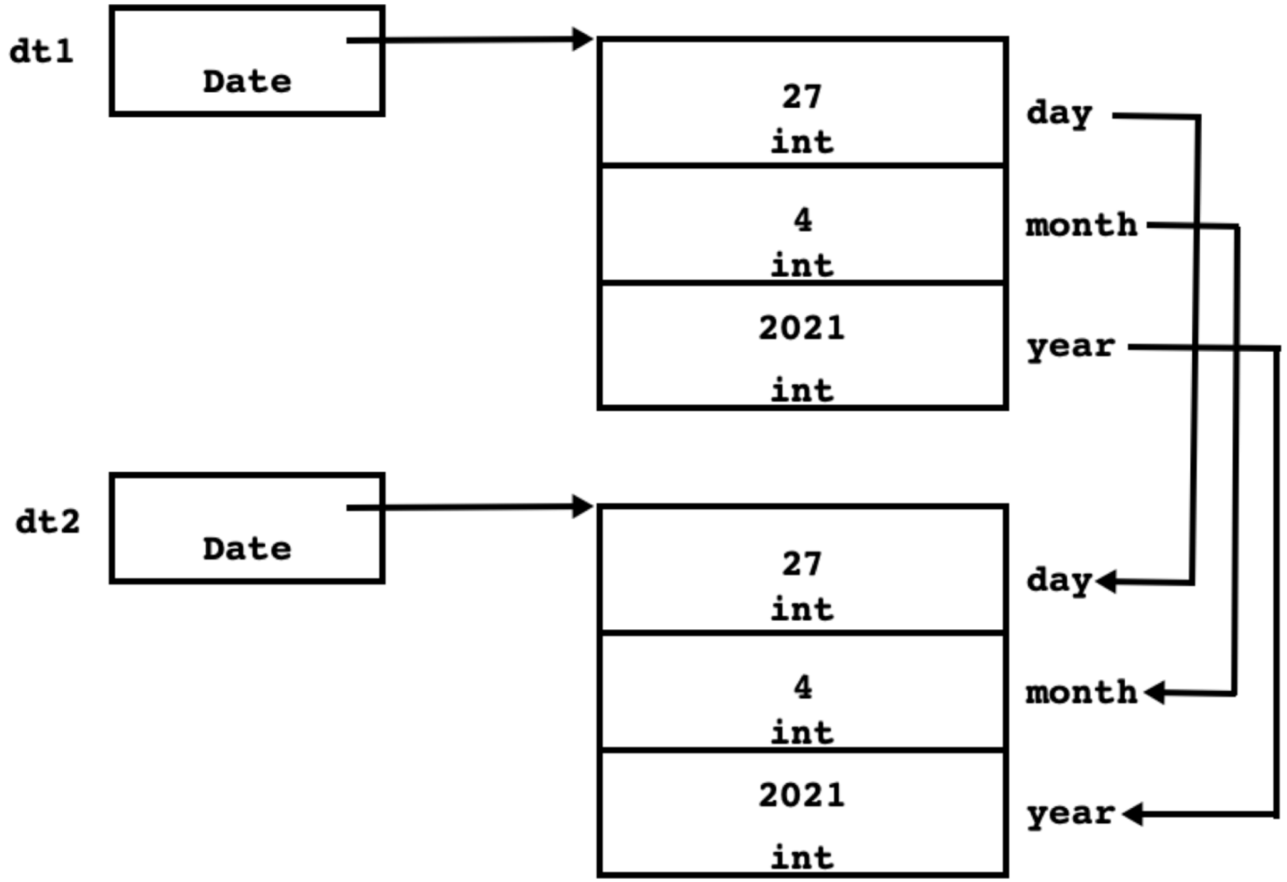
- Inside clone() method, if we want to create shallow copy instance then we should use super.clone( ) method.

- Cloneable is interface declared in java.lang package.

- Without implementing Cloneable interface, if we try to create clone of the instance then clone() method throws CloneNotSupportedException.

Cloneable Interface Implementation

- `Date dt1 = new Date( 27, 4, 2021 );`
- `Date dt2 = dt1.clone( ); //Shallow Copy Of Instance`



Marker Interface

- An interface which do not contain any member is called marker interface. In other words, empty interface is called as marker interface.
- Marker interface is also called as tagging interface.
- If we implement marker interface then Java compiler generates metadata for the JVM, which help JVM to clone/serialize or marshal state of object.
- Example:
  1. java.lang.Cloneable
  2. java.util.EventListener
  3. java.util.RandomAccess
  4. java.io.Serializable
  5. java.rmi.Remote

Comparable

- It is interface declared in java.lang package.
- **"int compareTo(T other)"** is a method of java.lang.Comparable interface.
- If state of current object is less than state of other object then compareTo() method should return negative integer(-1).
- If state of current object is greater than state of other object then compareTo() method should return positive integer(+1).
- If state of current object is equal to state of other object then compareTo() method should return zero(0).
- If we want to sort, array of non primitive type which contains all the instances of same type then we should implement Comparable interface.

Comparator

- It is interface declared in java.util package.
- **"int compare(T o1, T o2)"** is a method of java.util.Comparator interface.
- If state of current object is less than state of other object then compare() method should return negative integer(-1).
- If state of current object is greater than state of other object then compare() method should return positive integer(+1).
- If state of current object is equal to state of other object then compare() method should return zero(0).
- If we want to sort, array of instances of non primitive of different type then we should implement Comparator interface.

Iterable and Iterator Implementation

- Iterable<T> is interface declared in java.lang package.
- Implementing this interface allows an object to be the target of the "for-each loop" statement.
- It is introduced in JDK 1.5
- Methods of java.lang.Iterable interface:
    1. Iterator<T> iterator()
    2. default Spliterator<T> spliterator()
    3. default void forEach(Consumer<? super T> action)

Iterable and Iterator Implementation

- Iterator<E> is interface declared in java.util package.
- It is used to traverse collection in forward direction only.
- It is introduced in JDK 1.2
- Methods of java.util.Iterator interface:
    1. boolean hasNext()
    2. E next()
    3. default void remove()
    4. default void forEachRemaining(Consumer<? super E> action)

Iterable and Iterator Implementation

```
LinkedList<Integer> list = new LinkedList<>( );
    list.add(10);
    list.add(20);
    list.add(30);

    for( Integer e : list )
        System.out.println(e);
```

```
foreach loop implicitly work as follows
Integer element = null;
Iterator<Integer> itr = list.iterator();
while( itr.hasNext()) {
    element = itr.next();
    System.out.println(element);
}
```

Agenda

- Exception Handling

Operating System Resources

- Following are the operating system resources that we can use it in the program:

    1. Memory(RAM)
    2. File
    3. Thread
    4. Socket
    5. Connection
    6. IO Devices etc.

- Since OS resources are limited, we should handle it carefully. In other words, we should avoid their leakage.

Resource Type and resource in Java

- AutoCloseable is interface declared in java.lang package.
- Methods:
    1. void close() throws Exception
    2. This method is invoked automatically on objects managed by the try-with-resources statement.

- java.io.Closeable is sub interface of java.lang.AutoCloseable interface.
- Methods:
    1. void close() throws IOException
    2. This method is invoked automatically on objects managed by the try-with-resources statement.

Resource Type and resource in Java

```java
//Class Test => Resource Type
class Test implements AutoCloseable{
    private Scanner sc;
    public Test() {
        this.sc = new Scanner(System.in);
    }
    //TODO
    @Override
    public void close() throws Exception {
        this.sc.close();
    }
}
public class Program {
    public static void main(String[] args) {
        Test t = null;
        t = new Test( );    //Resource
    }
}
```

Resource Type and resource in Java

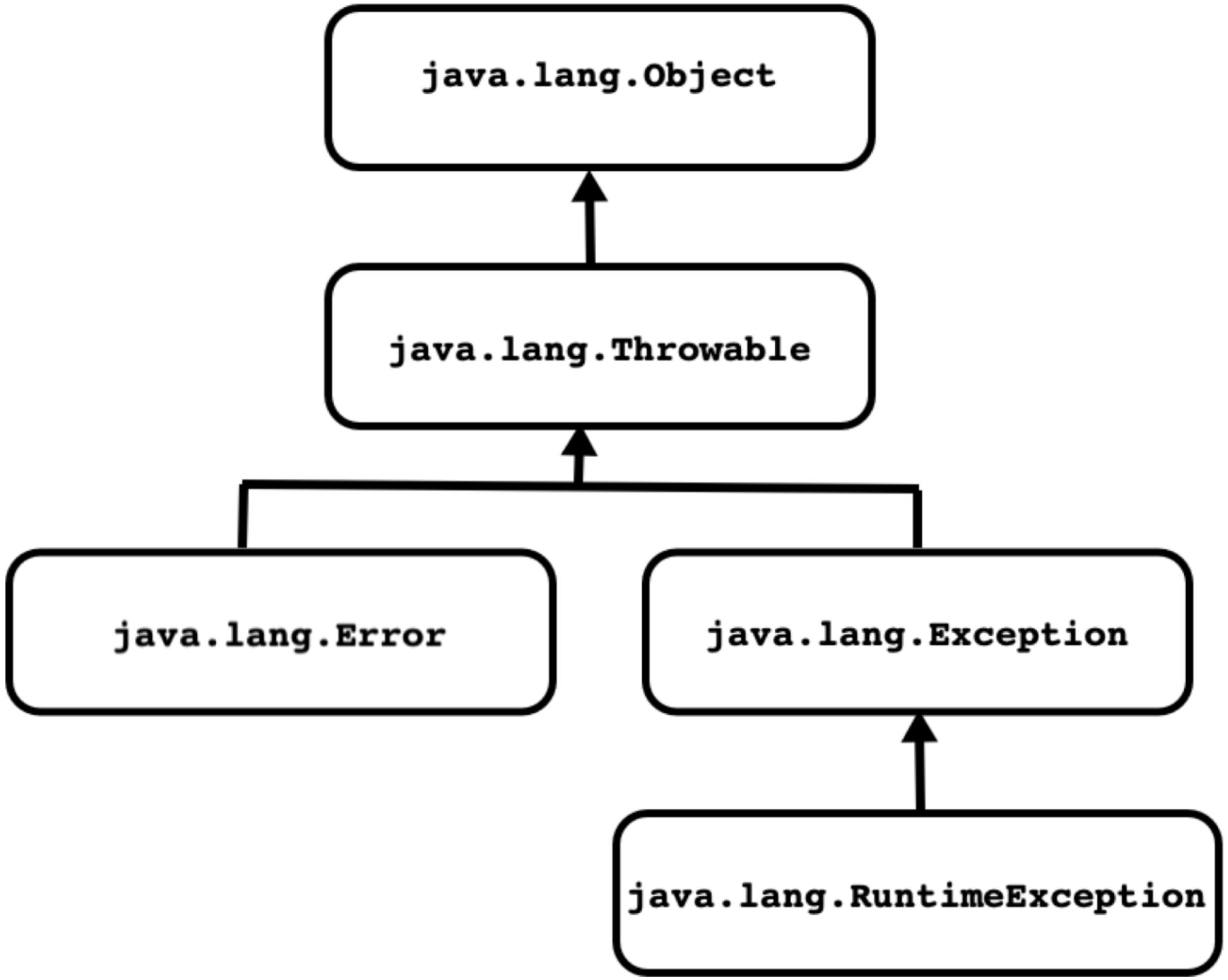
- In the context of exception handling, any class which implements java.lang.AutoCloseable or its sub interface(e.g. java.io.Closeable) is called resource type and its instance is called as resource.
- We can use instance of only resource type inside try-with-resource.
- java.util.Scanner class implements java.io.Closeable interface. Hence Scanner class is called as resource type.

Exception Handling

- **Why we should handle exception**
  1. To handle all runtime errors at single place. It helps developer to reduces maintenance.
  2. To avoid resource leakage/ to manage OS resources carefully.

- **How can we handle exception in Java?**
  1. try
  2. catch
  3. throw
  4. throws
  5. finally

Exception Handling



Throwable Class

- It is a class declared in java.lang package.
- The Throwable class is the super class of all errors and exceptions in the Java language.
- Only instances that are instances of Throwable class (or one of its subclasses) are thrown by the Java Virtual Machine or can be thrown by the Java throw statement.

```
throw 0;     //Not OK

int x = 0;
throw x;     //Not OK

class Test{
}
throw new Test( );   //Not OK

class MyExcetion extends Throwable{
}
throw new MyException();     //OK
```

Throwable Class

- Constructors of Throwable class:

```
1. public Throwable()
       Throwable t1 = new Throwable( );

2. public Throwable(String message)
       Throwable t1 = new Throwable( "exception message" );

3. public Throwable(Throwable cause)
       Throwable cause = new Throwable( );
       Throwable t1 = new Throwable( cause );

4. public Throwable(String message, Throwable cause)
       Throwable cause = new Throwable( );
       Throwable t1 = new Throwable( "exception message", cause );
```

Throwable Class

- **Methods of Throwable class:**

  1. public Throwable initCause(Throwable cause)
  2. public Throwable getCause()
  3. public String getMessage()
  4. public void printStackTrace()
  5. public void printStackTrace(PrintStream s)
  6. public void printStackTrace(PrintWriter s)

Error

- java.lang.Error is a sub class of Throwable class.

- It gets generated due to environmental condition/Runtime environment(For Example, problem in RAM/JVM, Crashing HDD etc.).

- We can not recover from error hence we should not try to catch error. But can write try-catch block to handle error.

- Example:
  1. VirtualMachineError
  2. OutOfMemoryError
  3. InternalError
  4. StackOverflowError

Exception

- java.lang.Exception is a sub class of Throwable class.
- It gets generated due to application.
- We can recover from exception hence it is recommended to write try-catch block to handle exception in Java.
- Example:
    1. NumberFormatException
    2. NullPointerException
    3. NegativeArraySizeException
    4. ArrayIndexOutOfBoundsException
    5. ArrayStoreException
    6. IllegalArgumentException
    7. ClassCastException

Types Of Exception

- **Unchecked Exception**
  - java.lang.RuntimeException and all its sub classes are considered as unchecked exception.
  - **It is not mandatory to handle unchecked exception.**
  - Example:
    1. NullPointerException
    2. ClassCastException
    3. ArrayIndexOutOfBoundsException
  - During the execution of arithmetic operation, if any exceptional situation occurs then JVM throws ArithmeticException.
- **Checked Exception**
  - java.lang.Exception and all its sub classes except java.lang.RuntimeException are considered as checked exception.
  - **It is mandatory to handle checked exception.**
  - Example:
    1. java.lang.CloneNotSupportedException
    2. java.lang.InterruptedException

Exception Handling

- **try**
  - It is a keyword in Java.
  - If we want to keep watch on statements for the exception then we should put all such statements inside try block/handler.
  - try block must have at least one:
    1. catch block or
    2. finally block or
    3. Resource
  - We can not define try block after catch or finally block.

Exception Handling

- **Catch**
  - It is a keyword in Java.
  - If we want to handle exception then we should use catch block/handler
  - Only Throwable class or one of its subclasses can be the argument type in a catch clause.
  - Catch block can handle exception thrown from try block only.
  - For single try block we can define multiple catch block.
  - Multi-catch block allows us to handle multiple specific exception inside single catch block.

```
try {
    //TODO
}catch (ArithmeticException | InputMismatchException e) {
   e.printStackTrace( );
}
```

Exception Handling

```
Let us consider hierarchy of ArithmeticException  class:
    - java.lang.Exception
        - java.lang.RuntimeException
            - java.lang.ArithmeticException

ArithmeticException e1 = new ArithmeticException( );     //OK
RuntimeException e2 = new ArithmeticException( );    //OK : Upcasting
Exception e3 = new ArithmeticException( );    //OK : Upcasting
```

```
Let us consider hierarchy of InterruptedException class:
    - java.lang.Exception
        - java.lang.InterruptedException

InterruptedException e1 = new InterruptedException( );
Exception e2 =  new InterruptedException( ); //OK : Upcasting
```

Exception Handling

- A catch block, which can handle all type of exception is called generic catch block.
- Exception class reference variable can contain reference of instance of any checked as well as unchecked exception. Hence to write generic catch block, we should use java.lang.Exception class.

```
try{

}catch( Exception ex ){ //Generic catch block
    ex.printStackTrace( );
}
```

Exception Handling

- In case of hierarchy, It is necessary to handle all sub type of exception first.

```
try {
    //TODO
}catch (ArithmeticException e) {
    e.printStackTrace();
}catch (RuntimeException e) {
    e.printStackTrace();
}catch (Exception e) {
    e.printStackTrace();
}
```

Exception Handling

- **throw**
  - It is a keyword in Java.
  - If we want to generate new exception then we should use throw keyword.
  - Only objects that are instances of Throwable class (or one of its subclasses) are thrown by the Java Virtual Machine or can be thrown by the Java throw statement.
  - throw statement is a jump statement.

Exception Handling

- **finally**
  - It is a keyword in Java.
  - If we want to release local resources then we should use finally block.
  - We can not define finally block before try and catch block.
  - Try block may have only one finally block.
  - JVM always execute finally block.
  - If we call System.exit(0) inside try block and catch block then JVM do not execute finally block.

Exception Handling

- **throws**
  - It is a keyword in Java.
  - If we want to redirect/delegate exception from one method to another then we should use throws clause.
  - Consider declaration of following methods:
    1. public static int parseInt(String s) throws NumberFormatException
    2. public static void sleep(long millis) throws InterruptedException

Exception Handling

- **try-with-resources**
  - The try-with-resources statement is a try statement that declares one or more resources.
  - A is an object that must be closed after the program is finished with it.
  - The try-with-resources statement ensures that each resource is closed at the end of the statement.
  - Any object that implements java.lang.AutoCloseable, which includes all objects which implement java.io.Closeable, can be used as a resource.

```
public static String readFirstLineFromFile(String path) throws IOException {
    try (BufferedReader br = new BufferedReader(new FileReader(path))) {
        return br.readLine();
    }
}
```

Custom Exception

- JVM can not understand, exceptional situations/conditions of business logic. If we want to handle such exceptional conditions then we should use custom exceptions.

Custom unchecked exception

```
class StackOverflowException extends RuntimeException{
    //TODO
}
```

Custom checked exception

```
class StackOverflowException extends Exception{
    //TODO
}
```

Agenda

- Boxing
- UnBoxing
- Generic programming using Object class
- Wrapper class hierarchy(Revision)
- Generic Programming Using Generics
- Why Generics
- Type Parameters
- Bounded Type Parameter
- Wild Card
- Generic Method
- Restrictions on generics.

Generic Programming

- If we want to write generic code in Java then we can use:
  1. java.lang.Object class
  2. Generics
- Generic Programming using java.lang.Object class.

```
class Box{
    private Object object;
    public Object getObject() {
        return object;
    }
    public void setObject(Object object) {
        this.object = object;
    }
}
```

Generic Programming(Using Object class)

```java
public static void main(String[] args) {
    Box b1 = new Box( );
    b1.setObject(123);  //b1.setObject(Integer.valueOf(123));
    Integer n1 = (Integer) b1.getObject();  //Downcasting
    int n2 = n1.intValue();
}
```

```java
public static void main2(String[] args) {
    Box b1 = new Box( );
    b1.setObject( new Date());
    Date date = (Date) b1.getObject();  //Downcasting
    System.out.println(date.toString());
}
```

```java
public static void main(String[] args) {
    Box b1 = new Box( );
    b1.setObject( new Date() );
    String str =  (String) b1.getObject(); //Downcasting : ClassCastException
}
```

- Using java.lang.Object class, we can write generic code but we can not write type-safe generic code.
- If we want to write type safe generic code then we should use generics.

Generic Programming(Using Generics)

```
class Box<T>{    //T : Type Parameter
    private T object;
    public T getObject() {
        return object;
    }
    public void setObject(T object) {
        this.object = object;
    }
}
```

```
Box<Date> b1 = new Box<Date>( );    //Date : Type Argument

Box<Date> b1 = new Box<>( ); //Type Inference
```

- By passing, data type as a argument, we can write generic code in Java. Hence parameterized class/type is called as generics.
- If we specify type argument during declaration of reference variable then specifying type argument during instance creation is optional. It is also called as type inference.

Generic Programming(Using Generics)

```
1. Box<String> b1 = new Box<String>( ); //OK

2. Box<String> b2 = new Box<>( ); //OK

3. Box<Object> b3 = new Box<String>( ); //NOT OK

4. Box<Object> b4 = new Box<Object>( ); //OK
```

Generic Programming(Using Generics)

- If we instantiate parameterized type without type argument then java.lang.Object is considered as default type argument.

```
Box b1 = new Box( );     //Class Box : Raw Type
//Box<Object> b1 = new Box<>( );
```

- If we instantiate parameterized type without type argument then parameterized type is called raw type.

- During the instantiation of parameterized class, type argument must be reference type.

```
//Box<int> b1 = new Box< >( );  //Not OK
Box<Integer> b1 = new Box< >( );    //OK
```

Why Generics?

1. It gives us stronger type checking at compile time. In other words, we can write type safe code.
2. No need of explicit type casting.
3. We can implement generic data structure and algorithm.

Syntax -- similar to c++ templates (angle brackets)
eg : ArrayList<Emp> , HashMap<Integer,Account> .....
1. Syntax is different than C++ for nested collections only.

A generic class means that the class declaration includes a type parameter.

```
Eg :  class MyGeneric<T>
{
 private T ref;
}
Eg. class MyGeneric<T,U> {...}
T ,U ---type  --- ref type
 ArrayList<Emp>
```

Type Parameters Used In Java API

1. T : Type
2. N : Number
3. E : Element
4. K : Key
5. V : Value
6. S, U : Second Type Parameter Names

Bounded Type Parameter

- If we want to put restriction on data type that can be used as type argument then we should specify bounded type parameter.

```
class Box<T extends Number>{     //T is bounded type parameter
    private T object;
    public T getObject() {
        return object;
    }
    public void setObject(T object) {
        this.object = object;
    }
}
```

- Specifying bounded type parameter is a job of class implementor.

Bounded Type Parameter

```
1. Box<Number> b1 = new Box<>();       //OK

2. Box<Boolean> b2 = new Box<>();      //Not OK

3. Box<Character> b3 = new Box<>();    //Not OK

4. Box<String> b4 = new Box<>();       //Not OK

5. Box<Integer> b5 = new Box<>();      //OK

6. Box<Double> b6 = new Box<>();       //OK

7. Box<Date> b7 = new Box<>();         //Not OK
```

Wild Card

- In generics "?" is called as wild card which represents unknown type.

- **Types of wild card:**
  1. Unbounded wild card
  2. Upper bounded wild card
  3. Lower bounded wilds card

Unbounded Wild Card

```java
private static void printRecord(ArrayList<?> list) {
    for (Object element : list) {
        System.out.println(element);
    }
}
```

- In above code, list will contain reference of ArrayList which can contain any type of element.

```java
public static void main(String[] args) {
    ArrayList<Integer> integerList = Program.getIntegerList();
    Program.printRecord( integerList ); //OK

    ArrayList<Double> doubleList = Program.getDoubleList();
    Program.printRecord( doubleList );  //OK

    ArrayList<String> stringList = Program.getStringList();
    Program.printRecord( stringList );  //OK
}
```

Upper Bounded Wild Card

```
private static void printRecord(ArrayList<? extends Number > list) {
    for (Object element : list) {
        System.out.println(element);
    }
}
```

- In above code, list will contain reference of ArrayList which can contain Number and its sub type of elements.

```
public static void main(String[] args) {
    ArrayList<Integer> integerList = Program.getIntegerList();
    Program.printRecord( integerList ); //OK

    ArrayList<Double> doubleList = Program.getDoubleList();
    Program.printRecord( doubleList );  //OK

    ArrayList<String> stringList = Program.getStringList();
    Program.printRecord( stringList );  //Not OK
}
```

Lower Bounded Wild Card

```
private static void printRecord(ArrayList< ? super Integer > list) {
    for (Object element : list) {
        System.out.println(element);
    }
}
```

- In above code, list will contain reference of ArrayList which can contain Integer and its super type of elements.

```
public static void main(String[] args) {
    ArrayList<Integer> integerList = Program.getIntegerList();
    Program.printRecord( integerList ); //OK

    ArrayList<Double> doubleList = Program.getDoubleList();
    Program.printRecord( doubleList );  //NOT OK

    ArrayList<String> stringList = Program.getStringList();
    Program.printRecord( stringList );  //NOT OK
}
```

Generic Method

```
private static <T> void print( T obj ) {
   System.out.println(obj);
}

private static <T extends Number> void print( T obj ) {
     System.out.println(obj);
}
```

Restrictions on Generics

1. Cannot Instantiate Generic Types with Primitive Types
2. Cannot Create Instances of Type Parameters
3. Cannot Declare Static Fields Whose Types are Type Parameters
4. Cannot Use Casts or instanceof with Parameterized Types
5. Cannot Create Arrays of Parameterized Types
6. Cannot Create, Catch, or Throw Objects of Parameterized Types
7. Cannot Overload a Method Where the Formal Parameter Types of Each Overload Erase to the Same Raw Type

Collection Framework

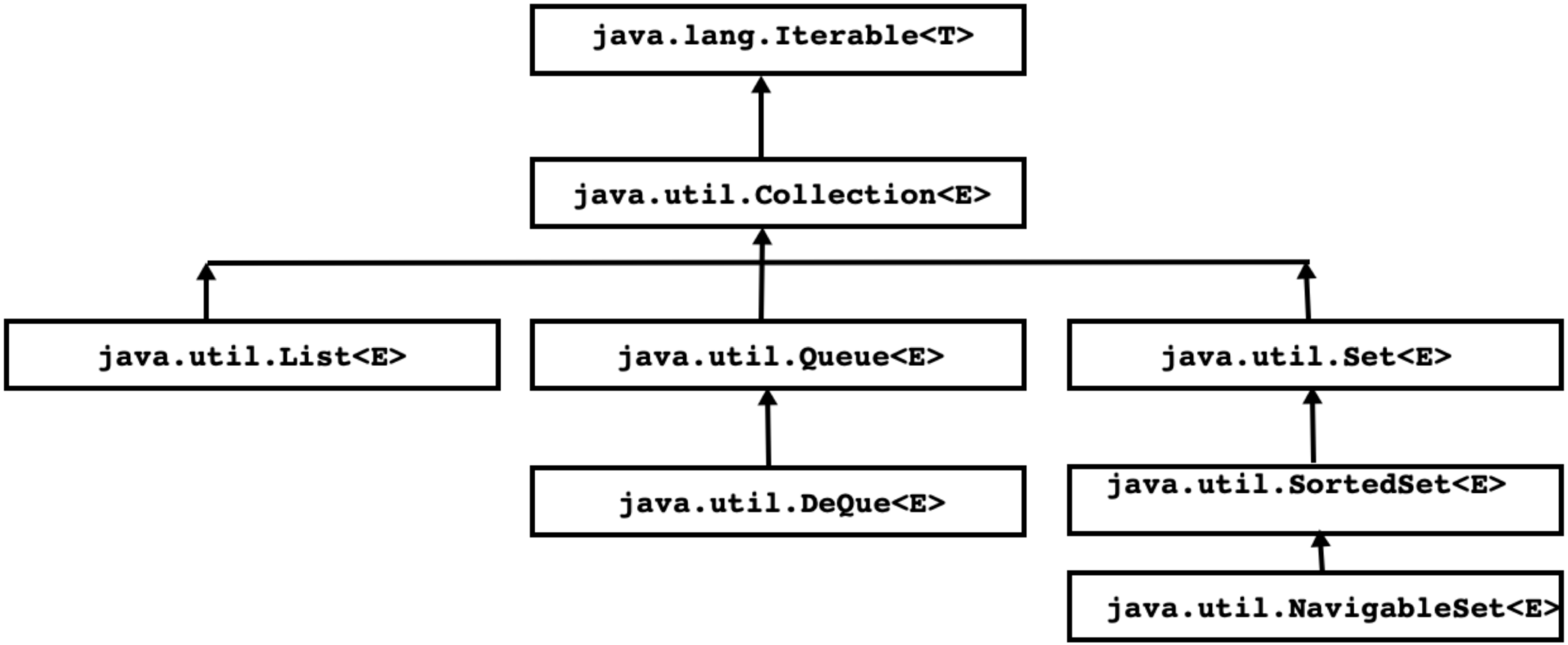
Collection Framework

- Every value/data stored in data structure is called element.
- A group of data (Object reference) handled as a single unit.
- Framework is library of reusable classes/interfaces that is used to develop application.
- **Library of reusable data structure classes that is used to develop java application is called collection framework.**
- Main purpose of collection framework is to manage data in RAM efficiently.
- Consider following Example:
    1. Person has-a birthdate
    2. Employee is a person
- In java, collection instance do not contain instances rather it contains reference of instances.
- If we want to use collection framework them we should **import java.util** package.

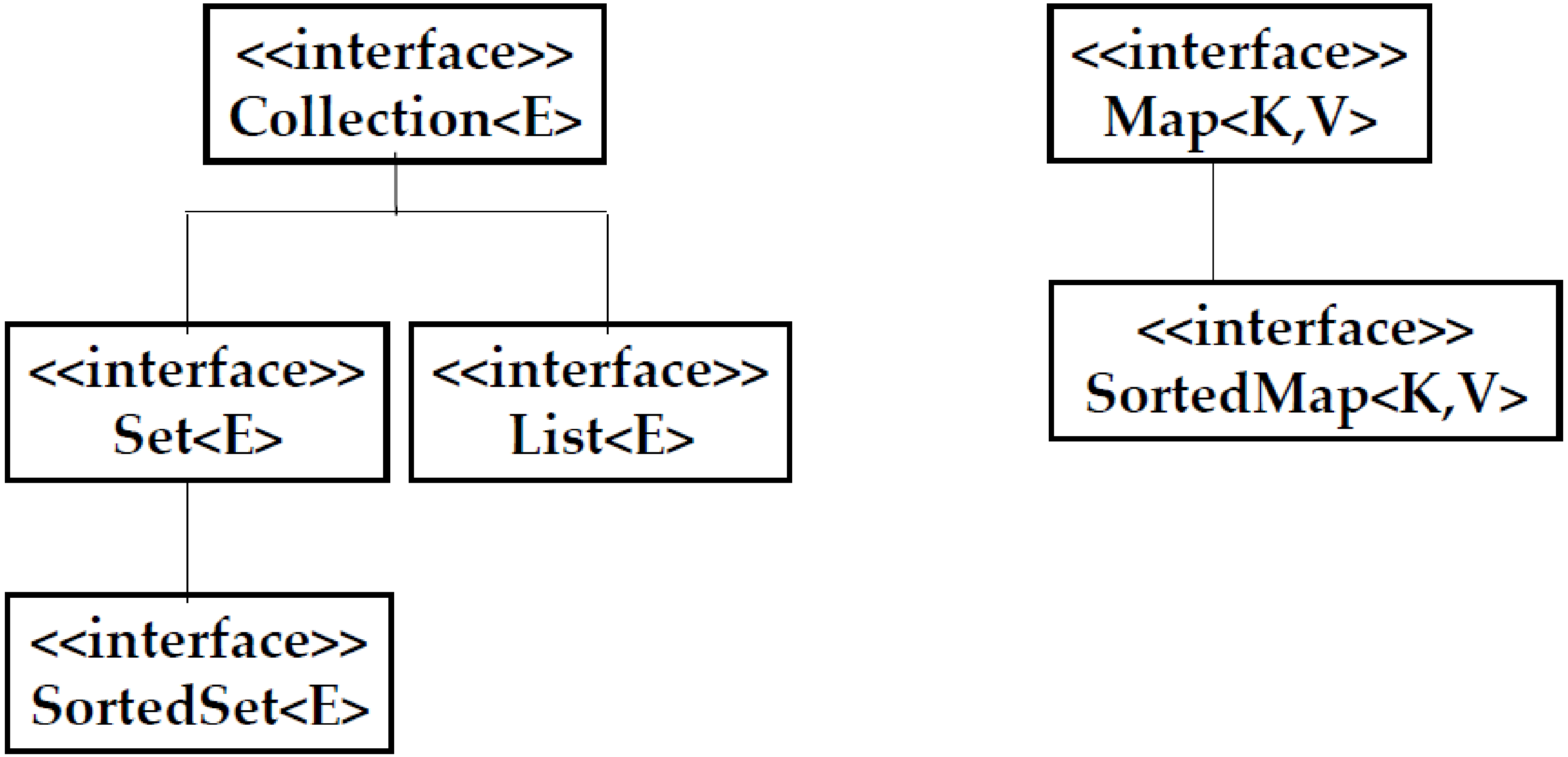
Collection Framework

- Collection frameworks encapsulates the algorithms
- Programmer don't have to worry abut the implementation of the various collections types.
- Nevertheless, still collection framework is encourages programmer to extend members of collection to create a specific implementation where one is needed

Collection Interface Hierarchy



Collection Framework Interface Hierarchy



Collection framework is in java.util package

Iterable<T>

- It is a interface declared in java.lang package.

- All the collection classes implements Iterable interface hence we can traverse it using for each loop

- Methods of Iterable interface:
    1. Iterator<T> **iterator**()
    2. default Spliterator<T> **spliterator**()
    3. default void **forEach**(Consumer<? super T> action)

Collection<E>

- Collection<E> is interface declared in java.util package.
- It is sub interface of Iterable interface.
- It is **root interface** in collection framework interface hierarchy.
- Default methods of Collection interface
  1. default Stream<E> **stream**()
  2. default Stream<E> **parallelStream**()
  3. default boolean **removeIf**(Predicate<? super E> filter)

Collection<E>

- Abstract Methods of Collection Interface

  1. boolean **add**(E e)
  2. boolean **addAll**(Collection<? extends E> c)
  3. void **clear**()
  4. boolean **contains**(Object o)
  5. boolean **containsAll**(Collection<?> c)
  6. boolean **isEmpty**()
  7. boolean **remove**(Object o)
  8. boolean **removeAll**(Collection<?> c)
  9. boolean **retainAll**(Collection<?> c)
  10. int **size**()
  11. Object[] **toArray**()
  12. <T> T[] **toArray**(T[] a)

There is no direct concrete implementation class for Collection interface but exists for sub interface

This interface supports the most basic and general operations and queries that can be performed on a group of objects.

List<E>

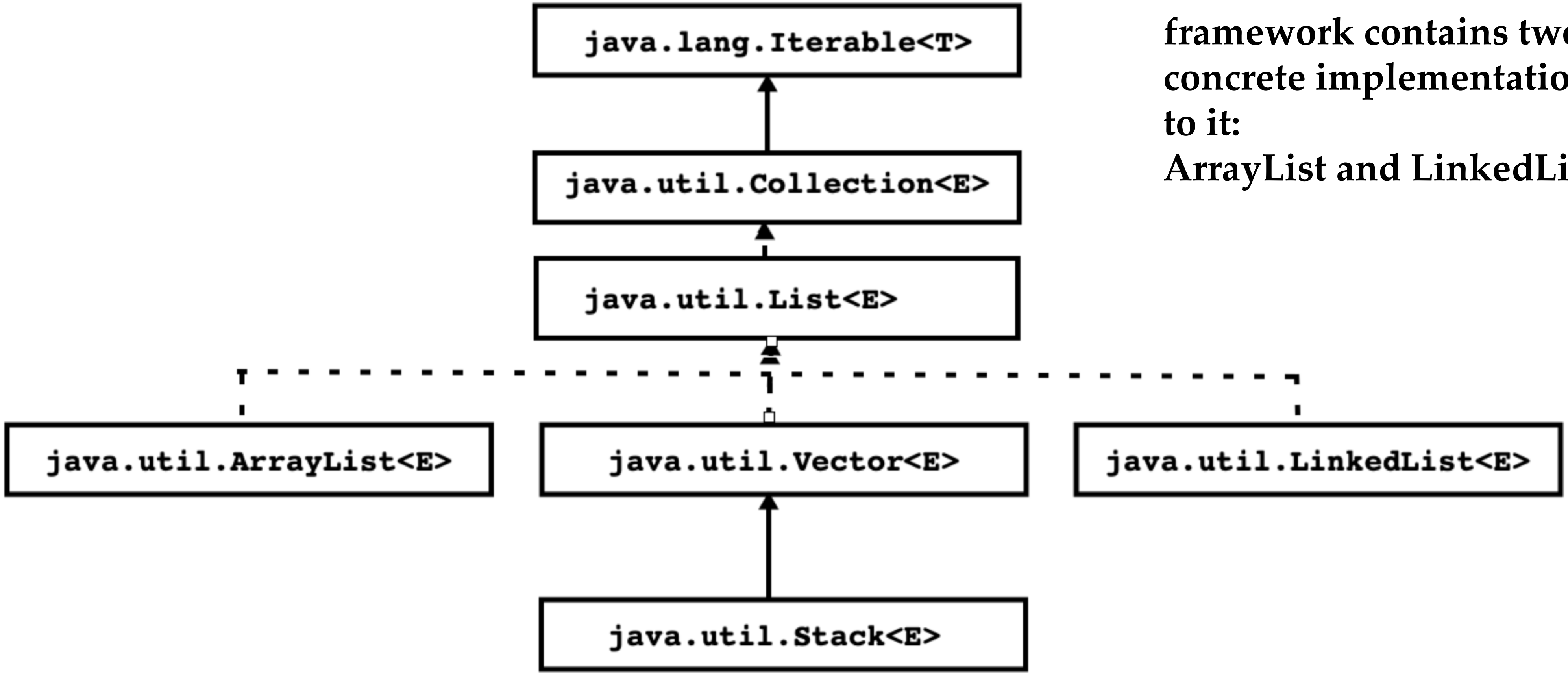
- It is sub interface of java.util.Collection interface.
- It is ordered/sequential collection.
- **ArrayList, Vector, Stack, LinkedList etc. implements List interface. It generally referred as "List collections".**
- List collection can contain duplicate element as well multiple elements.
- Using integer index, we can access elements from List collection.
- We can traverse elements of List collection using Iterator as well as ListIterator.
- A list is a collection in which duplicate elements are allowed, and where the order is significant null
- List interface inherits from Collection, but changes the semantics of some methods, and adds new methods. The list starts its index at 0.

  <a,b,c>, <c,a,b>and <a,b,b,c>are different lists

List<E>

- Abstract methods of List Interface
  1. void **add**(int index, E element)
  2. boolean **addAll**(int index, Collection<? extends E> c)
  3. E **get**(int index)
  4. int **indexOf**(Object o)
  5. int **lastIndexOf**(Object o)
  6. ListIterator<E> **listIterator**()
  7. ListIterator<E> **listIterator**(int index)
  8. E **remove**(int index)
  9. E **set**(int index, E element)
  10. List<E> **subList**(int fromIndex, int toIndex)

List Interface Hierarchy



List Hierarchy

The List collections framework contains two concrete implementations to it:
ArrayList and LinkedList.

ArrayList<E>

- It is resizable array.
- It implements List<E>, RandomAccess, Cloneable, Serializable interfaces.
- It is List collection.
- It is unsynchronized collection. Using"Collections.synchronizedList” method, we can make it synchronized.
  - ➢ List list = Collections.synchronizedList(new ArrayList(...));
- Initial capacity of ArrayList is 10. If ArrayList is full then its capacity gets increased by half of its existing capacity.
- ArrayList is recommended when you're adding and removing elements only to the end of the collection satisfies you and when you wish to access elements using their indices.
- It is less time-consuming than LinkedList is.

Vector<E>

- It is resizable array.
- It implements List<E>, RandomAccess, Cloneable, Serializable.
- It is List collection.
- It is synchronized collection.
- Default capacity of vector is 10. If vector is full then its capacity gets increased by its existing capacity.
- We can traverse elements of vector using Iterator, ListIterator as well as Enumeration.
- **Note:** If we want to manage elements of non final type inside Vector then non final type should override "equals" method.
- It is also called as growable array.

Vector<E>

- Duplicate elements are allowed in the vector class.
- It preserves the insertion order in Java.
- Null elements are allowed in the Java vector class.
- Heterogeneous elements are allowed in the vector class. Therefore, it can hold elements of any type and any number.
- Most of the methods present in the vector class are synchronized. That means it is a thread-safe. Two threads cannot access the same vector object at the same time. Only one thread can access can enter to access vector object at a time.
- Vector class is preferred where we are developing a multi-threaded application but it gives poor performance because it is thread-safety.
- Vector is rarely used in a non-multithreaded environment due to synchronized which gives you poor performance in searching, adding, delete, and update of its element.
- It can be iterated by a simple for loop, Iterator, ListIterator, and Enumeration.
- Vector is the best choice if the frequent operation is retrieval (getting).

Synchronized Collections

- 1. **Vector**
- 2. **Stack**(Sub class of Vector)
- 3. **Hashtable**
- 4. **Properties**(Sub class of Hashtable)

Enumeration<E>

- It is interface declared in java.util package.
- Methods of Enumeration I/F
    1. boolean hasMoreElements()
    2. E nextElement()
- It is used to traverse collection only in forward direction. During traversing, we can add, set or remove element from collection.
- It is introduced in jdk 1.0.
- "public Enumeration<E> elements()" is a method of Vector class.

```
Integer element = null;
Enumeration<Integer> e = v.elements();
while( e.hasMoreElements()){
    element = e.nextElement();
    System.out.println(element);
}
```

Iterator<E>

- It is a interface declared in java.util package.
- It is used to traverse collection only in forward direction. During traversing, we can not add or set element but we can remove element from collection.
- Methods of Iterator
    1. boolean hasNext()
    2. E next()
    3. default void remove()
    4. default void forEachRemaining(Consumer<? super E> action)
- It is introduced in jdk 1.2

```
Integer element = null;
Iterator<Integer> itr = v.iterator();
while( itr.hasNext()){
    element = itr.next();
    System.out.  println(element);
}
```

- **Iterator takes the place of Enumeration in the Java collections framework.**
- **Iterators allow the caller to remove elements from the underlying collection during the iteration.**

ListIterator<E>

- It is sub interface of Iterator interface.
- It is used to traverse only List Collection in bidirectional.
- During traversing, we can add, set as well as remove element from collection.
- It is introduced in jdk 1.2
- Methods of ListIterator
    1. boolean hasNext()
    2. E next()
    3. boolean hasPrevious()
    4. E previous()
    5. void add(E e)
    6. void set(E e)
    7. void remove()

ListIterator<E>

```java
Integer element = null;
ListIterator<Integer> itr = v.listIterator();
while( itr.hasNext()){
    element = itr.next();
    System.out.print(element+"   ");
}

while( itr.hasPrevious()){
    element = itr.previous();
    System.out.print(element+"   ");
}
```

Types of Iterator

- **Fail Fast Iterator**

- During traversing, using collection reference, if we try to modify state of collection and if iterator do not allows us to do the same then such iterator is called "Fail Fast" Iterator. In this case JVM throws **ConcurrentModificationException.**

```
Integer element = null;
Iterator<Integer> itr = v.iterator();
while( itr.hasNext()){
    element = itr.next();
    System.out.print(element+"  ");
    if( element == 50 )
        v.add(60); //ConcurrentModificationException
}
```

Types of Iterator

- **Fail Safe Iterator**
- During traversing, if iterator allows us to do changes in underlying collection then such iterator is called fail safe iterator.

```
Integer element = null;
Enumeration<Integer> e = v.elements();
while( e.hasMoreElements()){
    element = e.nextElement();
    System.out.print(element+"  ");
    if( element == 50 )
        v.add(60); //OK
}
```

Stack<E>

- It is linear data structure which is used to manage elements in Last In First Out order.
- It is sub class of Vector class.
- It is synchronized collection.
- It is List Collection.
- Methods of Stack class
    1. public boolean empty()
    2. public E push(E item)
    3. public E peek()
    4. public E pop()
    5. public int search(Object o)
- * Since it is synchronized collection, it slower in performance.
- * For high performance we should use ArrayDeque class.

LinkedList<E>

- It is a List collection.
- It implements List<E>, Deque<E>, Cloneable and Serializable interface.
- Its implementation is depends on Doubly linked list.
- It is unsynchronized collection. Using Collections.synchronizedList() method, we can make it synchronized.
  - **`List list = Collections.synchronizedList(new LinkedList(...));`**
- Note : If we want to manage elements of non-final type inside LinkedList then non final type should override "equals" method.
- Instantiation
  - **`List<Integer> list = new LinkedList<>();`**

LinkedList is best when add and remove operations happen anywhere, not only at the end.

LinkedList<E>

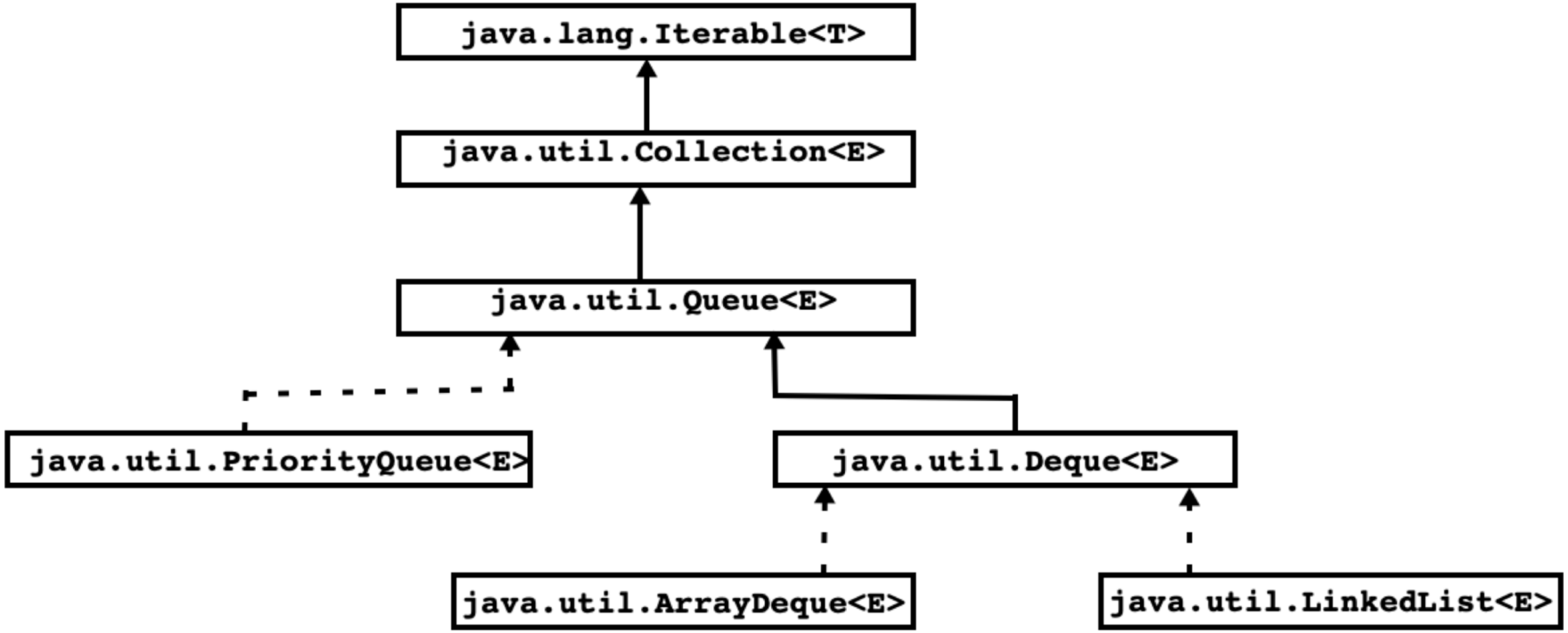
Arrays have certain limitations such as:

- Size of the array is fixed
- Array elements need contiguous memory locations
- Inserting an element in an array is performance wise expensive
- deleting an element from the array is also a performance wise expensive

Linked List by providing following features:

- Allows **dynamic memory allocation**
- elements **don’t need contiguous memory locations**
- Insert and delete operations in the Linked list are not performance wise expensive because adding and deleting an element from the linked list does’t require element shifting, only the pointer of the previous and the next node requires change.

Queue Interface Hierarchy



Queue Hierarchy

Queue<E>

- It is interface declared in java.util package.
- It is sub interface of Collection interface.
- It is introduced in jdk 1.5

Summary of Queue methods

	Throws exception	*Returns special value*
Insert	`add(e)`	`offer(e)`
Remove	`remove()`	`poll()`
Examine	`element()`	`peek()`

Since the Queue is an interface, we cannot provide the direct implementation of it.

Classes that implement Queue Interface in Java:

1. **Priority Queue**
2. **Dequeue**

Queue Interface Methods

add()

- Inserts the specified element into the queue. If the task is successful, add() returns true, if not it throws an exception.

offer()

- Inserts the specified element into the queue. If the task is successful, offer() returns true, if not it returns false.

element()

- Returns the head of the queue. Throws an exception if the queue is empty.

peek()

- Returns the head of the queue. Returns null if the queue is empty.

remove()

- Returns and removes the head of the queue. Throws an exception if the queue is empty.

poll()

- Returns and removes the head of the queue. Returns null if the queue is empty.

Queue<E>

```java
Queue<Integer> que = new ArrayDeque<>();
 que.offer(10);
 que.offer(20);
 que.offer(30);

 Integer ele = null;
 while( !que.isEmpty()){
     ele = que.peek();
     //TODO : processing
     que.poll();
 }
```

```java
Queue<Integer> que = new ArrayDeque<>();
que.add(10);
que.add(20);
que.add(30);
Integer ele = null;
while( !que.isEmpty()){
    ele = que.element();
    //TODO : Processing
    que.remove();
}
```

Deque<E>

- It is usually pronounced "deck".
- It is sub interface of Queue.
- It is introduced in jdk 1.6
- If we want to perform operations from bidirection then we should use Deque interface.

Summary of Deque methods

	First Element (Head)		Last Element (Tail)	
	Throws exception	*Special value*	*Throws exception*	*Special value*
Insert	addFirst(e)	offerFirst(e)	addLast(e)	offerLast(e)
Remove	removeFirst()	pollFirst()	removeLast()	pollLast()
Examine	getFirst()	peekFirst()	getLast()	peekLast()

Deque<E>

- Deque Interface is a linear collection that supports element insertion and removal at both ends.
- The class which implements this interface is ArrayDeque.
- It extends the Queue interface.
- Deque is an interface and has two implementations: LinkedList and ArrayDeque.
- **Creating a Deque**
  Syntax : Deque dq = new LinkedList();
  Deque dq = new ArrayDeque();

ArrayDeque

ArrayDeque class provides the facility of using deque and resizable-array.
It inherits the AbstractCollection class and implements the Deque interface.

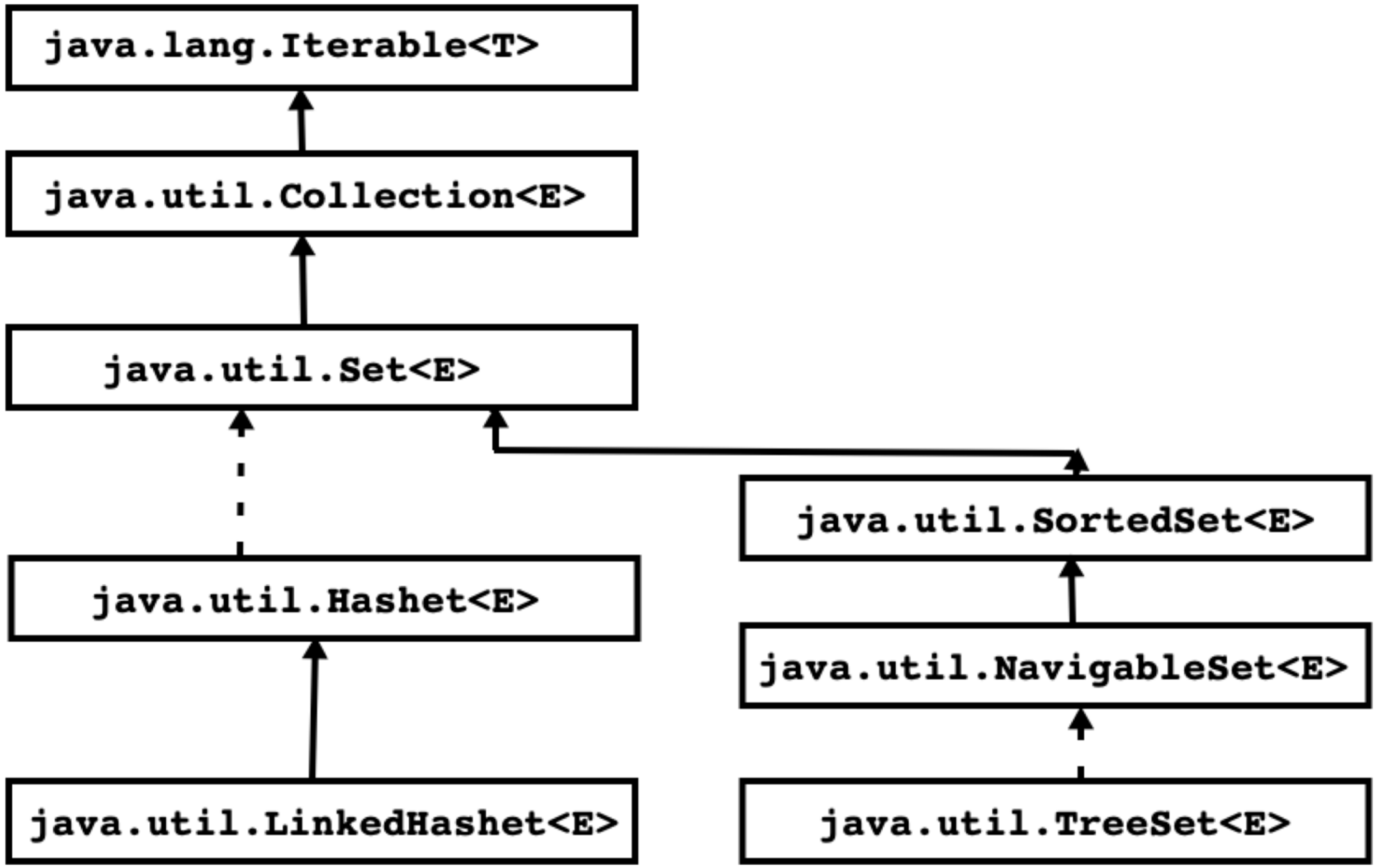
Syntax : **Deque<String> arr = new ArrayDeque<String>();**

Priority Queue

- PriorityQueue class provides the functionality of the heap data structure.
- The PriorityQueue class provides the facility of using a queue.
- It does not order the elements in a FIFO manner.
- It is based on Priority Heap.
- The elements of the priority queue are ordered according to the natural ordering, or by a Comparator provided at queue construction time, depending on which constructor is used.

Syntax : **PriorityQueue<Integer> numbers = new PriorityQueue<Integer>();**
// it will create PriorityQueue without any arguments
//head of the queue will be smallest element of the queue
//elements are removed in ascending order from the queue.

Set Interface Hierarchy



Set<E>

- It is sub interface of java.util.Collection interface.
- HashSet, LinkedHashSet, TreeSet etc. implements Set interface. It is also called as Set collection.
- Set collections do not contain duplicate elements.
- Set will not maintain any order for elements
- While adding new element it is using Object's equals() and hashCode() method to check , if such element is there or not in set

There are three concrete Set implementations that are part of the Collection Framework: HashSet, TreeSet, and LinkedHashSet.

HashSet and TreeSet, LinkedHashSet

- You use HashSet, which maintains its collection in an unordered manner.
- If this doesn't suit your needs, you can use TreeSet.
- A TreeSet keeps the elements in the collection in sorted order
- While HashSet has an undefined order for its elements, LinkedHashSet supports iterating through its elements in the order they were inserted.
- Understand that the additional features provided by TreeSet and LinkedHashSet add to the runtime costs.

TreeSet<E>

- It is Set collection.
- It can not contain duplicate element as well as null element.
- It is sorted collection.
- Its implementation is based on TreeMap
- It is unsynchronized collection.
- Using "Collections.synchronizedSortedSet()" method we can make it synchronized.
  - **SortedSet s = Collections.synchronizedSortedSet(new TreeSet(...));**
- It is introduced in jdk 1.2
- Note : If we want to manage elements of non final type inside TreeSet then non final type should implement Comparable interface.
- Instantiation
  - **Set<Integer> set = new TreeSet<>( );**

Hashing

- Hashing is a searching algorithm which is used to search element in constant time(faster searching).
- In case array, if we know index of element then we can locate it very fast.
- Hashing technique is based on "hashcode".
- Hashcode is not a reference or address of the object rather it is a logical integer number that can be generated by processing state of the object.
- Generating hashcode is a job of hash function/method.
- Generally hashcode is generated using prime number.

```java
//Hash Method
private static int getHashCode(int data)
{
    int result = 1;
    final int PRIME = 31;
    result = result * data + PRIME * data;
    return result;
}
```

Hashing

- If state of object/instance is same then we will get same hashcode.
- Hashcode is required to generate slot.
- If state of objects are same then their hashcode and slot will be same.
- By processing state of two different object's , if we get same slot then it is called collision.
- Collision resolution techniques:
  - Seperate Chaining / Open Hashing
  - Open Addressing / Close Hashing
    1. Linear Probing
    2. Quadratic Probing
    3. Double Hashing / Rehashing

Hashing

- Collection(LinkedList/Tree) maintained per slot is called bucket.
- Load Factor = (Count of bucket / Total elements);
- **In hashcode based collection, if we want manage elements of non final type then reference type should override equals() and hashcode() method.**
- hashCode() is non final method of java.lang.Object class.
- Syntax:
  - public native int hashCode( );
- On the basis of state of the object, we want to generate hashcode then we should override hashCode() method in sub class.
- The hashCode method defined by class Object does return distinct integers for distinct objects. This is typically implemented by converting the internal address of the object into an integer.

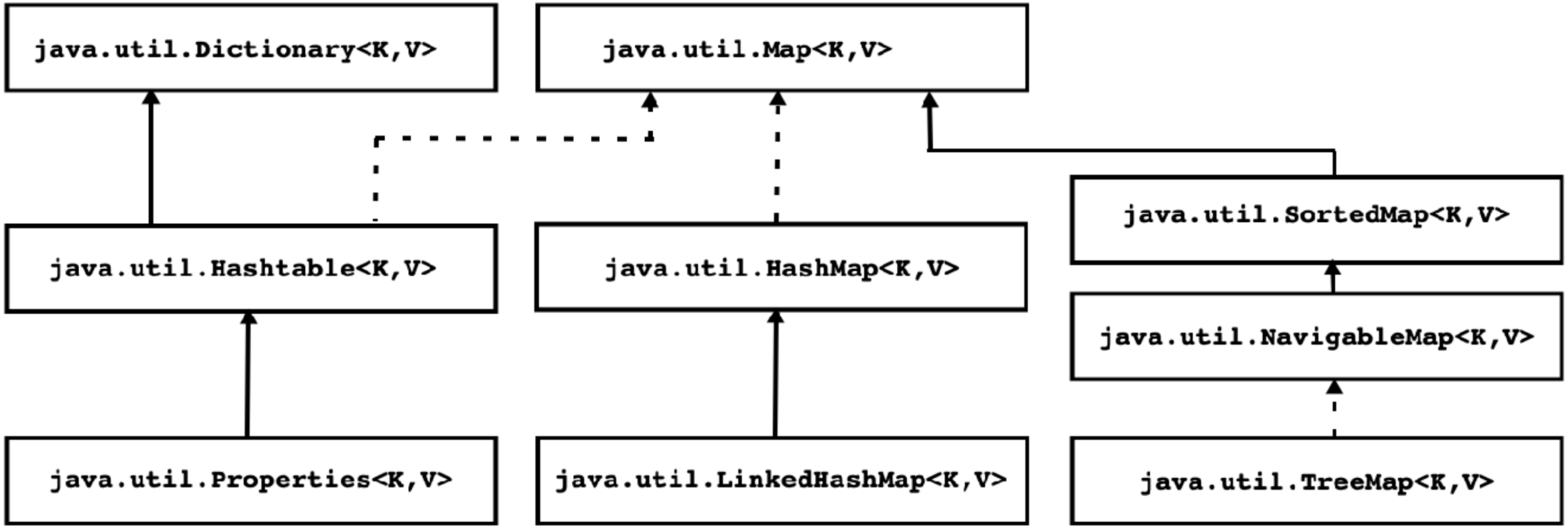
HashSet<E>

- It Set Collection.
- It can not contain duplicate elements but it can contain null element.
- It's implementation is based on HashTable.
- It is unordered collection.
- It is unsynchronized collection. Using Collections.synchronizedSet() method, we can make it synchronized.
- It is introduced in jdk 1.2
- Note : If we want to manage elements of non final type inside HashSet then non final type should override equals and hashCode() method.
- Instantiation:
  - **Set<Integer> set = new HashSet<>();**

LinkedHashSet<E>

- It is sub class of HashSet class.
- Its implementation is based on linked list and Hashtable.
- It is ordered collection.
- It is unsynchronized collection. Using Collections.synchronizedSet() method we can make it synchronized.
  - **Set s = Collections.synchronizedSet(new LinkedHashSet(...));**
- It is introduced in jdk 1.4
- It can not contain duplicate element but it can contain null element.

Map Interface Hierarchy



Dictionary<K,V>

- It is abstract class declared in java.util package.
- It is super class of Hashtable.
- It is used to store data in key/value pair format.
- It is not a part of collection framework
- It is introduced in jdk 1.0
- Methods:
  1. public abstract boolean isEmpty()
  2. public abstract V put(K key, V value)
  3. public abstract int size()
  4. public abstract V get(Object key)
  5. public abstract V remove(Object key)
  6. public abstract Enumeration<K> keys()
  7. public abstract Enumeration<V> elements()
- Implementation of Dictionary is Obsolete.

Map<K,V>

- It is part of collection framework but it doesn't extend Collection interface.
- HashMap, Hashtable, TreeMap etc are Map collection’s.
- This interface takes the place of the Dictionary class, which was a totally abstract class rather than interface.
- Map collection stores data in key/value pair format.
- In map we can not insert duplicate keys but we can insert duplicate values.
- It is introduced in jdk 1.2
- Map.Entry<K,V> is nested interface of Map<K,V>.
- Following are abstract methods of Map.Entry interface.

1. K getKey()
2. V getValue()
3. V setValue(V value)

Map<K,V>

- Abstract Methods of Map<K,V>

    1. boolean isEmpty()
    2. V put(K key, V value)
    3. void putAll(Map<? extends K,? extends V> m)
    4. int size()
    5. boolean containsKey(Object key)
    6. boolean containsValue(Object value)
    7. V get(Object key)
    8. V remove(Object key)
    9. void clear()
    10. Set<K> keySet()
    11. Collection<V> values()
    12. Set<Map.Entry<K,V>> entrySet()

- An instance, whose type implements Map.Entry<K,V> interface is called enrty instance.

Map Implementation
Collection framework gives two classes
HashMap and TreeMap

HashMap , TreeMap

- By default, choose HashMap, it serves the most needs.
- TreeMap implementation will maintain the keys of the map in a sorted order.
- it's better to simply keep everything in a HashMap while adding, and create a TreeMap at the end:
- Map <String,String> map = new HashMap<String,String>();// Add and remove elements from unsorted mapmap.put("Foo", "Bar");map.put("Bar", "Foo");map.remove("Foo");map.put("Foo", "Baz");// Then sort before displaying elements// in sorted ordermap = new TreeMap(map);

Hashtable<K,V>

- It is Map<K,V> collection which extends Dictionary class.
- It can not contain duplicate keys but it can contain duplicate values.
- In Hashtable, Key and value can not be null.
- It is synchronized collection.
- It is introduced in jdk 1.0
- In Hashtable, if we want to use instance non final type as key then it should override equals and hashCode method.

HashMap<K,V>

- It is map collection
- It's implementation is based on Hashtable.
- It can not contain duplicate keys but it can contain duplicate values.
- In HashMap, key and value can be null.
- It is unsynchronized collection. Using Collections.synchronizedMap() method, we can make it synchronized.
  - Map m = Collections.synchronizedMap(new HashMap(...));
- It is introduced in jdk 1.2.
- Instantiation
  - Map<Integer, String> map = new HashMap<>( );
- **Note : In HashMap, if we want to use element of non final type as a key then it should override equals() and hashCode() method.**

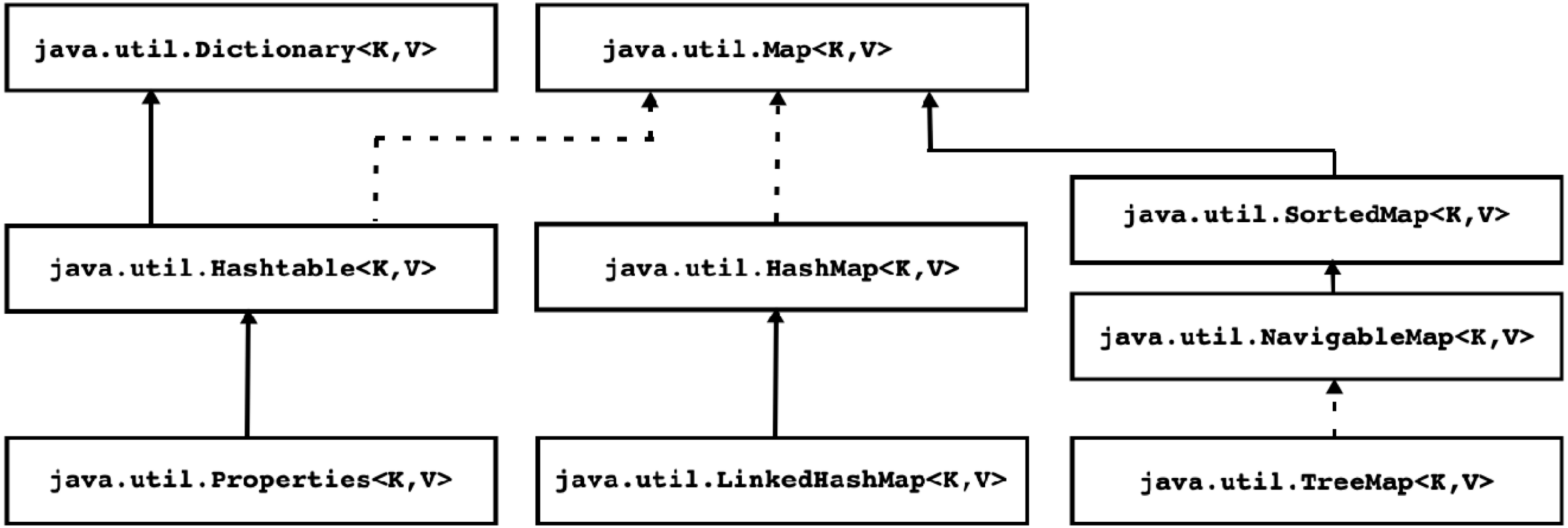
LinkedHashMap<K,V>

- It is sub class of HashMap<K,V> class
- Its implementation is based on LinkedList and Hashtable.
- It is Map collection hence it can not contain duplicate keys but it can contain duplicate values.
- In LinkedHashMap, key and value can be null.
- It is unsynchronized collection. Using Collections.synchronizedMap() method we can make it synchronized.
  - **Map m = Collections.synchronizedMap(new LinkedHashMap(...));**
- LinkedHashMap maintains order of entries according to the key.
- Instantiation:
  - **Map<Integer, String> map = new LinkedHashMap<>();**
- It is introduced in jdk 1.4

TreeMap<K,V>

- It is map collection.
- It can not contain duplicate keys but it can contain duplicate values.
- It TreeMap, key not be null but value can be null.
- Implementation of TreeMap is based on Red-Black Tree.
- It maintains entries in sorted form according to the key.
- It is unsynchronized collection. Using Collections.synchronizedSortedMap() method, we can make it synchronized.
    - **SortedMap m = Collections.synchronizedSortedMap(new TreeMap(...));**
- Instantiation:
    - **Map<Integer, String> map = new TreeMap<>();**
- It is introduced in jdk 1.2
- Note : In TreeMap, if we want to use element of non final type as a key then it should implement Comparable interface.

Map Interface Hierarchy



- Map is not considered to be a true collection, as the Map interface does not extend the *Collection* interface.
- *Map* is not a true collection, its characteristics and behaviors are different than the other collections like *List* or *Set*.

Dictionary<K,V>

- It is abstract class declared in java.util package.
- It is super class of Hashtable.
- It is used to store data in key/value pair format.
- It is not a part of collection framework
- It cannot contain duplicate keys and each key can map to at most one value
- Methods:
  1. public abstract boolean isEmpty()
  2. public abstract V put(K key, V value)
  3. public abstract int size()
  4. public abstract V get(Object key)
  5. public abstract V remove(Object key)
  6. public abstract Enumeration<K> keys()
  7. public abstract Enumeration<V> elements()
- Implementation of Dictionary is Obsolete.

Map<K,V>

- It is part of collection framework but it doesn't extend Collection interface.
- This interface takes the place of the Dictionary class, which was a totally abstract class rather than an interface.
- HashMap, Hashtable, TreeMap etc are Map collection’s.
- Map collection stores data in key/value pair format.
- In map we can not insert duplicate keys but we can insert duplicate values.
- It maps keys to values, or is a collection of Key-Value pairs
- Map.Entry<K,V> is nested interface of Map<K,V>.
- Following are abstract methods of Map.Entry interface.
    1. K getKey()
    2. V getValue()
    3. V setValue(V value)

Map<K,V>

- Abstract Methods of Map<K,V>

    1. boolean isEmpty()
    2. V put(K key, V value)
    3. void putAll(Map<? extends K,? extends V> m)
    4. int size()
    5. boolean containsKey(Object key)
    6. boolean containsValue(Object value)
    7. V get(Object key)
    8. V remove(Object key)
    9. void clear()
    10. Set<K> keySet()
    11. Collection<V> values()
    12. Set<Map.Entry<K,V>> entrySet()

- An instance, whose type implements Map.Entry<K,V> interface is called enrty instance.

When to use Map<K,V>

Some implementations allow null key and null value (*HashMap* and *LinkedHashMap*) but some does not (*TreeMap*).

The order of a map depends on specific implementations,
e.g TreeMap and *LinkedHashMap* have predictable order, while *HashMap* does not.

Maps are perfect for key-value association mapping such as dictionaries. Use Maps when you want to retrieve and update elements by keys, or perform look-ups by keys.

- A map of zip codes and cities.
- A map of managers and employees. Each manager (key) is associated with a list of employees (value) he manages.
- A map of classes and students. Each class (key) is associated with a list of students (value).

```
Map<Integer, String> hashMap = new HashMap<>();
Map<Integer, String> linkedHashMap = new LinkedHashMap<>();
Map<Integer, String> treeMap = new TreeMap<>();
```

Characterstics Map<K,V>

- HashMap: this implementation uses a hash table as the underlying data structure. It implements all of the Map operations and allows null values and one null key. This class is roughly equivalent to Hashtable - a legacy data structure before Java Collections Framework, but it is not synchronized and permits nulls. HashMap does not guarantee the order of its key-value elements. Therefore, consider to use a HashMap when order does not matter and nulls are acceptable.
- LinkedHashMap: this implementation uses a hash table and a linked list as the underlying data structures, thus the order of a LinkedHashMap is predictable, with insertion-order as the default order. This implementation also allows nulls like HashMap. So consider using a LinkedHashMap when you want a Map with its key-value pairs are sorted by their insertion order.
- TreeMap: this implementation uses a red-black tree as the underlying data structure. A TreeMap is sorted according to the natural ordering of its keys, or by a Comparator provided at creation time. This implementation does not allow nulls. So consider using a TreeMap when you want a Map sorts its key-value pairs by the natural order of the keys (e.g. alphabetic order or numeric order), or by a custom order you specify.So far you have understood the key differences of the 3 major Map’s implementations. And the code examples in this tutorial are around them.

Hashtable<K,V>

- It is Map<K,V> collection which extends Dictionary class.
- It can not contain duplicate keys but it can contain duplicate values.
- In Hashtable, Key and value can not be null.
- It is synchronized collection.
- It is introduced in jdk 1.0
- In Hashtable, if we want to use instance non final type as key then it should override equals and hashCode method.

HashMap<K,V>

- It is map collection
- It's implementation is based on Hashtable.
- It can not contain duplicate keys but it can contain duplicate values.
- In HashMap, key and value can be null.
- It is unsynchronized collection. Using Collections.synchronizedMap() method, we can make it synchronized.
  - Map m = Collections.synchronizedMap(new HashMap(...));
- It is introduced in jdk 1.2.
- Instantiation
  - Map<Integer, String> map = new HashMap<>( );
- **Note : In HashMap, if we want to use element of non final type as a key then it should override equals() and hashCode() method.**

LinkedHashMap<K,V>

- It is sub class of HashMap<K,V> class
- Its implementation is based on LinkedList and Hashtable.
- It is Map collection hence it can not contain duplicate keys but it can contain duplicate values.
- In LinkedHashMap, key and value can be null.
- It is unsynchronized collection. Using Collections.synchronizedMap() method we can make it synchronized.
  - **Map m = Collections.synchronizedMap(new LinkedHashMap(...));**
- LinkedHashMap maintains order of entries according to the key.
- Instantiation:
  - **Map<Integer, String> map = new LinkedHashMap<>();**
- It is introduced in jdk 1.4

TreeMap<K,V>

- It is map collection.
- It can not contain duplicate keys but it can contain duplicate values.
- It TreeMap, key not be null but value can be null.
- Implementation of TreeMap is based on Red-Black Tree.
- It maintains entries in sorted form according to the key.
- It is unsynchronized collection. Using Collections.synchronizedSortedMap() method, we can make it synchronized.
  - **SortedMap m = Collections.synchronizedSortedMap(new TreeMap(...));**
- Instantiation:
  - **Map<Integer, String> map = new TreeMap<>();**
- It is introduced in jdk 1.2
- Note : In TreeMap, if we want to use element of non final type as a key then it should implement Comparable interface.

Introduction

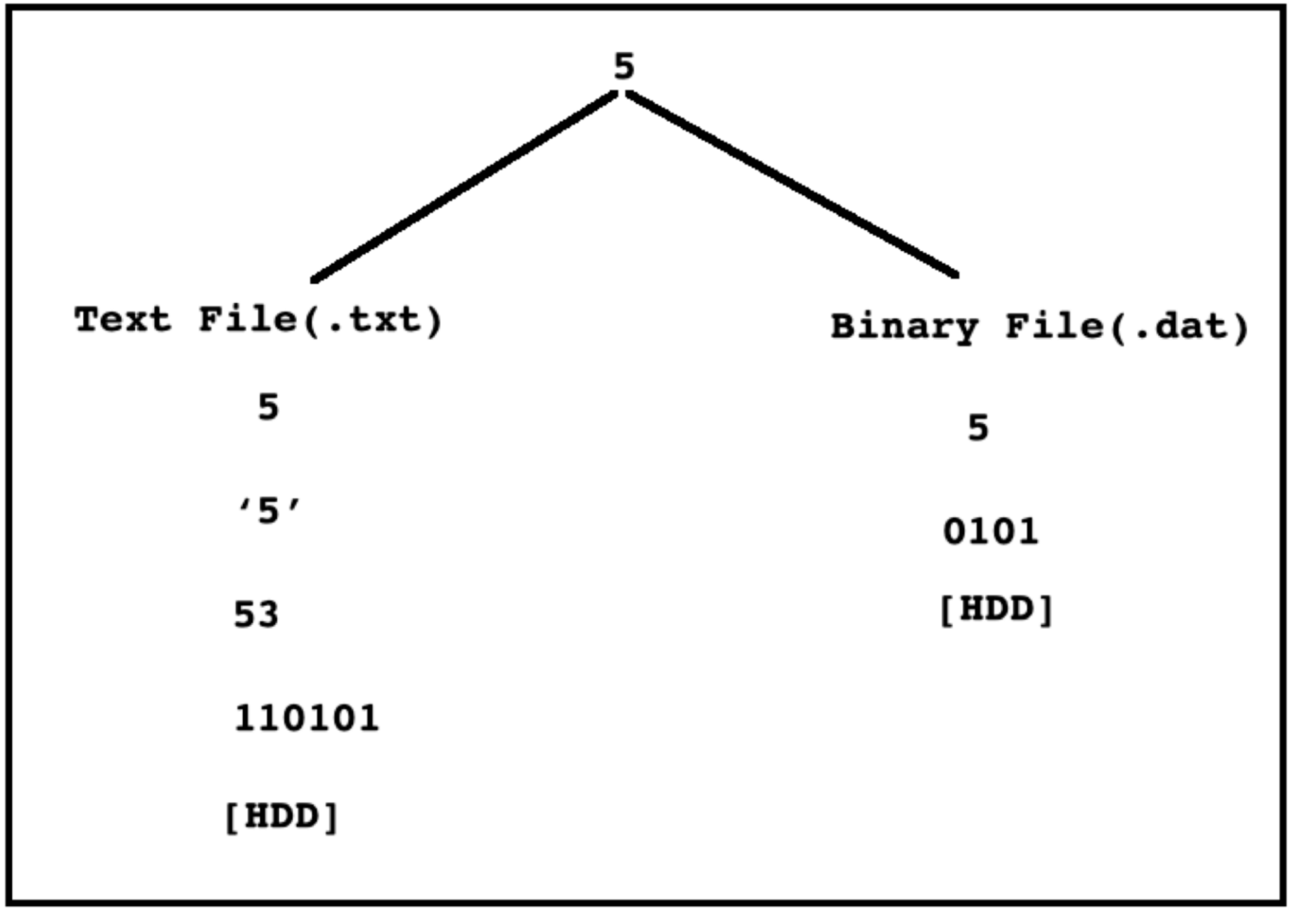
- **Variable**
  - It is temporary container, which is used to store data on RAM.

- **File**
  - It is permanent container, which is used to store data on HDD.

- File is operating system resource/non java resource.

- General types of file:
  1. Text File
  2. Binary File

Text File versus Binary File



Text File

- .txt, .rtf, .doc/.docx, .html/.css/.js/.xml, .c/cpp/.java etc.
- We can read text file using any text editor(example notepad).
- It contains data in human readable format.
- It requires more processing hence it is slower in performance.

Binary File

- .jpg/.jpeg/.png, .mp3/.mp4, .o/.obj, .class etc.
- To read binary file we need to use specific program.
- It doesn't contains data in human readable format.
- It requires less processing hence it is faster in performance.

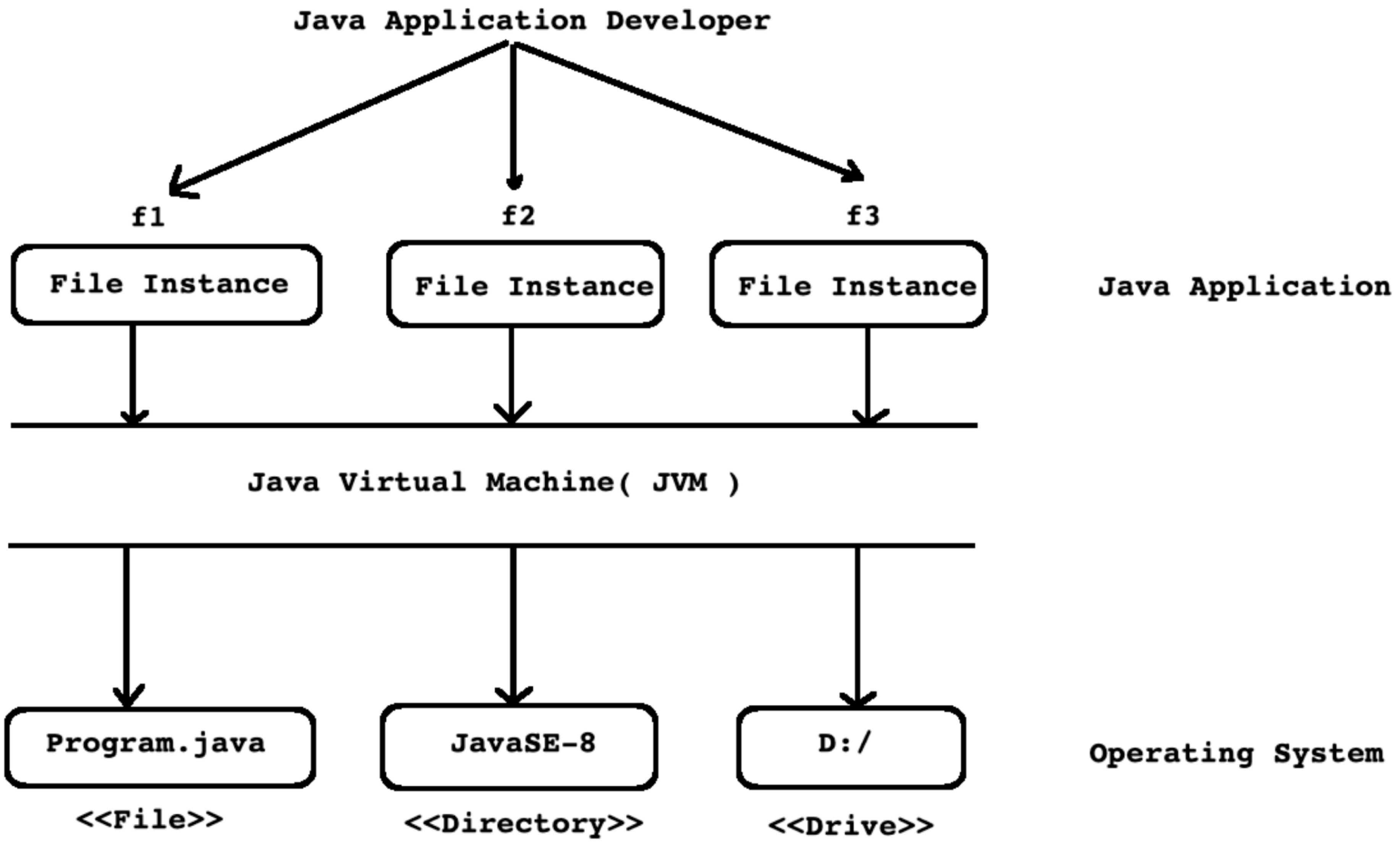
Absolute Path versus Relative Path

- A path of a file from root directory is called as absolute path.
  - Example : **D:\JavaSE8\Demo\src\Program.java**
- A path of a file from current directory is called as relative path.
  - Example : **./src/Program.java**
- Path represents location of file/directory on HDD. It contains:
  1. Root directory name
  2. Sub directories
  3. File Name
  4. Path separator character
  5. Windows : \
  6. Unix\Linux : /

File Handling In Java.

- If we want to manage file in Java then we should use types declared in **java.io and java.nio** package.
- Console is a class declared in java.io package which represents console/terminal associated with JVM
- File is a class declared in java.io package which represents Operating system Drive/directory/file.
- We should use File class:
  1. To create new empty file
  2. To create new empty directory
  3. To delete existing file/directory
  4. To read metadata of file/folder or directory/drive

File Handling In Java.

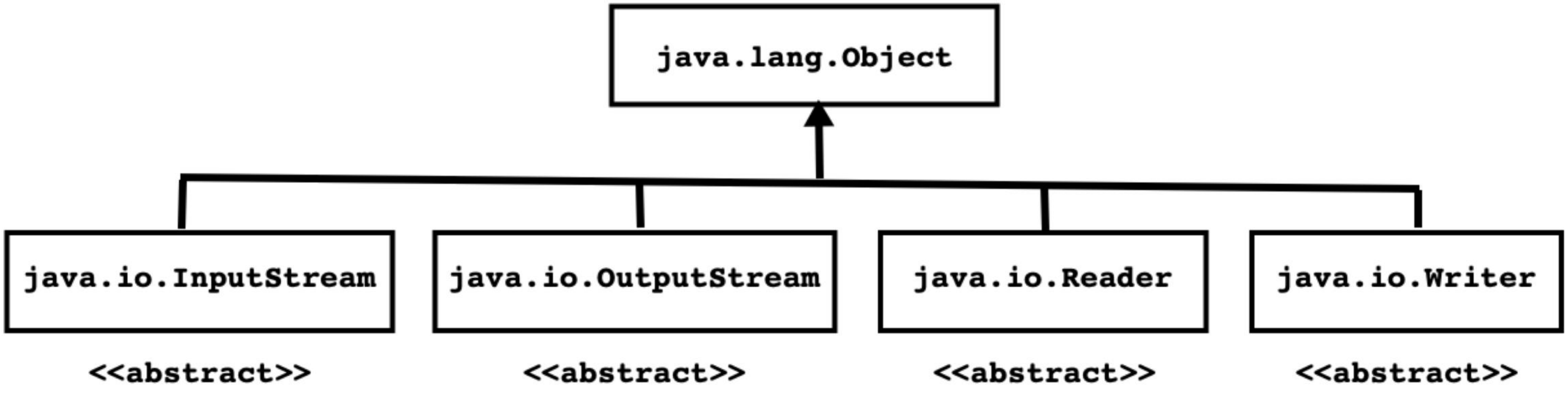


Methods of java.io.File class

1. To create new empty file
   - public boolean **createNewFile**() throws IOException
2. To create new empty directory
   - public boolean **mkdir**()
3. To delete existing file/directory
   - public boolean **delete**()
4. To read metadata of file/directory/drive
   - public String getName()
   - public String getParent()
   - public String getPath()
   - public long length()
   - public String[] list()
   - public File[] listFiles()
   - public long getTotalSpace()
   - public long getUsableSpace()
   - public long getFreeSpace()
   - public boolean isFile()
   - public boolean isDirectory()
   - public boolean isHidden()

File I/O

- If we want to read/write data to and from file then we should use stream.



- Stream is an abstraction(instance/object) which either consume(read)/produce(write) information from source to destination.
- InputStream, OutputStream and their sub classes are used to process binary file.
- Reader, Writer and their sub classes are used to process text file.
- Since all these classes implements Closeable interface, we can use its instance in try with resource syntax.

OutputStream Hierarchy

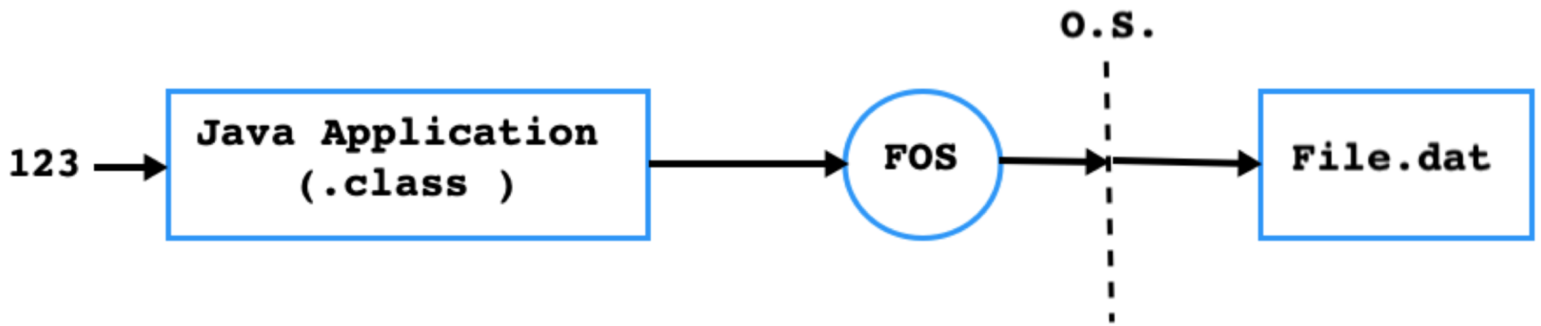
- java.lang.object
  - java.io.outputStream (implements java.io.Closeable, java.io.Flushable)
    - java.io.FileoutputStream
    - java.io.FilteroutputStream
      - java.io.BufferedoutputStream
      - java.io.DataoutputStream (implements java.io.Dataoutput)
      - java.io.PrintStream (implements java.lang.Appendable, java.io.Closeable)
    - java.io.objectoutputStream (implements java.io.objectoutput

InputStream Hierarchy

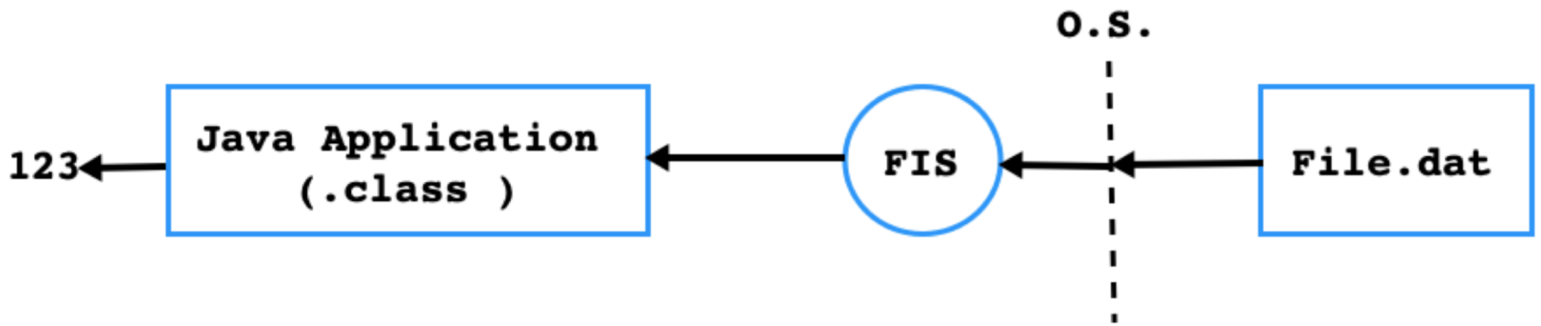
- java.lang.object
    - java.io.InputStream (implements java.io.Closeable)
        - java.io.FileInputStream
        - java.io.FilterInputStream
            - java.io.BufferedInputStream
            - java.io.DataInputStream (implements java.io.DataInput)
        - java.io.objectInputStream (implements java.io.objectInput)

FileInputStream and FileOutputStream

- Using FileOutputStream Instance, we can write single byte at a time into binary file.

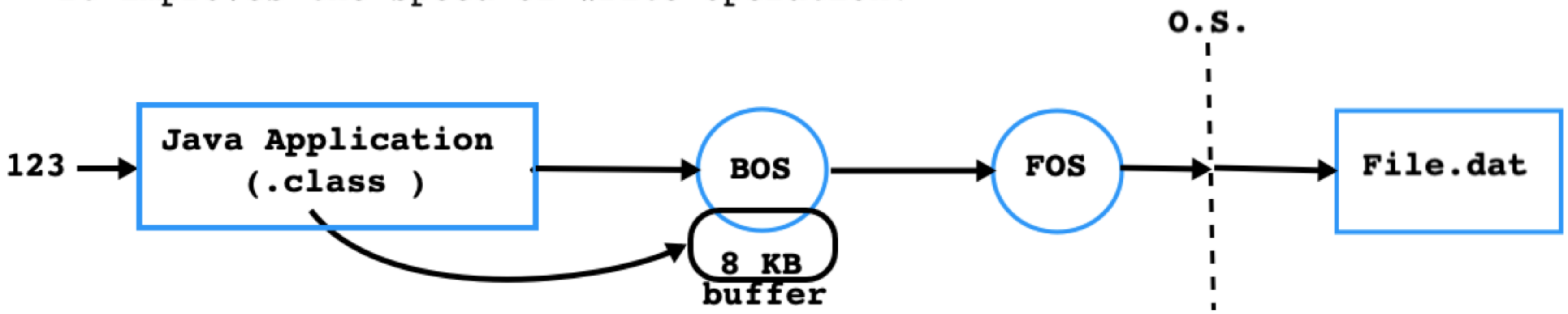


- Using FileInputStream Instance, we can read single byte at a time from binary file.

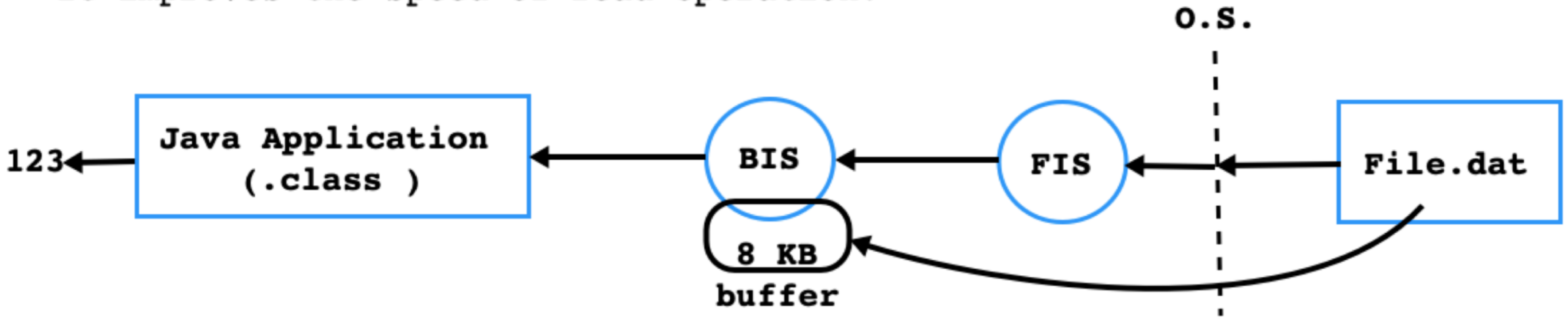


BufferedInputStream and BufferedOutputStream

- Using BufferedOutputStream Instance, we can write multiple bytes at a time into binary file.
- It improves the speed of write operation.

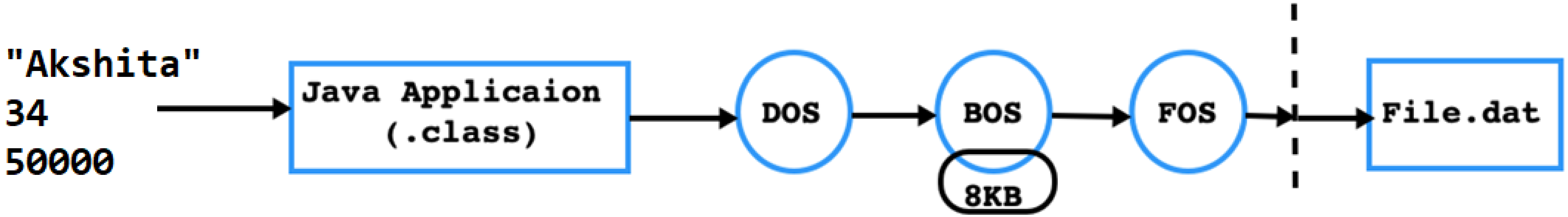


- Using BufferedInputStream Instance, we can read multiple bytes at a time from binary file.
- It improves the speed of read operation.

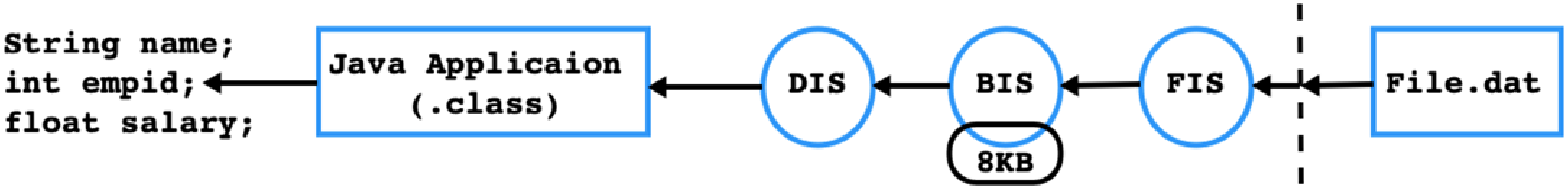


DataInputStream and DataOutputStream

- DataOutputStream instance is used to convert primitive values into binary data.

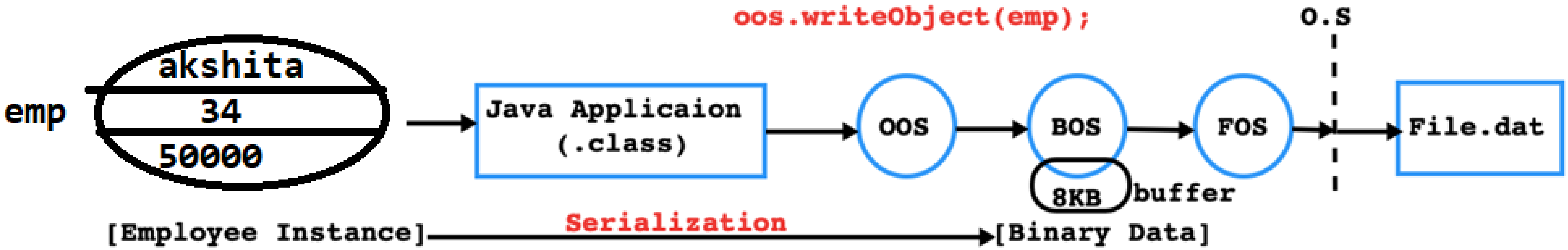


- DataInputStream instance is used to convert binary data into primitive values.

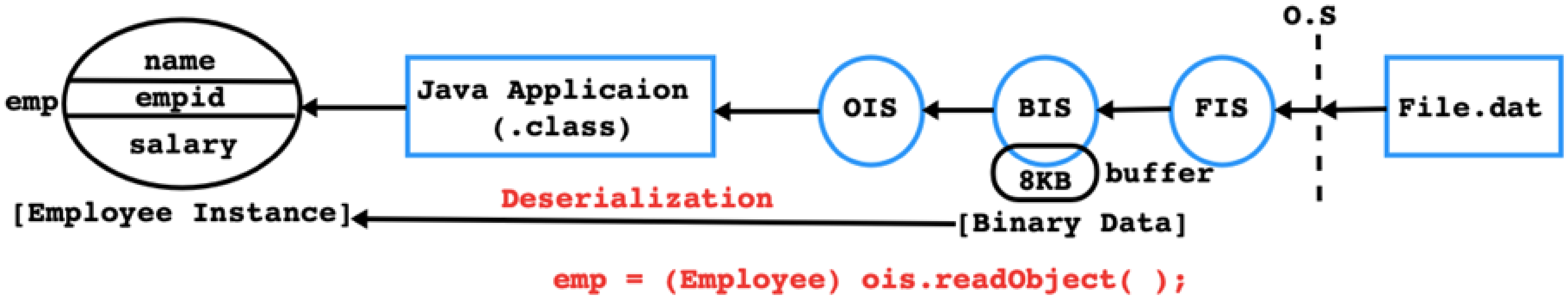


ObjectInputStream and ObjectOutputStream

- ObjectOutputStream instance is used to convert State of Java Instance into binary data.



- ObjectInputStream instance is used to convert binary into Java Instance .



Serialization

- ObjectOuput is a subinterface of DataOutput interface.
  - **"void writeObject(Object obj)throws IOException"** is a method of ObjectOutput interface.
- ObjectOutputStream class implements ObjectOuput interface.
- If we want to convert state of instance of class into binary data then we should use ObjectOuputStream class.
- This ***process of converting state of Java instance into binary data is called as Serialization.***
- If we want to serialize state of Java instance then its type/class must implement java.io.Serializable interface. Otherwise writeObject() method will throw NotSerializableException.
- Serializable is a marker interface.

Serialization

- In case of association, type of contained instance must also implement Serializable interface.

```
class Date implements Serializable{
   //TODO : Declare fields and methods
}
class Employee implements Serializable{
    private Date joinDate;  //Date must implement Serializable interface.
   //TODO : constructor, getter and setter
}
```

- transient is a keyword in Java.
- If we declare any field transient then JVM do not serialize its state.
- JVM do not serialize state of static and transient field.

Deserialization

- objectInput is a subinterface of DataInput interface.
  - **"Object readObject() throws ClassNotFoundException,IOException"** is a method of objectInput interface.
- objectInputStream class implements objectInput interface.
- If we want to convert binary data into state of instance of class then we should use objectInputStream class.
- This ***process of converting binary data into state of Java instance is called as deserialization.***

SerialVersionUID

- The serialization runtime associates with each serializable class a version number, called a serialVersionUID, which is used during deserialization to verify that the sender and receiver of a serialized object have loaded classes for that object that are compatible with respect to serialization. If the receiver has loaded a class for the object that has a different serialVersionUID than that of the corresponding sender's class, then deserialization will result in an InvalidClassException.
- A serializable class can declare its own serialVersionUID explicitly by declaring a field named "serialVersionUID" that must be static, final, and of type long:
  - **ANY-ACCESS-MODIFIER static final long serialVersionUID = 42L;**

SerialVersionUID

- If a serializable class does not explicitly declare a serialVersionUID, then the serialization runtime will calculate a default serialVersionUID value for that class based on various aspects of the class, as described in the Java(TM) Object Serialization Specification. However, it is strongly recommended that all serializable classes explicitly declare serialVersionUID values

```
class Employee implements Serializable{
    private static final long serialVersionUID = 7504310288177453321L;
}
```

Writer Hierarchy

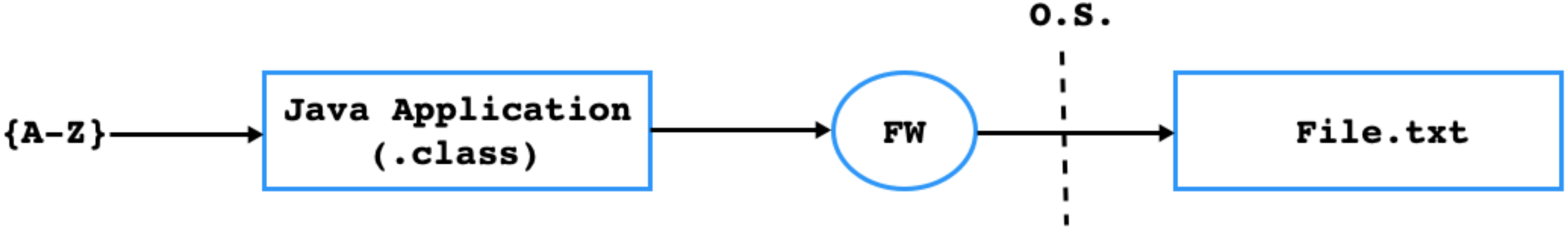
- java.lang.object
  - java.io.Writer (implements java.lang.Appendable, java.io.Closeable, java.io.Flushable)
    - java.io.BufferedWriter
    - java.io.CharArrayWriter
    - java.io.FilterWriter
    - java.io.outputStreamWriter
      - java.io.FileWriter
    - java.io.PipedWriter
    - java.io.PrintWriter
    - java.io.StringWriter

Reader Hierarchy

- java.lang.object
  - java.io.Reader (implements java.io.Closeable, java.lang.Readable)
    - java.io.BufferedReader
      - java.io.LineNumberReader
    - java.io.CharArrayReader
    - java.io.FilterReader
      - java.io.PushbackReader
    - java.io.InputStreamReader
      - java.io.FileReader
    - java.io.PipedReader
    - java.io.StringReader

FileWriter and FileReader

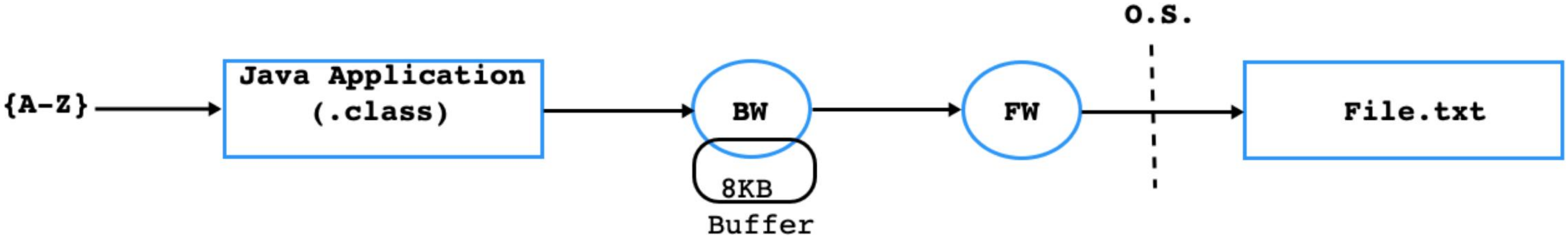
- FileWriter instance is used to write single character at a time inside file.



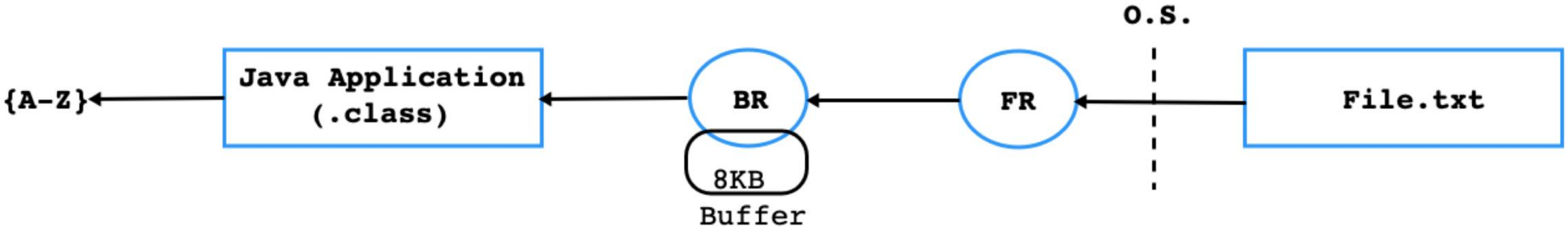
- FileReader instance is used to read single character at a time from file.

BufferedReader and BufferedWriter

- Using BufferedWriter instance, we can write multiple characters inside file.



- Using BufferedReader instance, we can read multiple characters from file.



Annotations

- *Annotations*, a form of metadata, provide data about a program.
- Annotations have a number of uses, among them:
  1. **Information for the compiler** — Annotations can be used by the compiler to detect errors or suppress warnings.
  2. **Compile-time and deployment-time processing** — Software tools can process annotation information to generate code, XML files, and so forth.
  3. **Runtime processing** — Some annotations are available to be examined at runtime.

Types of Annotation

1. **Marker Annotation**
   - Annotation without element is called marker annotation
   - Example : @Entity, @Id, @override, @Deprecated
2. **Single-value Annotation**
   - Annotation which is having single element is called single value annotation.
   - Example : @Table(name = “employees”)
3. **Multi-value Annotation**
   - Annotation which is having multiple elements is called multi value annotation.
   - Example: @Entity(tableName = “vehicles”, primaryKey=“id”)

Example Single value and Multiple Value Annotation

Single-value Annotation

```
@interface Demo{   int value(); } // declaration
@interface Demo{   int value() default 0; } // declaration along with default value
@Demo(value=10)  // applying the single value annotation
```

Multi-value Annotation

@interface Emp{ **int** value1(); String value2(); String value3(); } }	**@interface** Emp{ **int** value1() **default** 1; String value2() **default** ""; String value3() **default** “ABC"; }	@Emp(value1=20,value2="Akshita",value3=“Pune")

Predefined Annotation Types

- A set of annotation types are predefined in the Java SE API. Some annotation types are used by the Java compiler, and some apply to other annotations.
- Annotation Types Used by the Java Language
    1. @Deprecated
    2. @override
    3. @SuppressWarnings
    4. @SafeVarargs
    5. @FunctionalInterface

Predefined Annotation Types

- Annotations that apply to other annotations are called *meta-annotations*.
- There are several meta-annotation types defined in java.lang.annotation package.
- Annotations that apply to other annotations:
    1. @Retention
    2. @Documented
    3. @Target
    4. @Inherited
    5. @Repeatable
    6. @Native

Custom Annotation Type

- The annotation type definition looks similar to an interface definition where the keyword interface is preceded by the at sign (@) (@ = AT, as in annotation type).
- Annotation types are a form of *interface.*
- There are few points that we should remember
  1. Element definition should not have any parameter.
  2. Element definition not have any throws clauses
  3. Element definition should return one of the following:
     1. primitive data types,
     2. String,
     3. Class, enum or array of these data types.
  4. We should attach @ just before interface keyword to define annotation.
  5. It may assign a default value to the method.

Retention Policy

- **RetentionPolicy.SoURCE**
  - The marked annotation is retained only in the source level and is ignored by the compiler.
- **RetentionPolicy.CLASS**
  - The marked annotation is retained by the compiler at compile time, but is ignored by the Java Virtual Machine (JVM).
- **RetentionPolicy.RUNTIME**
  - The marked annotation is retained by the JVM so it can be used by the runtime environment.

Annotation Target

1. ANNOTATION_TYPE
2. CONSTRUCTOR
3. FIELD
4. LOCAL_VARIABLE
5. METHOD
6. PACKAGE
7. PARAMETER
8. TYPE
9. TYPE_PARAMETER
10. TYPE_USE

Object Oriented Programming with Java 8
Reflection

Akshita Chanchlani

Metadata

- A data which describes other data / data about data is called metadata.
- **Consider metadata for Interface**
  - What is name of the interface.
  - In which package it is declared.
  - Which is super interface of that interface.
  - Which annotations are used on interface.
  - Which is access modifier of the interface.
  - Which members are declared inside interface.

Metadata

- **Consider metadata for Class**
  - What is name of the class?
  - In which package it is declared?
  - Which is super class of it?
  - Which interfaces it has implemented?
  - Which is access modifier of it?
  - Whether it is abstract/final?
  - Which annotations are used on it?
  - Which members are declared inside class?

Metadata

- **Consider metadata for Field**
  - What is name of the field?
  - In which class it is declared?
  - Which is access modifier of the field?
  - Which modifiers used on field(static/final/transient)?
  - Which is type of field?
  - Whether it is inherited/declared-only field?
  - Which annotations are used on fields?

Metadata

- **Consider metadata for Method**
  - What is name of the method?
  - In Which class it is declared?
  - Whether it is inherited/declared-only/overridden method?
  - Which is access modifier of the method?
  - Which modifiers used on field(static/final/abstract/synchronized)?
  - Which is return type of the method?
  - What is parameter information of the method?
  - Which exceptions method can throw?
  - Which annotations are used on method?

Application Of Metadata

1. Metadata removes the need for native C/C++ header and library files when compiling because .class file contains bytecode and metadata(information about types defined inside same file and types referenced from other file)
2. IDE uses metadata to help you write code. Its IntelliSense feature parses metadata to tell you what methods, fields, nested types a class contain.
3. Metadata allows an object's fields to be serialized into a memory block, sent to another machine, and then deserialized, re-creating the object's state on the remote machine.
4. Metadata allows the garbage collector to track the lifetime of objects.

Reflection

- It is a Java language feature which provides types(interfaces / classes) that we can use:
    1. To explore metadata
    2. To access private fields of the class
    3. To manage behavior of the application at runtime.
- To use reflection we should use types declared in following package :
    1. java.lang
    2. java.lang.reflect
- Java Reflection is a process of examining or modifying the run time behavior of a class at run time.
- The java.lang.Class class provides many methods that can be used to get metadata, examine and change the run time behavior of a class.
- The java.lang and java.lang.reflect packages provide classes for java reflection.

Reflection

- The java.lang.reflect package provides classes and interfaces for obtaining reflective information about classes and objects.

- Reflection allows programmatic access to information about the fields, methods and constructors of loaded classes, and the use of reflected fields, methods, and constructors to operate on their underlying counterparts, within security restrictions.

- Classes in this package, along with java.lang.Class accommodate applications such as debuggers, interpreters, object inspectors, class browsers, and services such as object Serialization and JavaBeans that need access to either the public members of a target object (based on its runtime class) or the members declared by a given class.

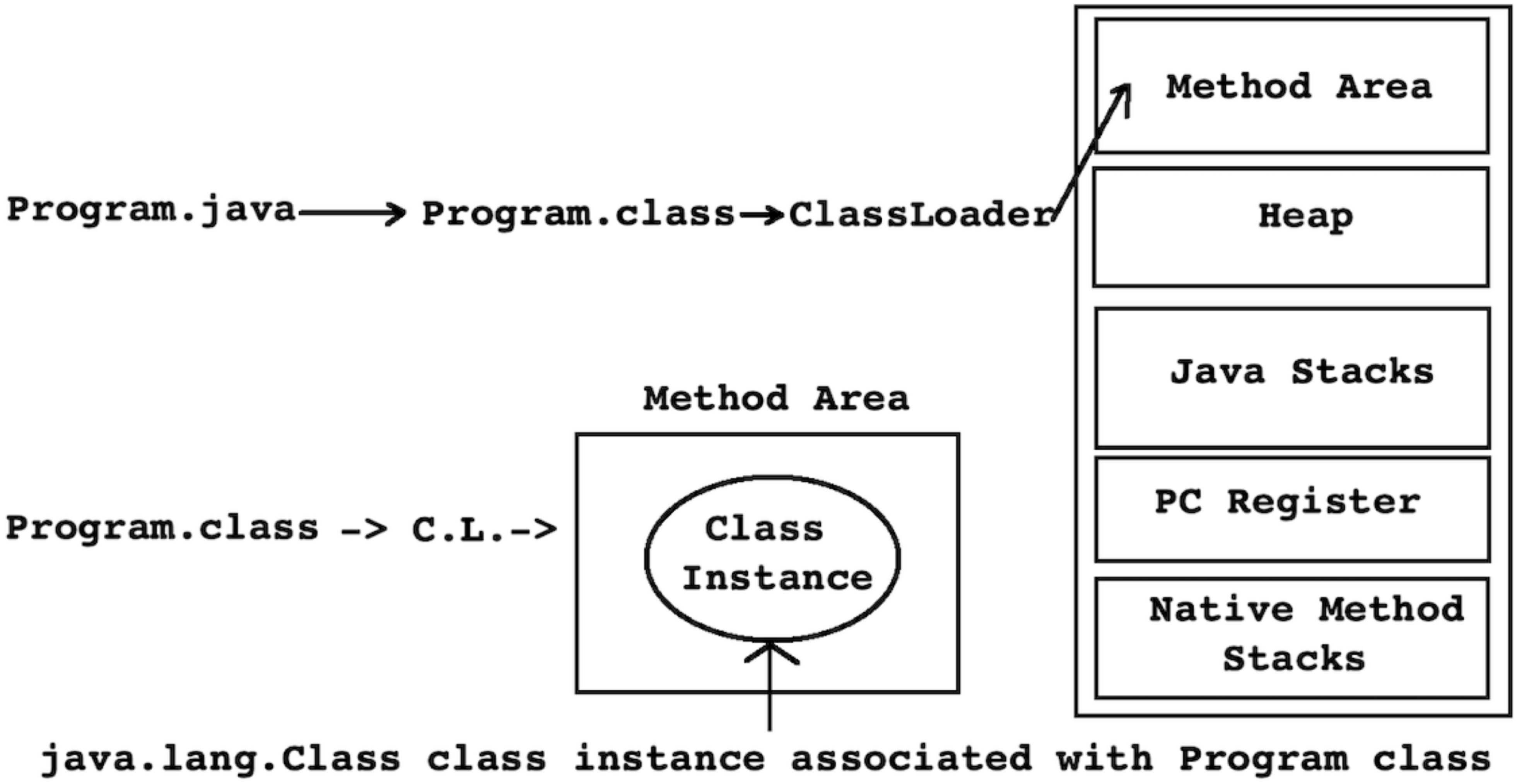
Reflection API

- Types declared in java.lang.reflect package:
    1. AccessibleObject
    2. Array
    3. Constructor
    4. Executable
    5. Field
    6. Method
    7. Modifier
    8. Parameter
    9. Proxy
    10. ReflectPermission
- Type declared in java.lang package:
    1. Class<T>

Class<T> class

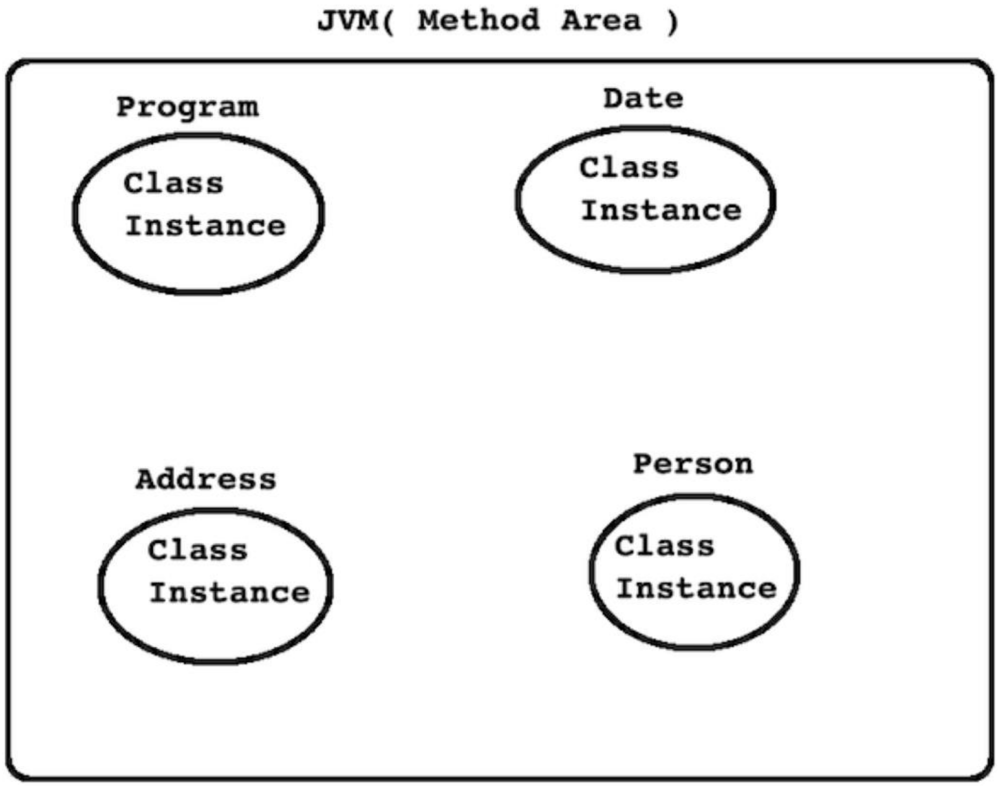
- Class<T> is a final class declared in java.lang package.
- Class has no public constructor. Instead Class objects are constructed automatically by the Java Virtual Machine.
- Instances of the class Class represent classes and interfaces in a running Java application. In other words, instance of java.lang.Class class contains metadata of loaded class.
- Methods of java.lang.Class<T>
    1. public static Class<?> forName(String className) throws ClassNotFoundException
    2. public T newInstance()
    3. public Package getPackage()
    4. public String getName()
    5. public String getSimpleName()

Flow Of Execution



Flow Of Execution

```
class Date{}  //Date.class
class Address{} //Address.class
class Person{ //Person.class
  String name;
  Date dob;
  Address address;
}
class Program{ //Program.class
  p.s.v.m( String[] args ){
    case 1: Date
    case 2: Address
    case 3: Person
  }
}
javac Program.java
Java Program( Press enter key ) - ClassLoader -
```



Retrieving Class Objects

- The entry point for all reflection operations is java.lang.Class.
- How to get reference of Class<T> class instance associated with loaded type?

```
1. Using getClass() method
   - "public Class<?> getClass( )" is a method of java.lang.Object class.
         Integer number = new Integer( 0 );
         Class<?> c = number.getClass();

2. Using .class syntax
   Class<?> c = Number.class;
   Class<?> c = Integer.class;

3. Using Class.forName( )
   - public static Class<?> forName(String className) is a method of Class<T>
         public static void main(String[] args) {
             try( Scanner sc = new Scanner(System.in)){
              System.out.print("F.Q Name  :   ");
             String className = sc.nextLine();   //java.io.File
              Class<?> c = Class.forName(className);
             } catch (ClassNotFoundException e) {
                 e.printStackTrace();
            }
         }
```

Get the object of Class class

There are 3 ways to get the instance of Class class.

1. forName() method of Class class
2. getClass() method of Object class
3. the .class syntax

1) forName() method of Class class

- is used to load the class dynamically.
- returns the instance of Class class.
- It should be used if you know the fully qualified name of class.This cannot be used for primitive types.

2) getClass() method of Object class

It returns the instance of Class class. It should be used if you know the type. Moreover, it can be used with primitives.

3) The .class syntax

If a type is available, but there is no instance, then it is possible to obtain a Class by appending ".class" to the name of the type. It can be used for primitive data types also.

Object Oriented Programming with Java 8

Functional Programming

Akshita Chanchlani

Functional Programming **Package : java.util.function**

Functional Programming (FP) is one of the type of programming pattern that helps the process of building application by using of higher order functions, avoiding shared state, mutable data.
Functional programming is the way of writing s/w applications that uses only pure fuctions & immutable values.

Need of Functional Programming

1. To write more readable , maintainable , clean & concise code.
2. To use APIs easily n effectively.
3. To enable parallel processing

Declarative vs Imperative :

- Functional programming is a declarative pattern means that the program logic is expressed without explicitly describing the flow control.(you will just have to specify what's to be done)

- Imperative programs spend lines of code describing the specific steps used to achieve the desired results by following flow control. (you will have to specify what's to be done & how)

- Declarative programs remove the flow control process, and instead spend lines of code describing the data flow.

Functions as Objects

- store in a variable, pass as a parameter, return as a result.
- Only variables and objects can be stored, passed, and returned.

- Functions can be represented as objects in Java. That is called as Functional Interface.

- We implement classes from Functional Interfaces.

- Then, we can create objects.

- These objects are called **First-Class Functions. Because** It is said that it is because functions are finally being treated as *first-class citizens*. When encapsulated in an object, they can finally be stored, returned, and used as parameters to other functions.

Functions can be expressions; therefore, they can exist inside methods, as the expressions that we create combining operators and values

We will need a new kind of expression called **Lambda Expressions**. They are functions too.

Types of Functional Programming

- Streams functional Programming
- Lambda Expressions functional Programming
- Method Reference functional Programming

Streams Functional Programming

```
objectName.stream();
```

Lambda Expressions

- Lambda expression used to represent a method interface with an expression.
- It helps to iterate, filtering and extracting data from collections.
- Lambda expression interface implementation is a functional interface.
- It reduces a lot of code.
- Lambda expression treated as a function so java compiler can't create .class

Syntax:

```
(arguments) ->
{
//code for implementation
}
Arguments:  argument-list can be have values or no values
Example: arguments1, arguments2, arguments3,……
->: Joins code implementation and arguments.
```

Lambda expression with a single argument

Syntax:

```
(argument1) ->
{
//code for implementation
}
```

Lambda expression without argument

Syntax:

```
() ->
{
//code for implementation
}
```

Method Reference

- Method reference used to refer to a method of functional interface.
- It is one more easy form of a lambda expression.
- If you use every time lambda expression to point a method, we can use method reference in place of method reference.

Syntax:

```
Class-Name:: static method name
```

Functional Programming Concepts

•**Higher-order functions:**
In functional programming, functions are to be considered as first-class citizens. That is, so far in the legacy style of coding, we can do below stuff with objects.

- We can pass **objects** to a function.
- We can create **objects** within function.
- We can return **objects** from a function.
- We can pass a **function** to a function.
- We can create a **function** within function.
- We can return a **function** from a function.

•**Pure functions:**
A function is called pure function if it always returns the same result for same argument values and it has no side effects like modifying an argument (or global variable) or outputting something.

•**Lambda expressions**
A Lambda expression is an anonymous method that has mutability at very minimum and it has only a parameter list and a body. The return type is always inferred based on the context. Also, make a note, Lambda expressions work in parallel with the functional interface.

The syntax of a lambda expression , `(parameter) -> body`

First-Class and Higher-Order Functions

- A programming language is said to have first-class functions if it treats functions as first-class citizens. Basically, it means that **functions are allowed to support all operations typically available to other entities**.
- These include assigning functions to variables, passing them as arguments to other functions, and returning them as values from other functions.
- This property makes it possible to define higher-order functions in functional programming. **Higher-order functions are capable of receiving function as arguments and returning a function as a result**.
- This further enables several techniques in functional programming like function composition and currying.
- Traditionally it was only possible to pass functions in Java using constructs like functional interfaces or anonymous inner classes. Functional interfaces have exactly one abstract method and are also known as Single Abstract Method (SAM) interfaces.

For example we have to provide a custom comparator to *Collections.sort* method:

```
Collections.sort(numbers, new Comparator<Integer>() {
@Override public int compare(Integer n1, Integer n2) {
return n1.compareTo(n2); } });
```

Functional Interface

- An interface which has exactly single abstract method(SAM) is called functional interface.

Eg. Runnable,Comparable,Comparator,Iterable etc.

- Annotation for Functional Interface

@FunctionalInterface

- Functional i/f references can be substituted by lambda expressions, method references, or constructor references.

Lambda Expression

- Lambdas are the most important new addition
- **Java treats a lambda expression as an *Object***, which is, in fact, the true first-class citizen in Java.
- A big challenge was to introduce lambdas without requiring recompilation of existing binaries

For example above example with Lambda Expression:

```
Collections.sort(numbers, (n1, n2) -> n1.compareTo(n2));
```

this is more concise and understandable

Syntax of Java 8 Lambdas

- A Java 8 lambda is basically a method in Java without a declaration usually written as (parameters) -> { body }. Examples,

  1. `(int x, int y) -> { return x + y; }`
  2. `x -> x * x`
  3. `( ) -> x`

- A lambda can have zero or more parameters separated by commas and their type can be explicitly declared or inferred from the context.
- Parenthesis are not needed around a single parameter.
- ( ) is used to denote zero parameters.
- The body can contain zero or more statements.
- Braces are not needed around a single-statement body.

Benefits of Lambdas in Java 8

- Enabling functional programming
- Writing leaner more compact code
- Facilitating parallel programming
- Developing more generic, flexible and reusable APIs
- Being able to pass behaviors as well as data to functions

Example 1:
Print a list of integers with a lambda

```
List<Integer> intSeq = Arrays.asList(1,2,3);

intSeq.forEach(x -> System.out.println(x));
```

x -> System.out.println(x) is a lambda expression that defines an anonymous function with one parameter named x of type Integer

Example 2:
A multiline lambda

```
List<Integer> intSeq = Arrays.asList(1,2,3);

intSeq.forEach(x -> {
   x += 2;
   System.out.println(x);
});
```

Braces are needed to enclose a multiline body in a lambda expression.

Example 3:
A lambda with a defined local variable

```
List<Integer> intSeq = Arrays.asList(1,2,3);

intSeq.forEach(x -> {
   int y = x * 2;
   System.out.println(y);
});
```

- Just as with ordinary functions, you can define local variables inside the body of a lambda expression

Example 4:
A lambda with a declared parameter type

```
List<Integer> intSeq = Arrays.asList(1,2,3);

intSeq.forEach((Integer x ->) {
   x += 2;
   System.out.println(x);
});
```

- You can, if you wish, specify the parameter type.

Variable Capture

- Lambdas can interact with variables defined outside the body of the lambda

- Using these variables is called variable capture

Local Variable Capture Example

```
List<Integer> intSeq = Arrays.asList(1,2,3);

    int var = 10;
    intSeq.forEach(x -> System.out.println(x + var));
```

- Note: local variables used inside the body of a lambda must be final or effectively final

Static Variable Capture Example

```
public class Demo {
  private static int var = 10;
  public static void main(String[] args) {
    List<Integer> intSeq = Arrays.asList(1,2,3);
    intSeq.forEach(x -> System.out.println(x + var));
  }
}
```

Method References

- Method references can be used to pass an existing function in places where a lambda is expected
- The signature of the referenced method needs to match the signature of the functional interface method

Conciseness with Method References

We can rewrite the statement

```
intSeq.forEach(x -> System.out.println(x));
```

more concisely using a method reference

```
intSeq.forEach(System.out::println);
```

What is a stream?

A stream is “a sequence of elements from a source that supports data processing operations.” Internal iteration.

Collections are held in memory space. You need the entire collection to iterate. SPACE

Streams are created on-demand and they are infinite. TIME

Declarative— More concise and readable
Composable— Greater flexibility
Parallelizable— Better performance

Stream API

- The new java.util.stream package provides utilities to support functional-style operations on streams of values.
- A common way to obtain a stream is from a collection:

```
Stream<T> stream = collection.stream();
```

- Streams can be sequential or parallel.
- Streams are useful for selecting values and performing actions on the results.

Sequence of Elements

Sequence of elements— Like a collection, a stream provides an interface to a sequenced set of values of a specific element type. Because collections are data structures, they’re mostly about storing and accessing elements, but streams are **also** about expressing computations such as filter, sorted, and map.

Source

Source— Streams consume from a data-providing source such as collections, arrays, or I/O resources.

Note that generating a stream from an ordered collection preserves the ordering. The elements of a stream coming from a list will have the same order as the list.

Data processing

Data processing— Streams support database-like operations and common operations from functional programming languages to manipulate data, such as filter, map, reduce, find, match, sort, and so on. Stream operations can be executed either **sequentially** or in **parallel**.

Pipelining

Pipelining— Many stream operations return a stream themselves, allowing operations to be chained and form a larger pipeline. This enables certain optimizations such as laziness and short-circuiting. A pipeline of operations can be viewed as a database-like query on the data source.

Stream Operations

- An intermediate operation keeps a stream open for further operations. Intermediate operations are lazy.
- A terminal operation must be the final operation on a stream. Once a terminal operation is invoked, the stream is consumed and is no longer usable.

Example Intermediate Operations

- `filter` excludes all elements that don’t match a Predicate.

- `map` performs a one-to-one transformation of elements using a Function.

A Stream Pipeline

A stream pipeline has three components:

1. A source such as a Collection, an array, a generator function, or an IO channel;
2. Zero or more intermediate operations; and
3. A terminal operation

Stream Example

```
int sum = widgets.stream()
                 .filter(w -> w.getColor() == RED)
                 .mapToInt(w -> w.getWeight())
                 .sum();
```

Here, `widgets` is a `Collection<Widget>`. We create a stream of `Widget` objects via `Collection.stream()`, filter it to produce a stream containing only the red widgets, and then transform it into a stream of `int` values representing the weight of each red widget. Then this stream is summed to produce a total weight.

Parting Example: Using lambdas and stream to sum the squares of the elements on a list

```
List<Integer> list = Arrays.asList(1,2,3);

int sum = list.stream().map(x -> x*x).reduce((x,y) -> x + y).get();

System.out.println(sum);
```

- Here map(x -> x*x) squares each element and then reduce((x,y) -> x + y) reduces all elements into a single number

http://viralpatel.net/blogs/lambda-expressions-java-tutorial/

Object Oriented Programming with Java 8

Multithreading

Akshita Chanchlani

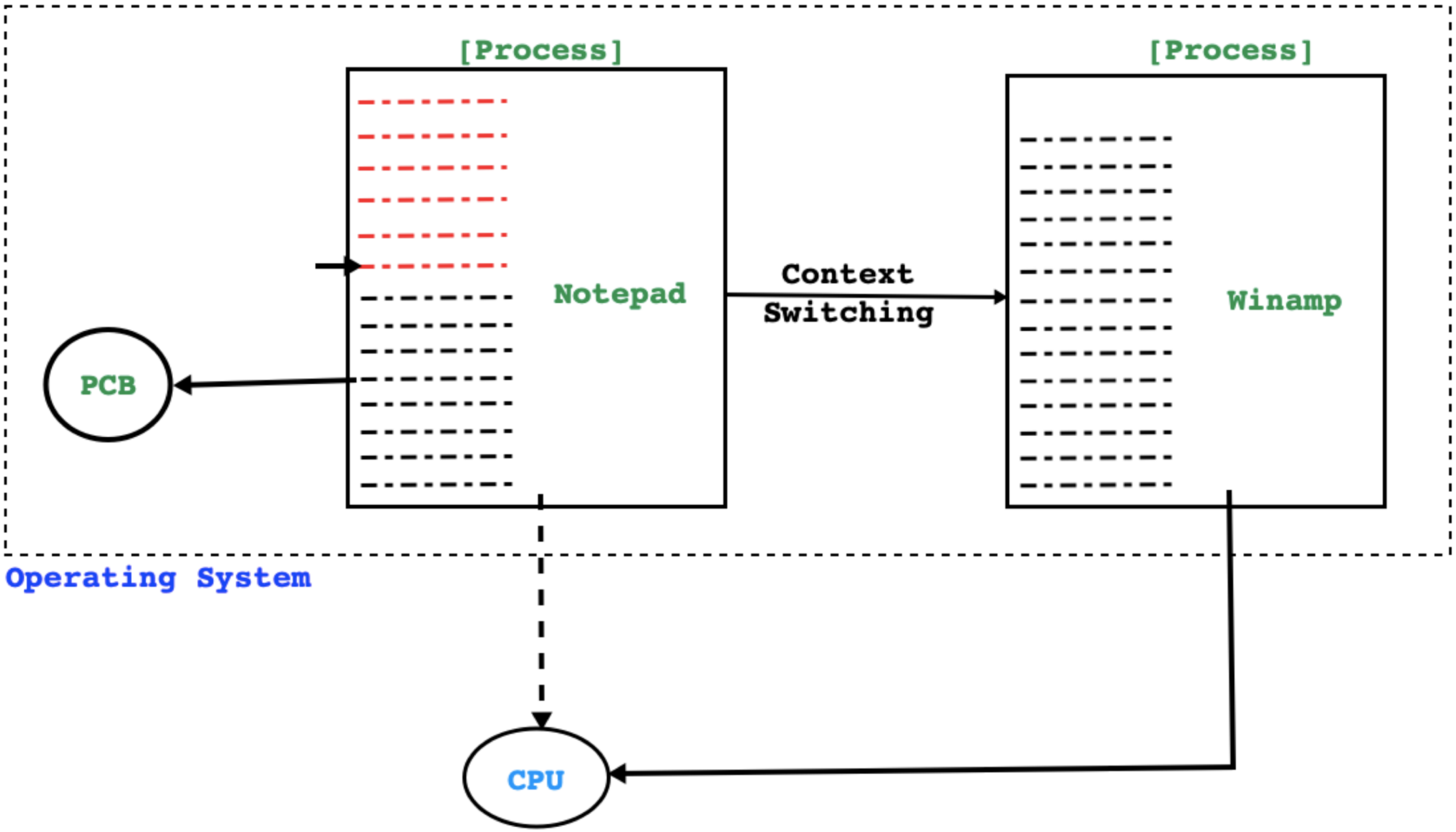
Process Introduction

- Process(also called as task)
  - Program in execution is called as process.
  - Running instance of a program is also called as process.
- Ability of an operating system to execute single process at a time is called as single tasking operating system.
  - Example : Microsoft Disk Operating System(MSDOS)
- Ability of an operating system to execute multiple processes at a time is called as multi tasking operating system
  - Example : Microsoft Windows, Unix/Linux, Mac OS
- This ability to run multiple processes or application at a time is called as concurrency in oops.

Thread Introduction

- Thread(also called as task)
  - Light weight process or sub process is also called thread.
  - In the context of Java, thread is a separate path of execution which runs independently.
- Thread is a operating system / Non Java resource.
- If we want to utilize hardware resources(e.g. CPU) efficiently then we should use thread.
- If application take help of single thread to execute application then it is called single threaded application.
- If application take help of multiple threads to execute application then it is called multi threaded application.
- Every Java application is multithread.

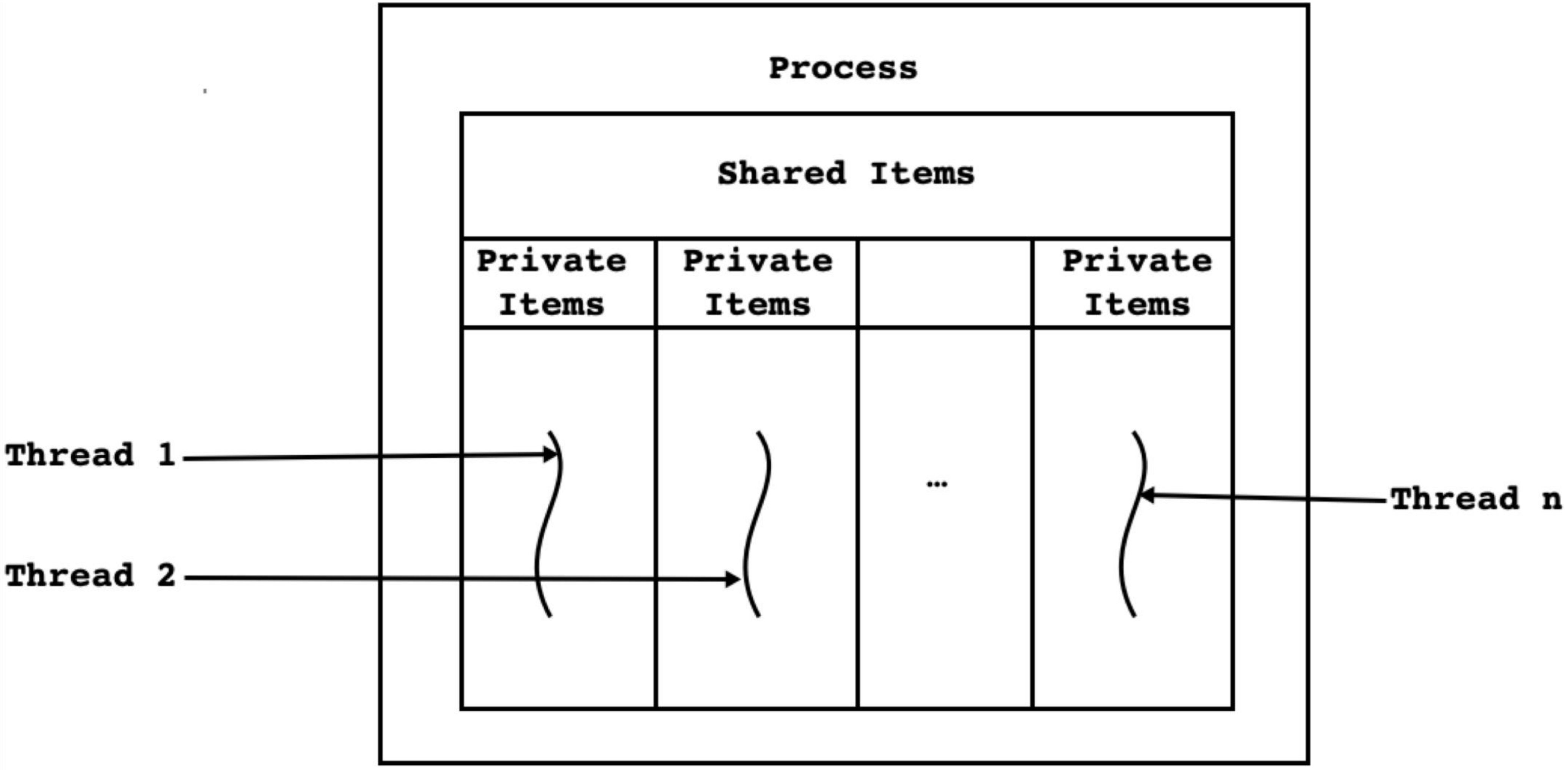
Process Based Multitasking



Process Based Multitasking

- If we want, operating system should execute multiple processes at the same time then OS must first save state of current process into process control block(PCB). Only after that control of CPU can be transferred to the another process. It is called as context switching.
- Creating / disposing process and context switching is a heavy task. Hence process Based multitasking is called heavy weight multitasking.

Thread Based Multitasking



The model of multithreaded Process

Thread Based Multitasking

- In comparison with process, thread creation and disposal/termination take less time.
- To access shared items of process, thread do not require context switching. Hence thread based multitasking is called as light weight multitasking.

Java is *Multithreaded* Programming Language

- When we start execution of Java application, JVM starts execution of main thread and garbage collector.
    - Main thread
        1. It is a *user thread*(also called as non daemon thread).
        2. It is responsible for invoking main method.
    - Garbage Collector(also called as *finalizer*)
        1. It is a *daemon thread*(also called as background thread).
        2. It is responsible for deallocating/releasing/reclaiming memory of unused instances.
- Thread is an OS resource. To access OS thread in application, Java application developer need not to do native programming. Sun/Oracle developers has already developed framework to access OS thread in Java application.

Thread Types

- Java offers two types of thread:
  1. User Thread
  2. Daemon Thread
- User threads are high priority threads. JVM will not terminate until all user threads gets terminated.
- Daemon threads are low priority threads. When thread is marked as daemon, JVM doesn’t wait to finish its task.
- Thread inherits properties from its parent. Main thread is user thread hence, if we create any thread from main then it is by default user thread. If we create any thread from daemon thread then it is by default daemon thread.
- Using setDaemon() method we can convert user thread to deamon or vice versa.

Thread Types

- Using isDaemon( ) method, we can check whether thread is user thread or daemon thread.
- We can use setDaemon( ) method to change type of thread. This method should be called after creating thread instance and before calling start method on thread instance.

```
public class Program {
    public static void main(String[] args){
        Thread thread = Thread.currentThread();
        System.out.println(thread.toString());  //Thread[main,5,main]
        if( !thread.isDaemon())
            thread.setDaemon(true); //IllegalThreadStateException
    }
}
```

Thread API

- **Packages**
  1. java.lang
  2. java.util.concurrent
- **Interface**
  - java.lang.Runnable
- **Class(es)**
  - Thread
  - ThreadGroup
  - ThreadLocal
- **Enum**
  - Thread.State
- **Exception**
  - IllegalThreadStateException
  - IllegalMonitorStateException
  - InterruptedException

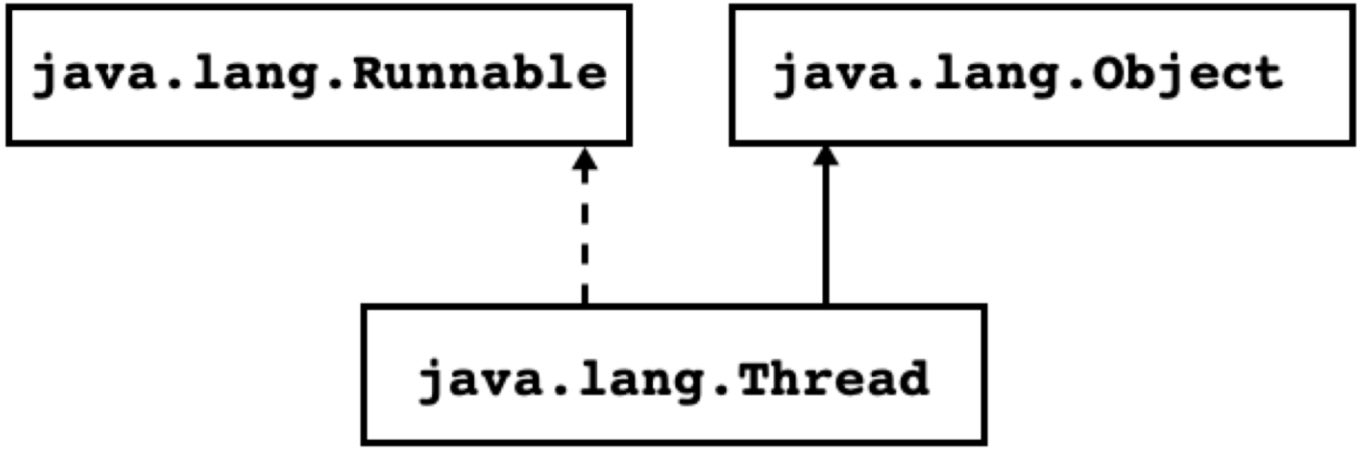
Runnable

- It is a functional interface declared in java.lang package.
- "void run( )" is a method / functional method of Runnable interface.
- Without sub classing java.lang.Thread, if we want to create thread then we should use Runnable interface.

```
class Task implements Runnable{
    private Thread thread;
    public Task( String name ) {
        this.thread = new Thread(this, name);
        this.thread.start();
    }
    @Override
    public void run() {
        //TODO : Write Business Logic Here
    }
}
```

Thread

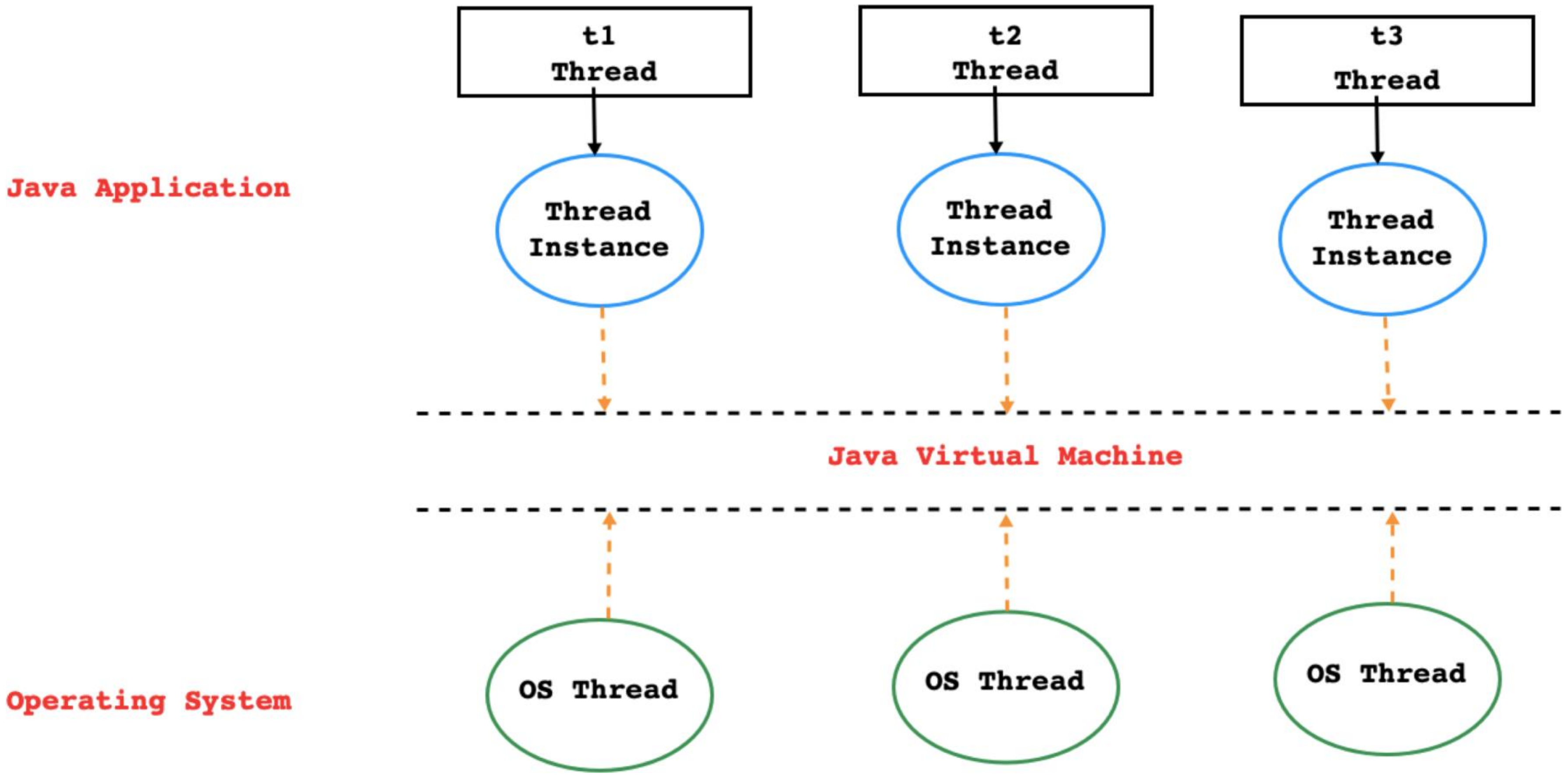
- It is a non final and concrete class declared in java.lang Package.
- In Java language, we can create thread using two ways:
  1. java.lang.Runnable interface
  2. java.lang.Thread class



- Java.lang.Thread is managed version(Java) of unmanaged thread(oS.)

Thread

- Instance of java.lang.Thread class is not an operating System thread. It represents operating System(actually kernel) thread.



Thread

- Thread creation using java.lang.Thread class:

```
class Task extends Thread{
    public Task( String name ) {
        //super( name );    //or
        this.setName(name);
        this.start();
    }
    @Override
    public void run() {
        //TODO : Write Business Logic Here
    }
}
```

Thread.State

- State is a static nested type(Enum) declared inside java.lang.Thread class.
- A thread can be in only one state at a given point in time. These states are virtual machine states which do not reflect any operating system thread states.
  - **NEW**
    - A thread that has not yet started is in this state.
  - **RUNNABLE**
    - A thread executing in the Java virtual machine is in this state.
  - **BLOCKED**
    - A thread that is blocked waiting for a monitor lock is in this state.
  - **WAITING**
    - A thread that is waiting indefinitely for another thread to perform a particular action is in this state.
  - **TIMED_WAITING**
    - A thread that is waiting for another thread to perform an action for up to a specified waiting time is in this state.
  - **TERMINATED**
    - A thread that has exited is in this state.

Fields and Constructor's of Thread Class

- **Field(s)**
  1. public static final int MIN_PRIoRITY
  2. public static final int NoRM_PRIoRITY
  3. public static final int MAX_PRIoRITY

- **Constructor(s)**
  1. public Thread()
  2. public Thread(String name)
  3. public Thread(Runnable target)
  4. public Thread(Runnable target, String name)
  5. public Thread(ThreadGroup group, String name)
  6. public Thread(ThreadGroup group, Runnable target)
  7. public Thread(ThreadGroup group, Runnable target, String name)

Methods Of Thread Class

1. public static <u>Thread</u> **currentThread**()
2. public static <u>void</u> **sleep**(long millis) throws InterruptedException
3. public <u>void</u> **start**()
4. public static <u>void</u> **yield**()
5. public final <u>String</u> **getName**()
6. public final <u>void</u> **setName**(String name)
7. public final <u>int</u> **getPriority**()
8. public final <u>void</u> **setPriority**(int newPriority)
9. public <u>Thread.State</u> **getState**()
10. public static <u>boolean</u> **interrupted**()
11. public <u>void</u> **interrupt**()
12. public final <u>boolean</u> **isAlive**()
13. public final <u>boolean</u> **isDaemon**()
14. public final <u>void</u> **setDaemon**(boolean on)
15. public final <u>void</u> **join**(long millis) throws InterruptedException
16. public <u>void</u> **setUncaughtExceptionHandler**(Thread.UncaughtExceptionHandler eh)

Main Thread

```java
public class Program {
    public static void main(String[] args){
        Thread thread = Thread.currentThread();
        System.out.println(thread.toString());  //Thread[main,5,main]
        System.out.println("Name      :    "+thread.getName());    //main
        System.out.println("Priority:    "+thread.getPriority());//5
        System.out.println("Group     :    "+thread.getThreadGroup().getName());//main
        System.out.println("State     :    "+thread.getState().name());    //RUNNABLE
        System.out.println("Type      :    "+(thread.isDaemon()?"Daemon":"User"));//User
        System.out.println("Status    :    "+(thread.isAlive()?"Alive":"Dead"));//Alive
    }
}
```

Finalizer / GC

```
class ResourceType{
    @Override
    protected void finalize() throws Throwable {
        Thread thread = Thread.currentThread();
        System.out.println(thread.toString());  //Thread[main,5,main]
        System.out.println("Name     :    "+thread.getName());     //Finalizer
        System.out.println("Priority:    "+thread.getPriority());//8
        System.out.println("Group    :    "+thread.getThreadGroup().getName());//system
        System.out.println("State    :    "+thread.getState().name());     //RUNNABLE
        System.out.println("Type     :    "+(thread.isDaemon()?"Daemon":"User"));//Daemon
        System.out.println("Status   :    "+(thread.isAlive()?"Alive":"Dead"));//Alive
    }
}
public class Program {
    public static void main(String[] args){
        ResourceType rt = new ResourceType();
        rt = null;
        System.gc();
    }
}
```

Thread Creation

Using Runnable Interface

```java
class Task implements Runnable{
    private Thread thread;
    public Task( String name ) {
        this.thread = new Thread(this, name);
        this.thread.start();
    }
    @Override
    public void run() {
        //TODO : Write Business Logic Here
    }
}
```

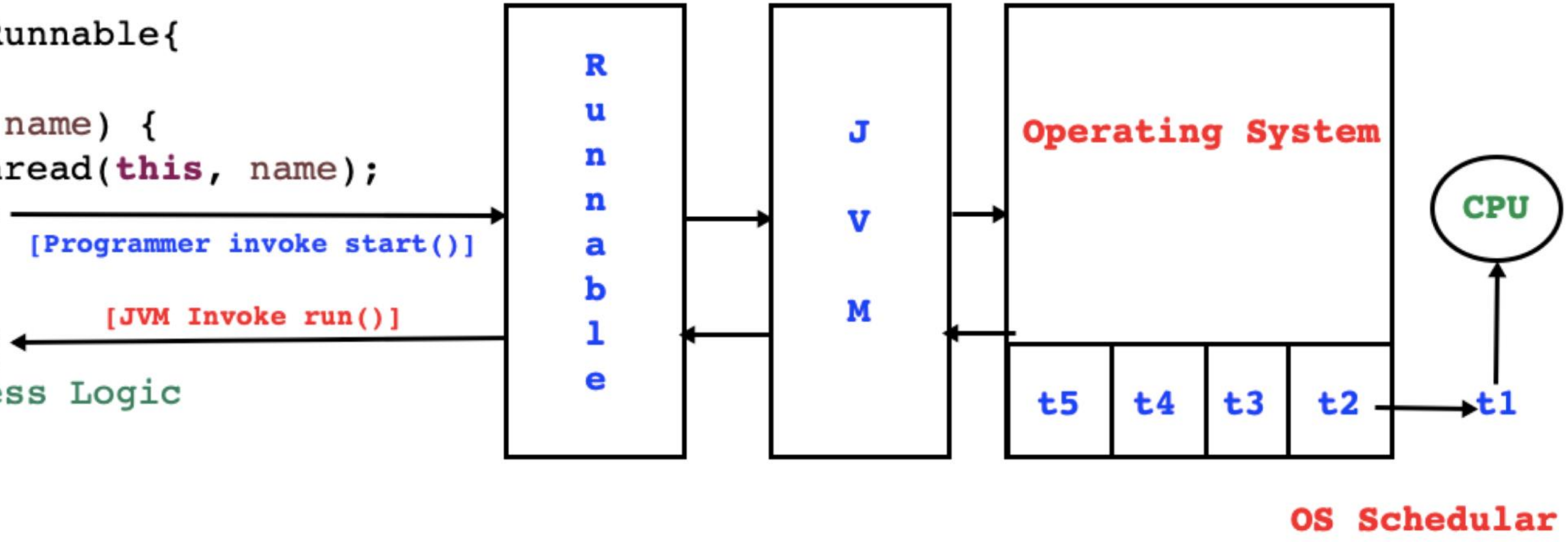
Using Thread class

```java
class Task extends Thread{
    public Task( String name ) {
        //super( name );    //or
        this.setName(name);
        this.start();
    }
    @Override
    public void run() {
        //TODO : Write Business Logic Here
    }
}
```

Relation Between start( ) and run( ) method.

- start() method do not call run method.
- If we call start() method on thread instance then JVM ask oS to map java thread instance to oS thread. When oS scheduler assign CPU to oS thread then oS ask JVM to invoke run() method on corresponding java instance.

```java
class Task implements Runnable{
    Thread thread;
    public Task(String name) {
        thread = new Thread(this, name);
        thread.start();
    }
    @Override
    public void run() {
        //TODO : Business Logic
    }
}
```



Thread termination

- If control come out of run( ) method then thread gets terminated.

- In following cases thread can come out of run( ) method:
  1. If JVM execute run method successfully.
  2. If JVM throw exception during execution of run method.
  3. If JVM execute return statement during execution of run method.

Blocking calls/Operations

- Following calls are considered as blocking calls in multithreaded programming:
  1. sleep( )
  2. suspend( ) [**Deprecated**]
  3. wait( )
  4. join
  5. input calls
- **sleep( ) method**
  - It is overloaded static method of java.lang.Thread class.
  - Syntax:
    - public static void sleep(long milliSeconds) throws InterruptedException
  - If we want to suspend current thread for specified number of milliseconds then we should use sleep method.
- **suspend( ) method**
  - It is deprecated non static method of java.lang.Thread class.
  - Syntax:
    - public final void suspend( )
  - If we want to suspend any thread for infinite time then we should use suspend(). method.

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  - If we want to suspend any thread for infinite time then we should use suspend(). method.

Thread Priorities

- In the Java programming language, every thread has a *priority.*

- Whenever the thread scheduler has a chance to pick a new thread, it prefers threads with higher priority.

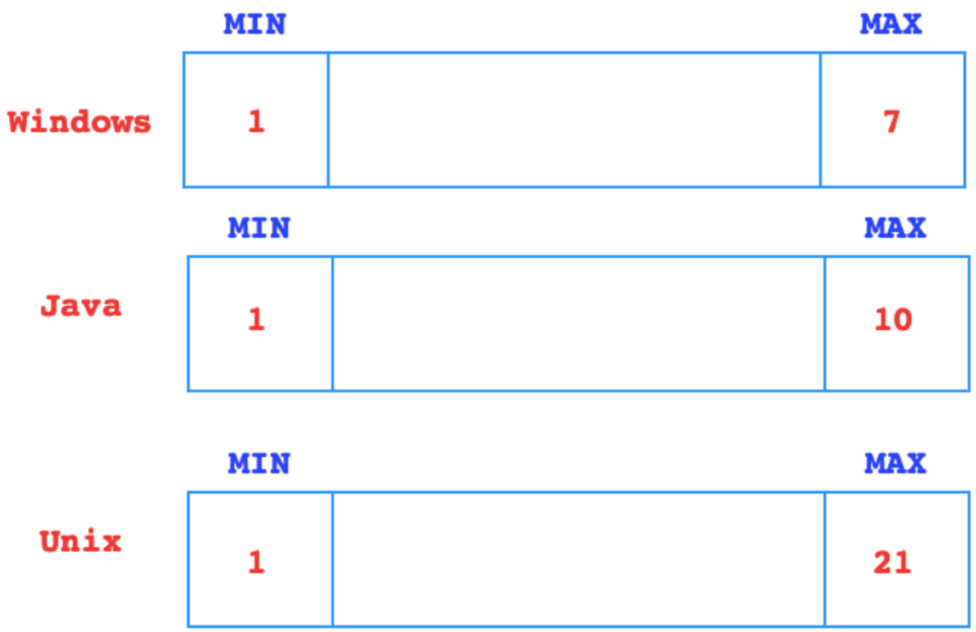
- By default, a thread inherits the priority of the thread that constructed it. We can increase or decrease the priority of any thread with the setPriority() method.

- We can set the priority to any value between MIN_PRIoRITY and MAX_PRIoRITY.

- If the priority is not in the range MIN_PRIoRITY to MAX_PRIoRITY the setPriority() method throws **IllegalArgumentException**

Thread Priorities

- Thread priorities are *highly system dependent*.
- When the virtual machine relies on the thread implementation of the host platform, the Java thread priorities are mapped to the priority levels of the host platform, which may have more or fewer thread priority levels.
- In the Oracle JVM for Linux, thread priorities are ignored altogether—all threads have the same priority.

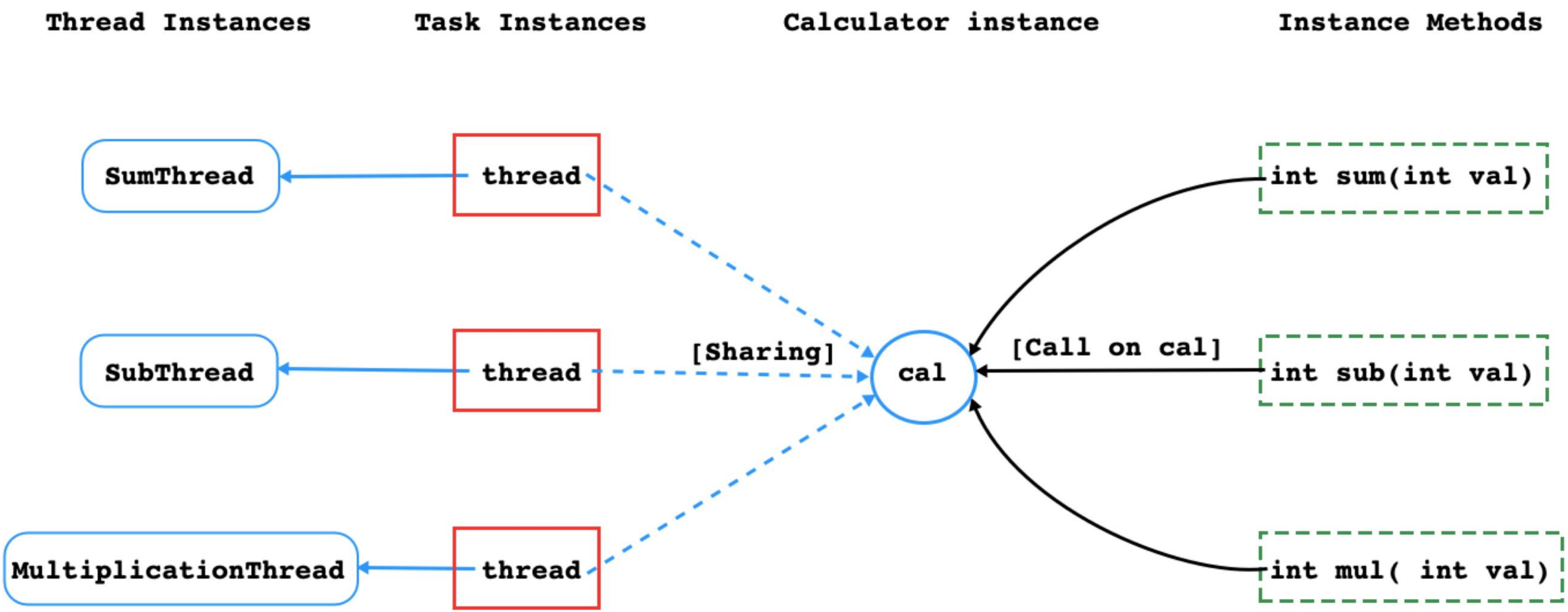


	Java	MS Windows	Unix
t1	8	7	16
t2	7	7	14
t3	2	2	4

Race Condition

- In most practical multithreaded applications, two or more threads need to share access to the same data. What happens if two threads have access to the same object and each calls a method that modifies the state of the object? As you might imagine, the threads can step on each other's toes.
- Depending on the order in which the data were accessed, corrupted objects can result. Such a situation is often called a *race condition*.
- To avoid corruption of shared data by multiple threads, you must learn how to *synchronize the access*.

Race Condition

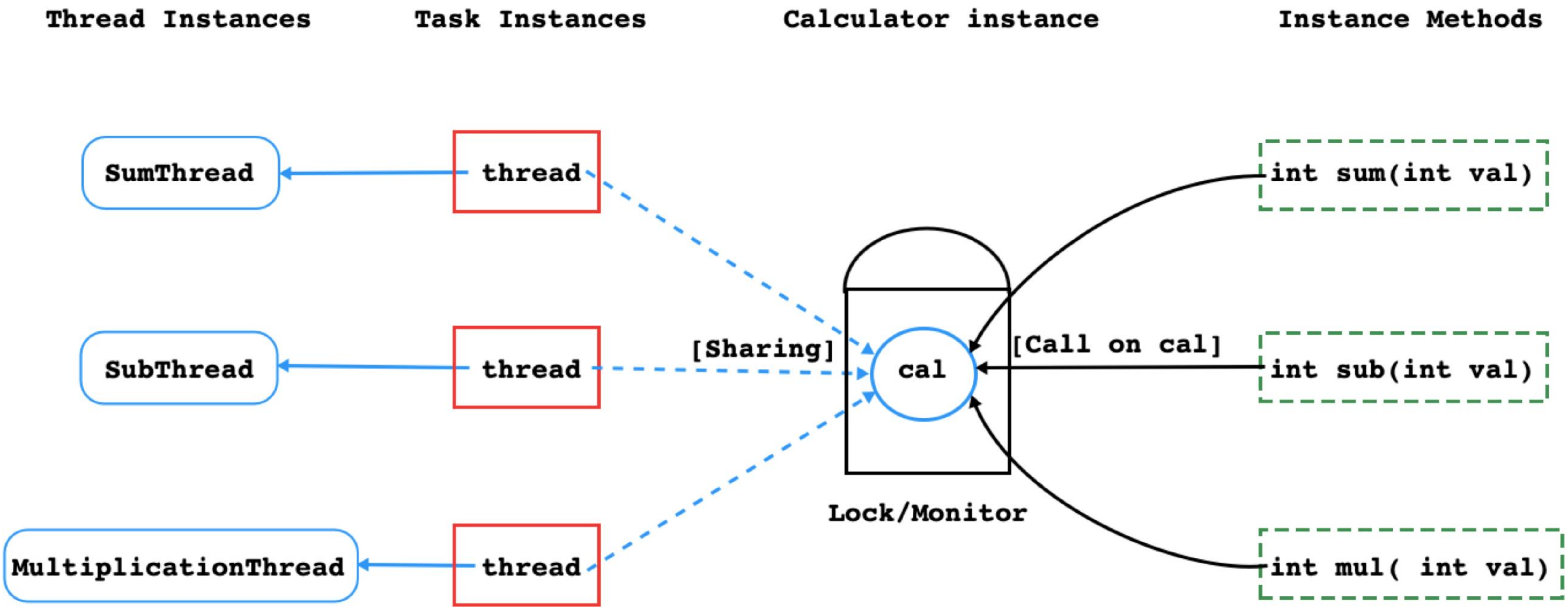


Lock Objects

- There are two mechanisms for protecting a code block from concurrent access.
  1. A synchronized keyword.
  2. The ReentrantLock class.
- The synchronized keyword automatically provides a lock as well as an associated “condition,” which makes it powerful and convenient for most cases that require explicit locking.
- The basic outline for protecting a code block with a ReentrantLock is:

```
myLock.lock(); // a ReentrantLock object try
{
    critical section
} finally {
    myLock.unlock(); //lock is unlocked even if an exception is thrown
}
```

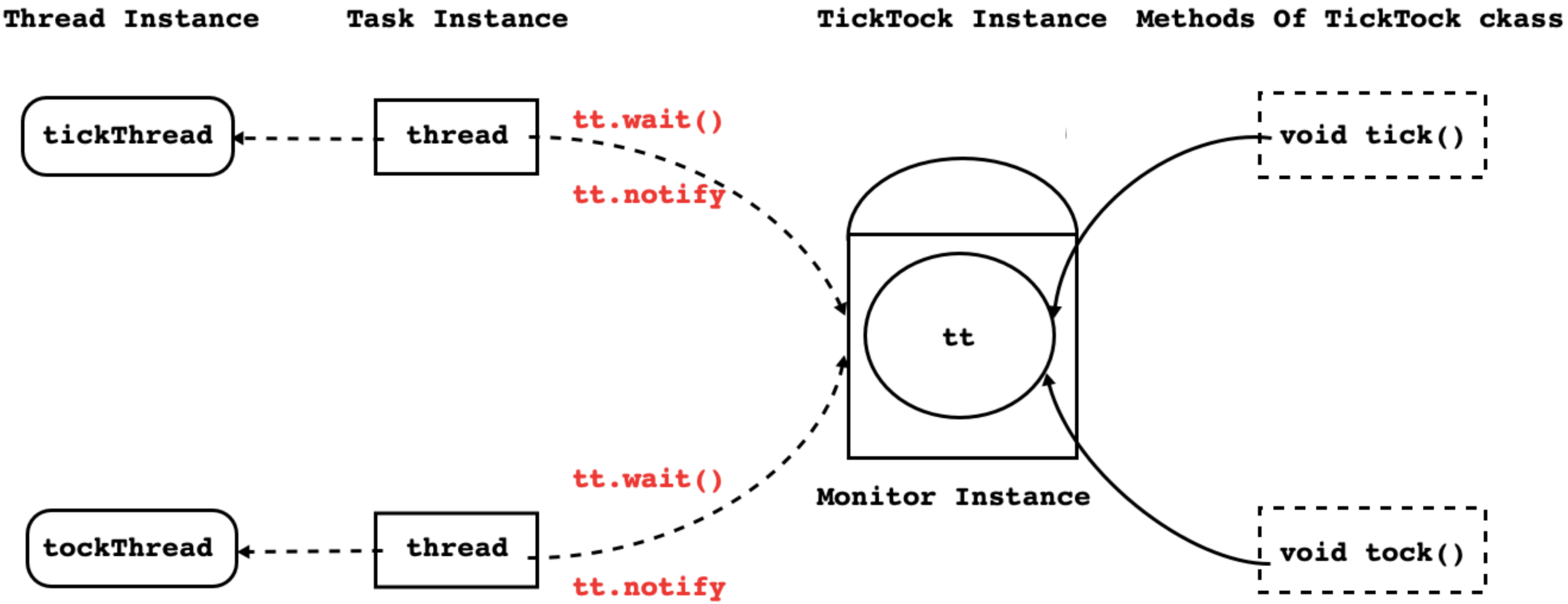
Monitor Concept



Thread Synchronization

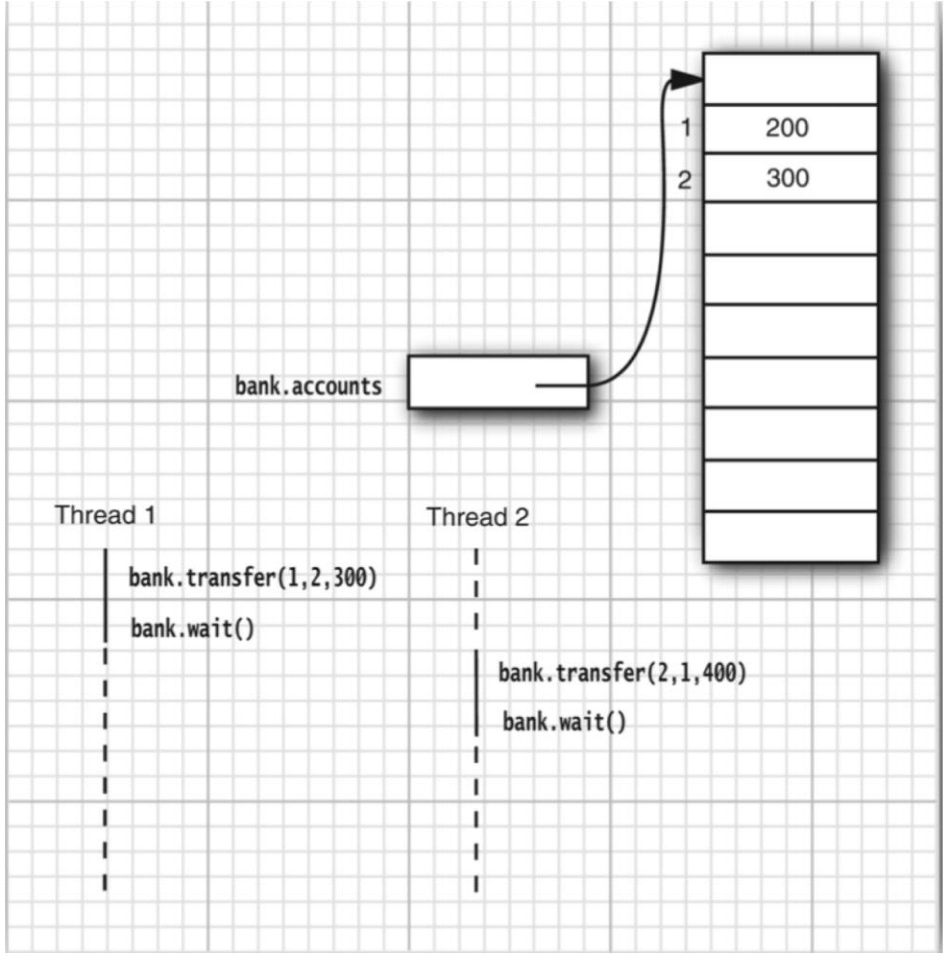
- Using same object's monitor, if multiple threads try to communicate with each other then it is called inter thread communication. And inter thread communication represents synchronization.
- To achieve synchronization, we can use methods declared in java.lang.Object class:
  1. public final void wait() throws InterruptedException
  2. public final void wait(long timeout) throws InterruptedException
  3. public final void wait(long timeout, int nanos) throws InterruptedException
  4. public final void notify()
  5. public final void notifyAll( )
- Resource locking / inter thread communication is based on monitor object associated with shared resource. Type of every shared resource is directly or indirectly extended from java.lang.Object class. Hence wait/notify/notifyAll methods are declared in java.lang.Object class.

Thread Synchronization

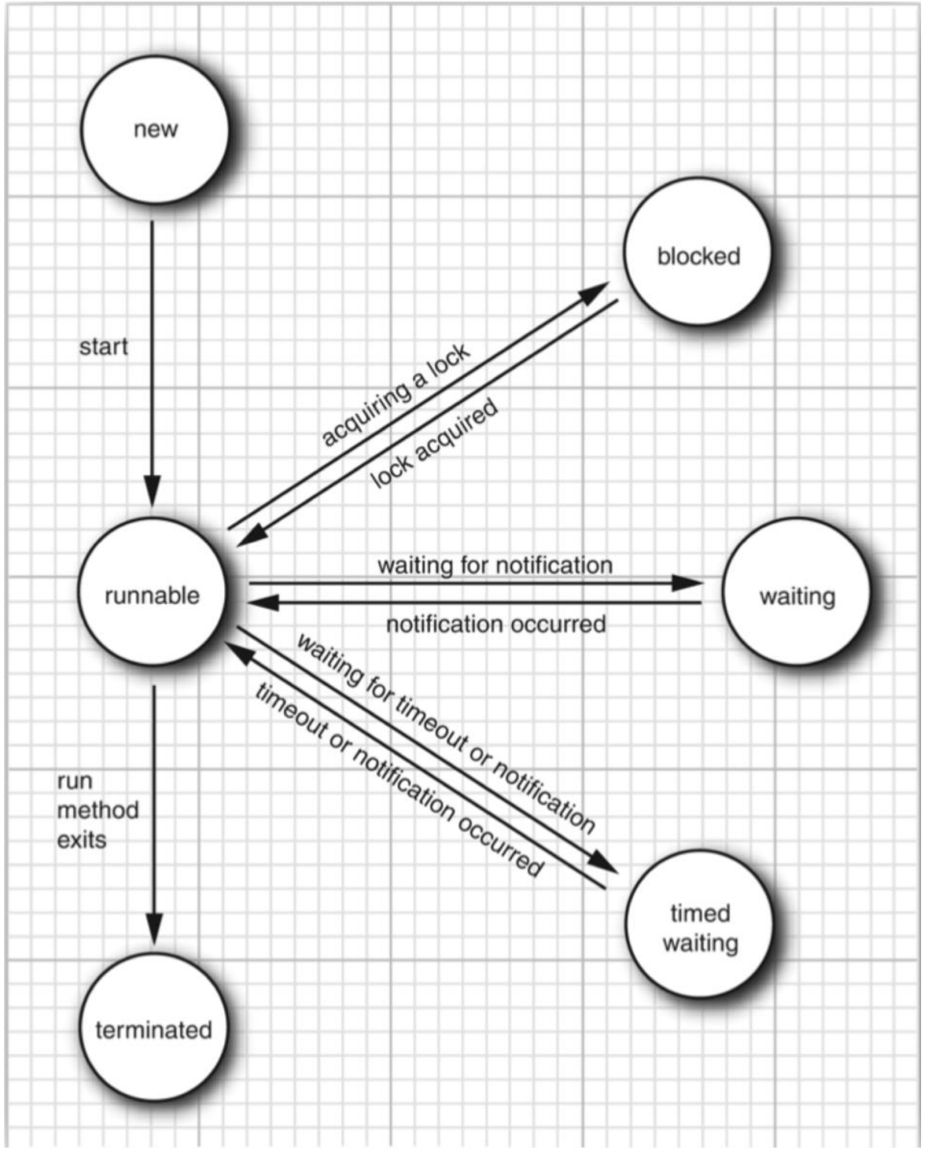


Deadlock

- *Deadlock* describes a situation where two or more threads are blocked forever, waiting for each other.



Thread Life Cycle



Thank You.

[akshita.chanchlani@sunbeaminfo.com]