UNIT III

Exceptions :

The **Exception Handling in Java** is one of the powerful *mechanism to handle the runtime errors* so that the normal flow of the application can be maintained.

In this tutorial, we will learn about Java exceptions, it's types, and the difference between checked and unchecked exceptions.

What is Exception in Java?

Dictionary Meaning: Exception is an abnormal condition.

In Java, an exception is an event that disrupts the normal flow of the program. It is an object which is thrown at runtime.

What is Exception Handling?

Exception Handling is a mechanism to handle runtime errors such as ClassNotFoundException, IOException, SQLException, RemoteException, etc.

dvantage of Exception Handling

The core advantage of exception handling is **to maintain the normal flow of the application**. An exception normally disrupts the normal flow of the application; that is why we need to handle exceptions. Let's consider a scenario:

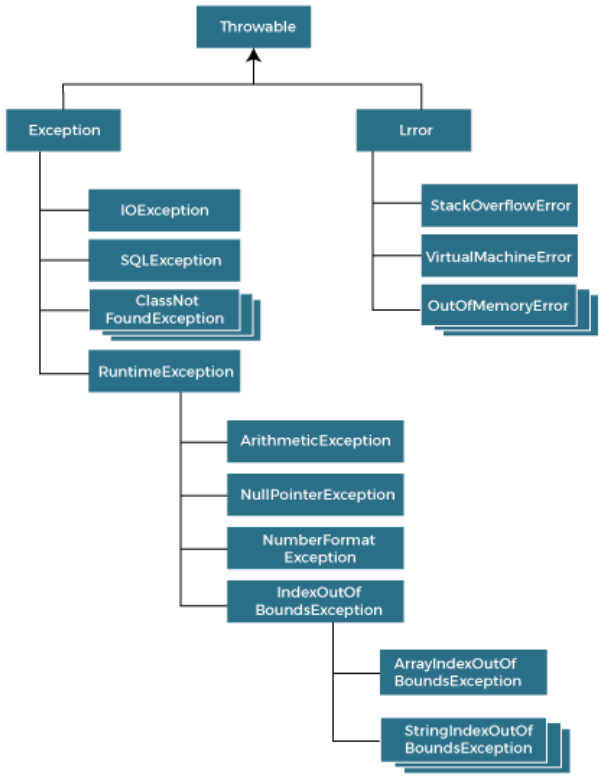
1. statement 1;
2. statement 2;
3. statement 3;
4. statement 4;
5. statement 5;//exception occurs
6. statement 6;
7. statement 7;
8. statement 8;

9. statement 9;
10. statement 10;

Suppose there are 10 statements in a Java program and an exception occurs at statement 5; the rest of the code will not be executed, i.e., statements 6 to 10 will not be executed. However, when we perform exception handling, the rest of the statements will be executed. That is why we use exception handling in Java.

Hierarchy of Java Exception classes

The java.lang.Throwable class is the root class of Java Exception hierarchy inherited by two subclasses: Exception and Error. The hierarchy of Java Exception classes is given below:

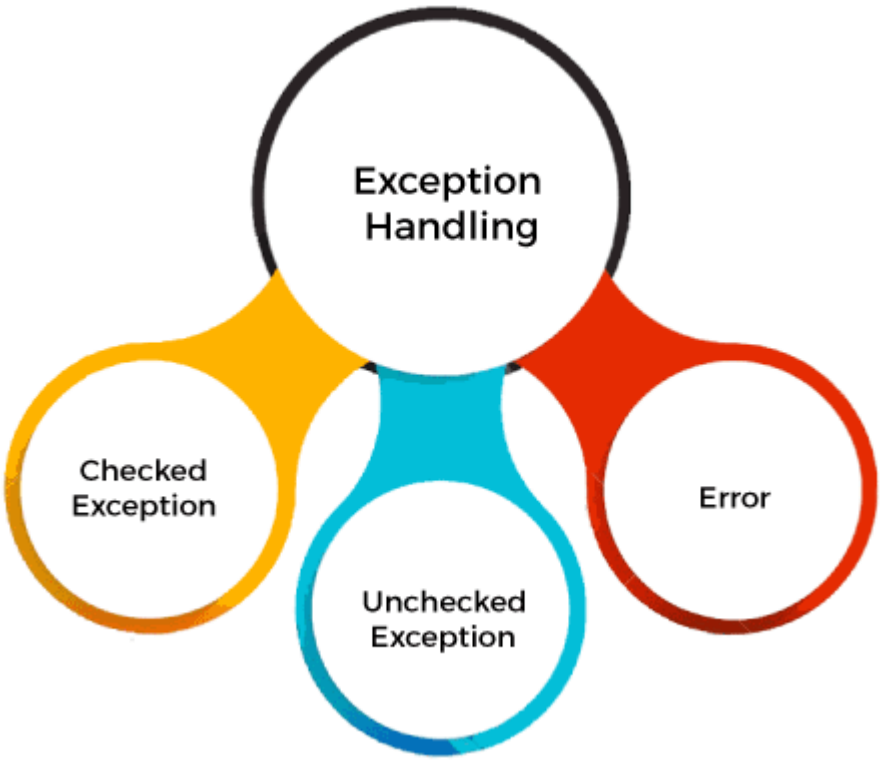


Types of Java Exceptions

There are mainly two types of exceptions: checked and unchecked. An error is considered as the unchecked exception. However, according to Oracle, there are three types of exceptions namely:

1. Checked Exception

2. Unchecked Exception
3. Error



Difference between Checked and Unchecked Exceptions

1) Checked Exception

The classes that directly inherit the Throwable class except RuntimeException and Error are known as checked exceptions. For example, IOException, SQLException, etc. Checked exceptions are checked at compile-time.

2) Unchecked Exception

The classes that inherit the RuntimeException are known as unchecked exceptions. For example, ArithmeticException, NullPointerException, ArrayIndexOutOfBoundsException, etc. Unchecked exceptions are not checked at compile-time, but they are checked at runtime.

3) Error

Error is irrecoverable. Some example of errors are OutOfMemoryError, VirtualMachineError, AssertionError etc.

Java Exception Keywords

Java provides five keywords that are used to handle the exception. The following table describes each.

Keyword	Description
try	The "try" keyword is used to specify a block where we should place an exception code. It means we can't use try block alone. The try block must be followed by either catch or finally.
catch	The "catch" block is used to handle the exception. It must be preceded by try block which means we can't use catch block alone. It can be followed by finally block later.
finally	The "finally" block is used to execute the necessary code of the program. It is executed whether an exception is handled or not.
throw	The "throw" keyword is used to throw an exception.
throws	The "throws" keyword is used to declare exceptions. It specifies that there may occur an exception in the method. It doesn't throw an exception. It is always used with method signature.

Java Exception Handling Example

Let's see an example of Java Exception Handling in which we are using a try-catch statement to handle the exception.

JavaExceptionExample.java

```
1. public class JavaExceptionExample{
2.  public static void main(String args[]){
3.   try{
4.     //code that may raise exception
5.     int data=100/0;
6.   }catch(ArithmeticException e){System.out.println(e);}
7.   //rest code of the program
8.   System.out.println("rest of the code...");
9.  }
10.}
```

Output:

```
Exception in thread main java.lang.ArithmeticException:/ by zero
rest of the code...
```

In the above example, 100/0 raises an ArithmeticException which is handled by a try-catch block.

Common Scenarios of Java Exceptions

There are given some scenarios where unchecked exceptions may occur. They are as follows:

1) A scenario where ArithmeticException occurs

If we divide any number by zero, there occurs an ArithmeticException.

```
1. int a=50/0;//ArithmeticException
```

2) A scenario where NullPointerException occurs

If we have a null value in any variable, performing any operation on the variable throws a NullPointerException.

```
1. String s=null;
2. System.out.println(s.length());//NullPointerException
```

3) A scenario where NumberFormatException occurs

If the formatting of any variable or number is mismatched, it may result into NumberFormatException. Suppose we have a string variable that has characters; converting this variable into digit will cause NumberFormatException.

```
1. String s="abc";
2. int i=Integer.parseInt(s);//NumberFormatException
```

4) A scenario where ArrayIndexOutOfBoundsException occurs

When an array exceeds to it's size, the ArrayIndexOutOfBoundsException occurs. there may be other reasons to occur ArrayIndexOutOfBoundsException. Consider the following statements.

```
1. int a[]=new int[5];
2. a[10]=50; //ArrayIndexOutOfBoundsException
```

Java try-catch block

Java try block

Java **try** block is used to enclose the code that might throw an exception. It must be used within the method.

If an exception occurs at the particular statement in the try block, the rest of the block code will not execute. So, it is recommended not to keep the code in try block that will not throw an exception.

Java try block must be followed by either catch or finally block.

Syntax of Java try-catch

```
1. try{
2. //code that may throw an exception
3. }catch(Exception_class_Name ref){}
```

Syntax of try-finally block

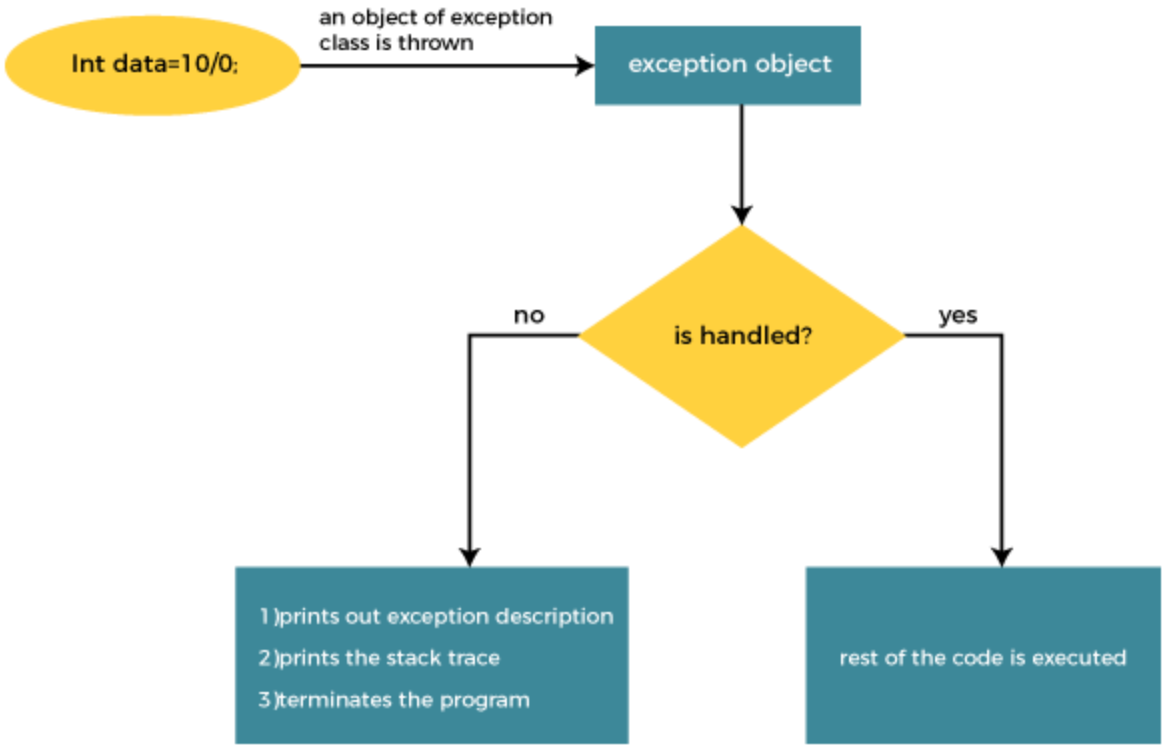
```
1. try{
2. //code that may throw an exception
3. }finally{}
```

Java catch block

Java catch block is used to handle the Exception by declaring the type of exception within the parameter. The declared exception must be the parent class exception (i.e., Exception) or the generated exception type. However, the good approach is to declare the generated type of exception.

The catch block must be used after the try block only. You can use multiple catch block with a single try block.

Internal Working of Java try-catch block



The JVM firstly checks whether the exception is handled or not. If exception is not handled, JVM provides a default exception handler that performs the following tasks:

- Prints out exception description.
- Prints the stack trace (Hierarchy of methods where the exception occurred).
- Causes the program to terminate.

But if the application programmer handles the exception, the normal flow of the application is maintained, i.e., rest of the code is executed.

Problem without exception handling

Let's try to understand the problem if we don't use a try-catch block.

Example 1

TryCatchExample1.java

```
1. public class TryCatchExample1 {
2.
3.     public static void main(String[] args) {
```

```
4.
5.         int data=50/0; //may throw exception
6.
7.         System.out.println("rest of the code");
8.
9.     }
10.
11.}
```

Output: Exception in thread "main" java.lang.ArithmeticException: / by zero

As displayed in the above example, the **rest of the code** is not executed (in such case, the **rest of the code** statement is not printed).

There might be 100 lines of code after the exception. If the exception is not handled, all the code below the exception won't be executed.

Solution by exception handling

Let's see the solution of the above problem by a java try-catch block.

Example 2

TryCatchExample2.java

```
1.  public class TryCatchExample2 {
2.
3.     public static void main(String[] args) {
4.         try
5.         {
6.         int data=50/0; //may throw exception
7.         }
8.            //handling the exception
9.         catch(ArithmeticException e)
10.        {
11.           System.out.println(e);
12.        }
13.        System.out.println("rest of the code");
```

```
14.  }
15.
16.}
```

Output:

```
java.lang.ArithmeticException: / by zero
rest of the code
```

Java Catch Multiple Exceptions

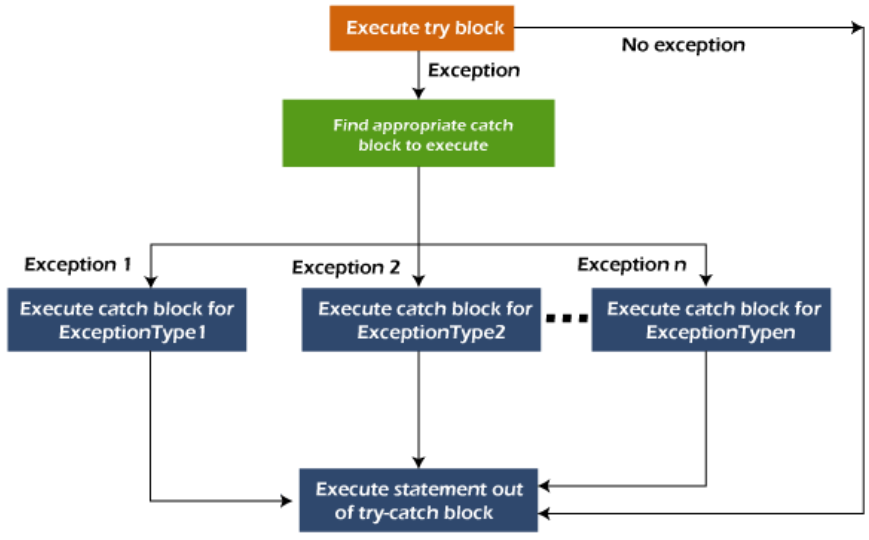
Java Multi-catch block

A try block can be followed by one or more catch blocks. Each catch block must contain a different exception handler. So, if you have to perform different tasks at the occurrence of different exceptions, use java multi-catch block.

Points to remember

- At a time only one exception occurs and at a time only one catch block is executed.
- All catch blocks must be ordered from most specific to most general, i.e. catch for ArithmeticException must come before catch for Exception.

Flowchart of Multi-catch Block



Example 1

Let's see a simple example of java multi-catch block.

MultipleCatchBlock1.java

```
1. public class MultipleCatchBlock1 {
2.
3.    public static void main(String[] args) {
4.
5.          try{
6.              int a[]=new int[5];
7.              a[5]=30/0;
8.             }
9.             catch(ArithmeticException e)
10.              {
11.               System.out.println("Arithmetic Exception occurs");
12.              }
13.            catch(ArrayIndexOutOfBoundsException e)
14.              {
15.               System.out.println("ArrayIndexOutOfBounds Exception occurs");
16.              }
17.            catch(Exception e)
18.              {
19.               System.out.println("Parent Exception occurs");
20.              }
21.            System.out.println("rest of the code");
22.   }
23.}
```

Output :

```
Arithmetic Exception occurs
rest of the code
```

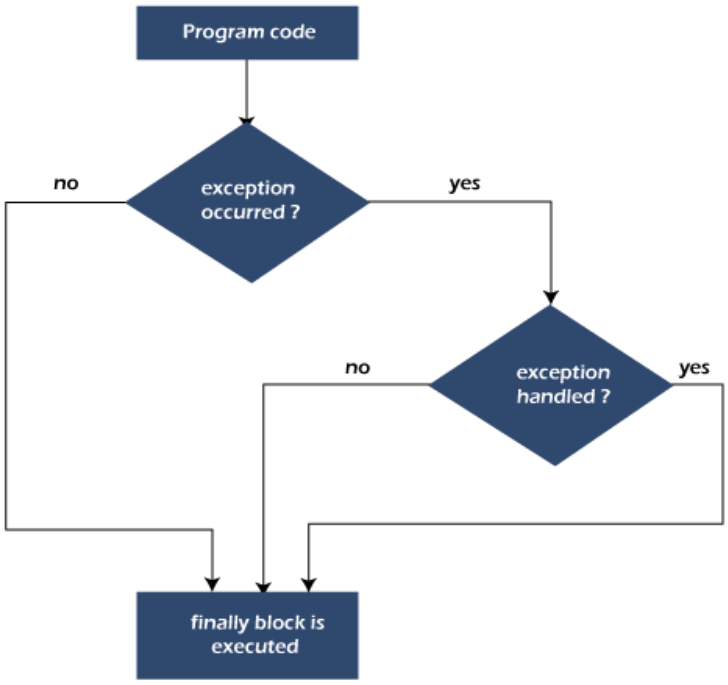
Java finally block

Java finally block is a block used to execute important code such as closing the connection, etc.

Java finally block is always executed whether an exception is handled or not. Therefore, it contains all the necessary statements that need to be printed regardless of the exception occurs or not.

The finally block follows the try-catch block.

Flowchart of finally block



Note: If you don't handle the exception, before terminating the program, JVM executes finally block (if any).

Why use Java finally block?

- finally block in Java can be used to put "**cleanup**" code such as closing a file, closing connection, etc.
- The important statements to be printed can be placed in the finally block.

Usage of Java finally

Let's see the different cases where Java finally block can be used.

Case 1: When an exception does not occur

Let's see the below example where the Java program does not throw any exception, and the finally block is executed after the try block.

TestFinallyBlock.java

```
1. class TestFinallyBlock {
2.   public static void main(String args[]){
3.   try{
4. //below code do not throw any exception
5.    int data=25/5;
6.    System.out.println(data);
7.   }
8. //catch won't be executed
9.   catch(NullPointerException e){
10.System.out.println(e);
11.}
12.//executed regardless of exception occurred or not
13. finally {
14.System.out.println("finally block is always executed");
15.}
16.
17.System.out.println("rest of phe code...");
18.  }
19.}
```

Output:

```
C:\Users\Anurati\Desktop\abcDemo>javac TestFinallyBlock.java

C:\Users\Anurati\Desktop\abcDemo>java TestFinallyBlock
5
finally block is always executed
rest of the code...
```

Case 2: When an exception occurr but not handled by the catch block

Let's see the the fillowing example. Here, the code throws an exception however the catch block cannot handle it. Despite this, the finally block is executed after the try block and then the program terminates abnormally.

TestFinallyBlock1.java

```
1.  public class TestFinallyBlock1{
2.      public static void main(String args[]){
3.
4.      try {
5.
6.       System.out.println("Inside the try block");
7.
8.       //below code throws divide by zero exception
9.      int data=25/0;
10.     System.out.println(data);
11.     }
12.     //cannot handle Arithmetic type exception
13.     //can only accept Null Pointer type exception
14.     catch(NullPointerException e){
15.      System.out.println(e);
16.     }
17.
18.     //executes regardless of exception occured or not
19.     finally {
20.      System.out.println("finally block is always executed");
21.     }
22.
23.     System.out.println("rest of the code...");
```

```
24.    }
25.  }
```

Output:

```
C:\Users\Anurati\Desktop\abcDemo>javac TestFinallyBlock1.java

C:\Users\Anurati\Desktop\abcDemo>java TestFinallyBlock1
Inside the try block
finally block is always executed
Exception in thread "main" java.lang.ArithmeticException: / by zero
        at TestFinallyBlock1.main(TestFinallyBlock1.java:9)
```

Case 3: When an exception occurs and is handled by the catch block

Example:

Let's see the following example where the Java code throws an exception and the catch block handles the exception. Later the finally block is executed after the try-catch block. Further, the rest of the code is also executed normally.

TestFinallyBlock2.java

```
1.  public class TestFinallyBlock2{
2.      public static void main(String args[]){
3.
4.      try {
5.
6.       System.out.println("Inside try block");
7.
8.       //below code throws divide by zero exception
9.      int data=25/0;
10.     System.out.println(data);
11.    }
12.
13.    //handles the Arithmetic Exception / Divide by zero exception
14.    catch(ArithmeticException e){
15.     System.out.println("Exception handled");
16.     System.out.println(e);
```

```
    }

    //executes regardless of exception occured or not
    finally {
      System.out.println("finally block is always executed");
    }

    System.out.println("rest of the code...");
    }
  }
```

Output:

```
C:\Users\Anurati\Desktop\abcDemo>javac TestFinallyBlock2.java

C:\Users\Anurati\Desktop\abcDemo>java TestFinallyBlock2
Inside try block
Exception handled
java.lang.ArithmeticException: / by zero
finally block is always executed
rest of the code...
```

Rule: For each try block there can be zero or more catch blocks, but only one finally block.

Note: The finally block will not be executed if the program exits (either by calling System.exit() or by causing a fatal error that causes the process to abort).

Java throw Exception

In Java, exceptions allows us to write good quality codes where the errors are checked at the compile time instead of runtime and we can create custom exceptions making the code recovery and debugging easier.

Java throw keyword

The Java throw keyword is used to throw an exception explicitly.

We specify the **exception** object which is to be thrown. The Exception has some message with it that provides the error description. These exceptions may be related to user inputs, server, etc.

We can throw either checked or unchecked exceptions in Java by throw keyword. It is mainly used to throw a custom exception. We will discuss custom exceptions later in this section.

We can also define our own set of conditions and throw an exception explicitly using throw keyword. For example, we can throw ArithmeticException if we divide a number by another number. Here, we just need to set the condition and throw exception using throw keyword.

The syntax of the Java throw keyword is given below.

throw Instance i.e.,

```
1. throw new exception_class("error message");
```

Let's see the example of throw IOException.

```
1. throw new IOException("sorry device error");
```

Where the Instance must be of type Throwable or subclass of Throwable. For example, Exception is the sub class of Throwable and the user-defined exceptions usually extend the Exception class.

Java throw keyword Example

Example 1: Throwing Unchecked Exception

In this example, we have created a method named validate() that accepts an integer as a parameter. If the age is less than 18, we are throwing the ArithmeticException otherwise print a message welcome to vote.

TestThrow1.java

In this example, we have created the validate method that takes integer value as a parameter. If the age is less than 18, we are throwing the ArithmeticException otherwise print a message welcome to vote.

```
1. public class TestThrow1 {
2.   //function to check if person is eligible to vote or not
3.   public static void validate(int age) {
```

```
4.        if(age<18) {
5.           //throw Arithmetic exception if not eligible to vote
6.           throw new ArithmeticException("Person is not eligible to vote");
7.        }
8.        else {
9.           System.out.println("Person is eligible to vote!!");
10.       }
11.    }
12.    //main method
13.    public static void main(String args[]){
14.       //calling the function
15.       validate(13);
16.       System.out.println("rest of the code...");
17.    }
18.}
```

Output:

```
C:\Users\Anurati\Desktop\abcDemo>javac TestThrow1.java

C:\Users\Anurati\Desktop\abcDemo>java TestThrow1
Exception in thread "main" java.lang.ArithmeticException: Person is not eligible to
 vote
        at TestThrow1.validate(TestThrow1.java:8)
        at TestThrow1.main(TestThrow1.java:18)
```

The above code throw an unchecked exception. Similarly, we can also throw unchecked and user defined exceptions.

Note: If we throw unchecked exception from a method, it is must to handle the exception or declare in throws clause.

If we throw a checked exception using throw keyword, it is must to handle the exception using catch block or the method must declare it using throws declaration.

Example 2: Throwing Checked Exception

Note: Every subclass of Error and RuntimeException is an unchecked exception in Java. A checked exception is everything else under the Throwable class.

TestThrow2.java

```
1. import java.io.*;
2.
3. public class TestThrow2 {
4.
5.    //function to check if person is eligible to vote or not
6.    public static void method() throws FileNotFoundException {
7.
8.       FileReader file = new FileReader("C:\\Users\\Anurati\\Desktop\\abc.txt");
9.       BufferedReader fileInput = new BufferedReader(file);
10.
11.
12.      throw new FileNotFoundException();
13.
14.   }
15.   //main method
16.   public static void main(String args[]){
17.      try
18.      {
19.         method();
20.      }
21.      catch (FileNotFoundException e)
22.      {
23.         e.printStackTrace();
24.      }
25.      System.out.println("rest of the code...");
26.  }
27.}
```

Output:

```
C:\Users\Anurati\Desktop\abcDemo>javac TestThrow2.java

C:\Users\Anurati\Desktop\abcDemo>java TestThrow2
java.io.FileNotFoundException
        at TestThrow2.method(TestThrow2.java:12)
        at TestThrow2.main(TestThrow2.java:22)
rest of the code...
```

Example 3: Throwing User-defined Exception

exception is everything else under the Throwable class.

TestThrow3.java

```
1. // class represents user-defined exception
2. class UserDefinedException extends Exception
3. {
4.     public UserDefinedException(String str)
5.     {
6.         // Calling constructor of parent Exception
7.         super(str);
8.     }
9. }
10. // Class that uses above MyException
11. public class TestThrow3
12. {
13.     public static void main(String args[])
14.     {
15.         try
16.         {
17.             // throw an object of user defined exception
18.             throw new UserDefinedException("This is user-defined exception");
19.         }
20.         catch (UserDefinedException ude)
21.         {
22.             System.out.println("Caught the exception");
23.             // Print the message from MyException object
24.             System.out.println(ude.getMessage());
```

```
25.     }
26.   }
27.}
```

Output:

```
C:\Users\Anurati\Desktop\abcDemo>javac TestThrow3.java

C:\Users\Anurati\Desktop\abcDemo>java TestThrow3
Caught the exception
This is user-defined exception
```

Java throws keyword

The **Java throws keyword** is used to declare an exception. It gives an information to the programmer that there may occur an exception. So, it is better for the programmer to provide the exception handling code so that the normal flow of the program can be maintained.

Exception Handling is mainly used to handle the checked exceptions. If there occurs any unchecked exception such as NullPointerException, it is programmers' fault that he is not checking the code before it being used.

Syntax of Java throws

```
1. return_type method_name() throws exception_class_name{
2. //method code
3. }
```

Which exception should be declared?

Ans: Checked exception only, because:

- **unchecked exception:** under our control so we can correct our code.
- **error:** beyond our control. For example, we are unable to do anything if there occurs VirtualMachineError or StackOverflowError.

Advantage of Java throws keyword

Now Checked Exception can be propagated (forwarded in call stack).

It provides information to the caller of the method about the exception.

Java throws Example

Let's see the example of Java throws clause which describes that checked exceptions can be propagated by throws keyword.

Testthrows1.java

```
1. import java.io.IOException;
2. class Testthrows1{
3.   void m()throws IOException{
4.     throw new IOException("device error");//checked exception
5.   }
6.   void n()throws IOException{
7.     m();
8.   }
9.   void p(){
10.   try{
11.    n();
12.   }catch(Exception e){System.out.println("exception handled");}
13. }
14. public static void main(String args[]){
15.   Testthrows1 obj=new Testthrows1();
16.   obj.p();
17.   System.out.println("normal flow...");
18. }
19.}
```

Output:

```
exception handled
normal flow...
```

Rule: If we are calling a method that declares an exception, we must either caught or declare the exception.

There are two cases:

1. **Case 1:** We have caught the exception i.e. we have handled the exception using try/catch block.
2. **Case 2:** We have declared the exception i.e. specified throws keyword with the method.

Case 1: Handle Exception Using try-catch block

In case we handle the exception, the code will be executed fine whether exception occurs during the program or not.

Testthrows2.java

```
1. import java.io.*;
2. class M{
3.  void method()throws IOException{
4.   throw new IOException("device error");
5.  }
6. }
7. public class Testthrows2{
8.    public static void main(String args[]){
9.     try{
10.     M m=new M();
11.     m.method();
12.    }catch(Exception e){System.out.println("exception handled");}
13.
14.    System.out.println("normal flow...");
15.  }
16.}
```

Output:

```
exception handled
    normal flow...
```

Case 2: Declare Exception

- In case we declare the exception, if exception does not occur, the code will be executed fine.
- In case we declare the exception and the exception occurs, it will be thrown at runtime because **throws** does not handle the exception.

Let's see examples for both the scenario.

A) If exception does not occur

Testthrows3.java

```
1. import java.io.*;
2. class M{
3.  void method()throws IOException{
4.   System.out.println("device operation performed");
5.  }
6. }
7. class Testthrows3{
8.    public static void main(String args[])throws IOException{//declare exception
9.      M m=new M();
10.    m.method();
11.
12.   System.out.println("normal flow...");
13.  }
14.}
```

Output:

```
device operation performed
    normal flow...
```

B) If exception occurs

Testthrows4.java

```
1. import java.io.*;
2. class M{
3.  void method()throws IOException{
4.   throw new IOException("device error");
5.  }
6. }
7. class Testthrows4{
8.    public static void main(String args[])throws IOException{//declare exception
9.      M m=new M();
10.     m.method();
11.
12.   System.out.println("normal flow...");
13.  }
14.}
```

Output:

```
Exception in thread "main" java.io.IOException: device error
    at M.method(Testthrows4.java:4)
    at Testthrows4.main(Testthrows4.java:10)
```

Difference between throw and throws in Java

The throw and throws is the concept of exception handling where the throw keyword throw the exception explicitly from a method or a block of code whereas the throws keyword is used in signature of the method.

There are many differences between throw and throws keywords. A list of differences between throw and throws are given below:

Sr. no.	Basis of Differences	throw	throws
1.	Definition	Java throw keyword is used throw an exception explicitly in the code, inside the function or the block of code.	Java throws keyword is used in the method signature to declare an exception which might be thrown by the function while the execution of the code.
2.	Type of exception Using throw keyword, we can only propagate unchecked exception i.e., the checked exception cannot be propagated using throw only.	Using throws keyword, we can declare both checked and unchecked exceptions. However, the throws keyword can be used to propagate checked exceptions only.	
3.	Syntax	The throw keyword is followed by an instance of Exception to be thrown.	The throws keyword is followed by class names of Exceptions to be thrown.
4.	Declaration	throw is used within the method.	throws is used with the method signature.
5.	Internal implementation	We are allowed to throw only one exception at a time i.e. we cannot throw multiple exceptions.	We can declare multiple exceptions using throws keyword that can be thrown by the method. For example, main() throws IOException, SQLException.

Difference between final, finally and finalize

The final, finally, and finalize are keywords in Java that are used in exception handling. Each of these keywords has a different functionality. The basic difference between final, finally and finalize is that the **final** is an access modifier, **finally** is the block in Exception Handling and **finalize** is the method of object class.

Along with this, there are many differences between final, finally and finalize. A list of differences between final, finally and finalize are given below:

Sr. no.	Key	final	finally	finalize
1.	Definition	final is the keyword and access modifier which is used to apply restrictions on a class, method or variable.	finally is the block in Java Exception Handling to execute the important code whether the exception occurs or not.	finalize is the method in Java which is used to perform clean up processing just before object is garbage collected.
2.	Applicable to	Final keyword is used with the classes, methods and variables.	Finally block is always related to the try and catch block in exception handling.	finalize() method is used with the objects.
3.	Functionality	(1) Once declared, final variable becomes constant and cannot be modified. (2) final method cannot be overridden by sub class. (3) final class cannot be inherited.	(1) finally block runs the important code even if exception occurs or not. (2) finally block cleans up all the resources used in try block	finalize method performs the cleaning activities with respect to the object before its destruction.
4.	Execution	Final method is executed only when we call it.	Finally block is executed as soon as the try-catch block is executed. It's execution is not dependant on the exception.	finalize method is executed just before the object is destroyed.

Multithreading :

Multithreading in Java is a process of executing multiple threads simultaneously.

A thread is a lightweight sub-process, the smallest unit of processing. Multiprocessing and multithreading, both are used to achieve multitasking.

However, we use multithreading than multiprocessing because threads use a shared memory area. They don't allocate separate memory area so saves memory, and context-switching between the threads takes less time than process.

Java Multithreading is mostly used in games, animation, etc.

Advantages of Java Multithreading

1) It **doesn't block the user** because threads are independent and you can perform multiple operations at the same time.

2) You **can perform many operations together, so it saves time**.

3) Threads are **independent**, so it doesn't affect other threads if an exception occurs in a single thread.

Multitasking

Multitasking is a process of executing multiple tasks simultaneously. We use multitasking to utilize the CPU. Multitasking can be achieved in two ways:

- Process-based Multitasking (Multiprocessing)
- Thread-based Multitasking (Multithreading)

1) Process-based Multitasking (Multiprocessing)

- Each process has an address in memory. In other words, each process allocates a separate memory area.
- A process is heavyweight.
- Cost of communication between the process is high.
- Switching from one process to another requires some time for saving and loading registers, memory maps, updating lists, etc.

2) Thread-based Multitasking (Multithreading)

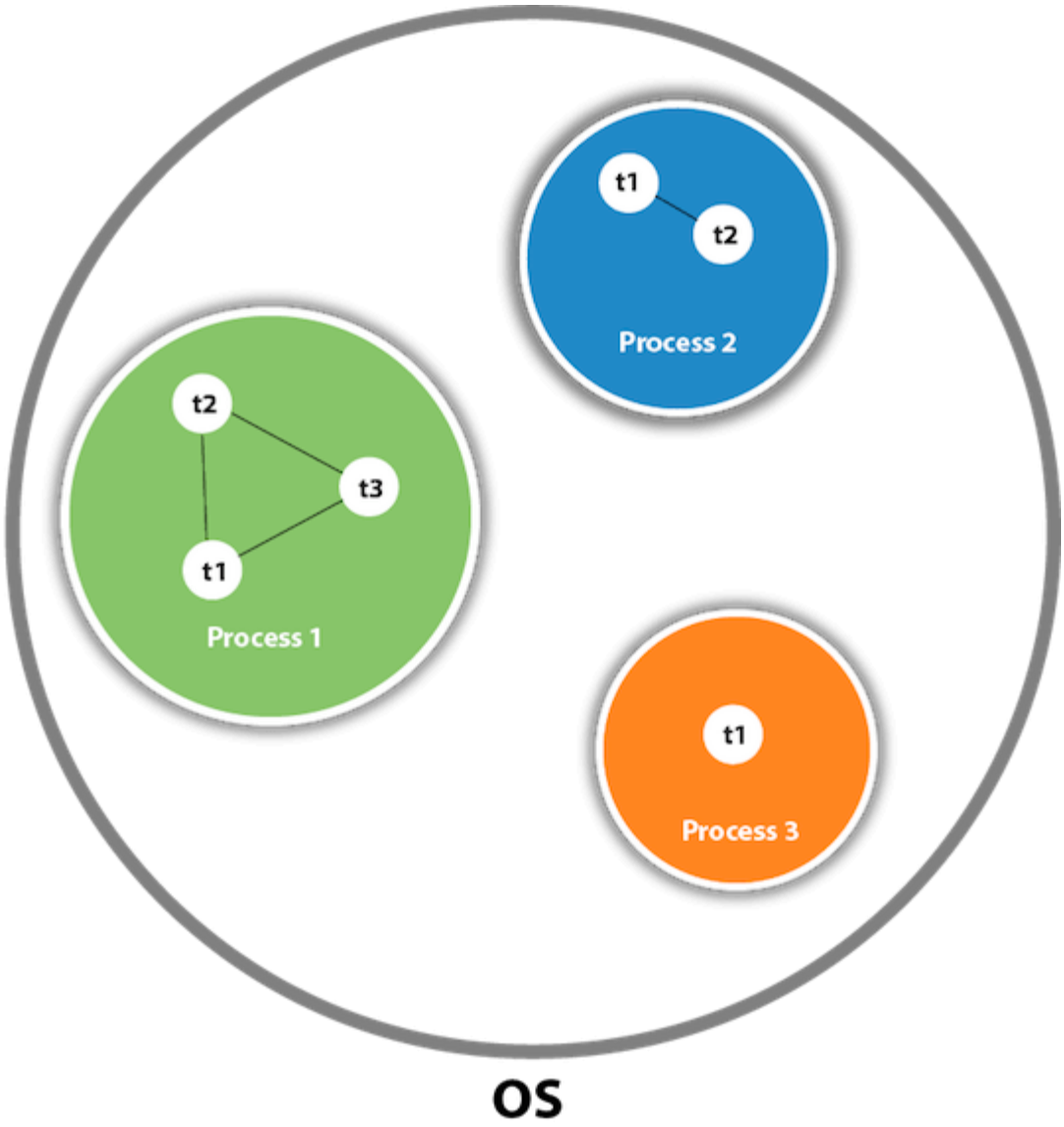
- Threads share the same address space.
- A thread is lightweight.
- Cost of communication between the thread is low.

Note: At least one process is required for each thread.

What is Thread in java

A thread is a lightweight subprocess, the smallest unit of processing. It is a separate path of execution.

Threads are independent. If there occurs exception in one thread, it doesn't affect other threads. It uses a shared memory area.



As shown in the above figure, a thread is executed inside the process. There is context-switching between the threads. There can be multiple processes inside the OS, and one process can have multiple threads.

Note: At a time one thread is executed only.

Java Thread class

Java provides **Thread class** to achieve thread programming. Thread class provides constructors and methods to create and perform operations on a thread. Thread class extends Object class and implements Runnable interface.

Java Thread Methods

S.N.	Modifier and Type	Method	Description
1)	void	start()	It is used to start the execution of the thread.
2)	void	run()	It is used to do an action for a thread.
3)	static void	sleep()	It sleeps a thread for the specified amount of time.
4)	static Thread	currentThread()	It returns a reference to the currently executing thread object.
5)	void	join()	It waits for a thread to die.
6)	int	getPriority()	It returns the priority of the thread.
7)	void	setPriority()	It changes the priority of the thread.
8)	String	getName()	It returns the name of the thread.
9)	void	setName()	It changes the name of the thread.
10)	long	getId()	It returns the id of the thread.
11)	boolean	isAlive()	It tests if the thread is alive.
12)	static void	yield()	It causes the currently executing thread object to pause and allow other threads to execute temporarily.
13)	void	suspend()	It is used to suspend the thread.
14)	void	resume()	It is used to resume the suspended thread.
15)	void	stop()	It is used to stop the thread.
16)	void	destroy()	It is used to destroy the thread group and all of its subgroups.
17)	boolean	isDaemon()	It tests if the thread is a daemon thread.
31)	void	notify()	It is used to give the notification for only one thread which is waiting for a particular object.
32)	void	notifyAll()	It is used to give the notification to all waiting threads of a particular object.

Life cycle of a Thread (Thread States)

In Java, a thread always exists in any one of the following states. These states are:

1. New
2. Active
3. Blocked / Waiting
4. Timed Waiting
5. Terminated

Explanation of Different Thread States

New: Whenever a new thread is created, it is always in the new state. For a thread in the new state, the code has not been run yet and thus has not begun its execution.

Active: When a thread invokes the start() method, it moves from the new state to the active state. The active state contains two states within it: one is **runnable**, and the other is **running**.

- **Runnable:** A thread, that is ready to run is then moved to the runnable state. In the runnable state, the thread may be running or may be ready to run at any given instant of time. It is the duty of the thread scheduler to provide the thread time to run, i.e., moving the thread the running state.
  A program implementing multithreading acquires a fixed slice of time to each individual thread. Each and every thread runs for a short span of time and when that allocated time slice is over, the thread voluntarily gives up the CPU to the other thread, so that the other threads can also run for their slice of time. Whenever such a scenario occurs, all those threads that are willing to run, waiting for their turn to run, lie in the runnable state. In the runnable state, there is a queue where the threads lie.
- **Running:** When the thread gets the CPU, it moves from the runnable to the running state. Generally, the most common change in the state of a thread is from runnable to running and again back to runnable.

Blocked or Waiting: Whenever a thread is inactive for a span of time (not permanently) then, either the thread is in the blocked state or is in the waiting state.

For example, a thread (let's say its name is A) may want to print some data from the printer. However, at the same time, the other thread (let's say its name is B) is using the printer to print some data. Therefore, thread A has to wait for thread B to use the printer. Thus, thread A is in the blocked state. A thread in the blocked state is unable to perform any execution and thus never consume any cycle of the Central Processing Unit (CPU). Hence, we can say that thread A remains idle until the thread scheduler reactivates thread A, which is in the waiting or blocked state.

When the main thread invokes the join() method then, it is said that the main thread is in the waiting state. The main thread then waits for the child threads to complete their tasks. When the child threads complete their job, a notification is sent to the main thread, which again moves the thread from waiting to the active state.

If there are a lot of threads in the waiting or blocked state, then it is the duty of the thread scheduler to determine which thread to choose and which one to reject, and the chosen thread is then given the opportunity to run.

Timed Waiting: Sometimes, waiting for leads to starvation. For example, a thread (its name is A) has entered the critical section of a code and is not willing to leave that critical section. In such a scenario, another thread (its name is B) has to wait forever, which leads to starvation. To avoid such scenario, a timed waiting state is given to thread B. Thus, thread lies in the waiting state for a specific span of time, and not forever. A real example of timed waiting is when we invoke the sleep() method on a specific thread. The sleep() method puts the thread in the timed wait state. After the time runs out, the thread wakes up and start its execution from when it has left earlier.

Terminated: A thread reaches the termination state because of the following reasons:

- When a thread has finished its job, then it exists or terminates normally.
- **Abnormal termination:** It occurs when some unusual events such as an unhandled exception or segmentation fault.

A terminated thread means the thread is no more in the system. In other words, the thread is dead, and there is no way one can respawn (active after kill) the dead thread.

The following diagram shows the different states involved in the life cycle of a thread.

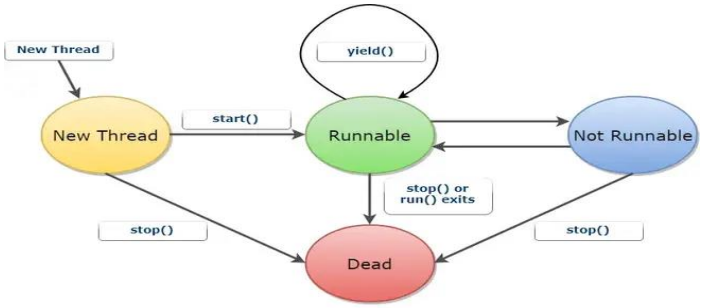


Fig: Life Cycle of a Thread in Java

Implementation of Thread States

In Java, one can get the current state of a thread using the **Thread.getState()** method. The **java.lang.Thread.State** class of Java provides the constants ENUM to represent the state of a thread. These constants are:

1. **public static final** Thread.State NEW

   It represents the first state of a thread that is the NEW state.

1. **public static final** Thread.State RUNNABLE

   It represents the runnable state.It means a thread is waiting in the queue to run.

1. **public static final** Thread.State BLOCKED

   It represents the blocked state. In this state, the thread is waiting to acquire a lock.

1. **public static final** Thread.State WAITING

   It represents the waiting state. A thread will go to this state when it invokes the Object.wait() method, or Thread.join() method with no timeout. A thread in the waiting state is waiting for another thread to complete its task.

1. **public static final** Thread.State TIMED_WAITING

   It represents the timed waiting state. The main difference between waiting and timed waiting is the time constraint. Waiting has no time constraint, whereas timed waiting has the time constraint. A thread invoking the following method reaches the timed waiting state.

   - sleep

- join with timeout
- wait with timeout
- parkUntil
- parkNanos

1. **public static final** Thread.State TERMINATED

   It represents the final state of a thread that is terminated or dead. A terminated thread means it has completed its execution.

Java Program for Demonstrating Thread States

The following Java program shows some of the states of a thread defined above.

```
class MultiThread extends Thread{
   public void run(){
      System.out.println("Running Thread Name: "+
this.currentThread().getName());
      System.out.println("Running Thread Priority: "+
this.currentThread().getPriority());
   }
}
public class MultiThrd {
   public static void main(String[] args) {
                try
                {
                        MultiThread multiThread1 = new MultiThread();
                        multiThread1.setName("First Thread");
                        multiThread1.setPriority(Thread.MIN_PRIORITY);
```

```
                MultiThread multiThread2 = new MultiThread();
                multiThread2.setName("Second Thread");
                multiThread2.setPriority(Thread.MAX_PRIORITY);

                MultiThread multiThread3 = new MultiThread();
                multiThread3.setName("Third Thread");

                multiThread1.start();
                multiThread1.sleep(2000);
                multiThread2.start();multiThread2.sleep(4000);
                multiThread3.start();
            }
            catch(InterruptedException e)
            {
                System.out.println(e);
            }
    }
}
```

Output :

```
Running Thread Name: First Thread
Running Thread Priority: 1
Running Thread Name: Second Thread
Running Thread Priority: 10
Running Thread Name: Third Thread
Running Thread Priority: 5
```

Package :

A **java package** is a group of similar types of classes, interfaces and sub-packages.

Package in java can be categorized in two form, built-in package and user-defined package.

There are many built-in packages such as java, lang, awt, javax, swing, net, io, util, sql etc.

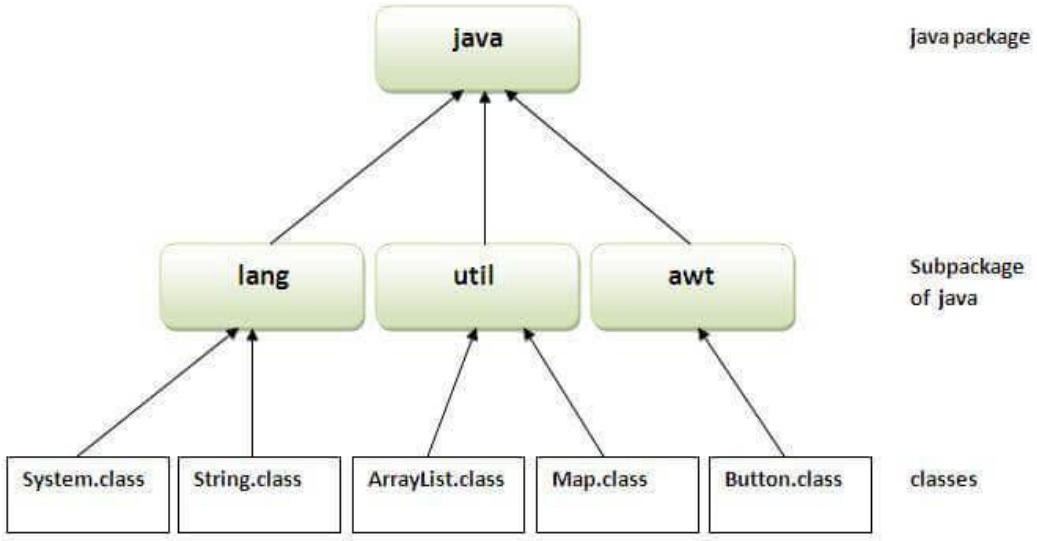
Here, we will have the detailed learning of creating and using user-defined packages.

Advantage of Java Package

1) Java package is used to categorize the classes and interfaces so that they can be easily maintained.

2) Java package provides access protection.

3) Java package removes naming collision.



Simple example of java package

The **package keyword** is used to create a package in java.

```
1. //save as Simple.java
2. package mypack;
3. public class Simple{
4.  public static void main(String args[]){
5.    System.out.println("Welcome to package");
6.   }
7. }
```

How to compile java package

If you are not using any IDE, you need to follow the **syntax** given below:

```
1. javac -d directory javafilename
```

For **example**

```
1. javac -d . Simple.java
```

The -d switch specifies the destination where to put the generated class file. You can use any directory name like /home (in case of Linux), d:/abc (in case of windows) etc. If you want to keep the package within the same directory, you can use . (dot).

How to run java package program

You need to use fully qualified name e.g. mypack.Simple etc to run the class.

To Compile: javac -d . Simple.java

To Run: java mypack.Simple

```
Output:Welcome to package
```

The -d is a switch that tells the compiler where to put the class file i.e. it represents destination. The . represents the current folder.

How to access package from another package?

There are three ways to access the package from outside the package.

1. import package.*;
2. import package.classname;
3. fully qualified name.

*1) Using packagename.**

If you use package.* then all the classes and interfaces of this package will be accessible but not subpackages.

The import keyword is used to make the classes and interface of another package accessible to the current package.

Example of package that import the packagename.*

```
1. //save by A.java
2. package pack;
3. public class A{
4.   public void msg(){System.out.println("Hello");}
5. }
1. //save by B.java
2. package mypack;
3. import pack.*;
4.
5. class B{
6.   public static void main(String args[]){
7.    A obj = new A();
8.    obj.msg();
9.   }
```

```
10.}
```

Output:Hello

---

2) Using packagename.classname

If you import package.classname then only declared class of this package will be accessible.

Example of package by import package.classname

```
1. //save by A.java
2.
3. package pack;
4. public class A{
5.   public void msg(){System.out.println("Hello");}
6. }
1. //save by B.java
2. package mypack;
3. import pack.A;
4.
5. class B{
6.   public static void main(String args[]){
7.    A obj = new A();
8.    obj.msg();
9.   }
10.}
```

Output:Hello

---

3) Using fully qualified name

If you use fully qualified name then only declared class of this package will be accessible. Now there is no need to import. But you need to use fully qualified name every time when you are accessing the class or interface.

It is generally used when two packages have same class name e.g. java.util and java.sql packages contain Date class.

Example of package by import fully qualified name

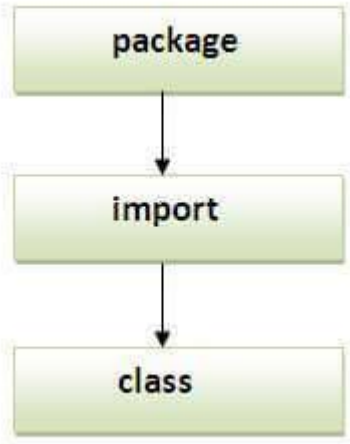
```
1. //save by A.java
2. package pack;
3. public class A{
4.   public void msg(){System.out.println("Hello");}
5. }
1. //save by B.java
2. package mypack;
3. class B{
4.   public static void main(String args[]){
5.    pack.A obj = new pack.A();//using fully qualified name
6.    obj.msg();
7.   }
8. }
```

Output:Hello

Note: If you import a package, subpackages will not be imported.

If you import a package, all the classes and interface of that package will be imported excluding the classes and interfaces of the subpackages. Hence, you need to import the subpackage as well.

Note: Sequence of the program must be package then import then class.



Subpackage in java

Package inside the package is called the **subpackage**. It should be created **to categorize the package further**.

Let's take an example, Sun Microsystem has definded a package named java that contains many classes like System, String, Reader, Writer, Socket etc. These classes represent a particular group e.g. Reader and Writer classes are for Input/Output operation, Socket and ServerSocket classes are for networking etc and so on. So, Sun has subcategorized the java package into subpackages such as lang, net, io etc. and put the Input/Output related classes in io package, Server and ServerSocket classes in net packages and so on.

The standard of defining package is domain.company.package e.g. com.javatpoint.bean or org.sssit.dao.

Example of Subpackage

```
1. package com.javatpoint.core;
2. class Simple{
3.   public static void main(String args[]){
4.    System.out.println("Hello subpackage");
5.   }
6. }
```

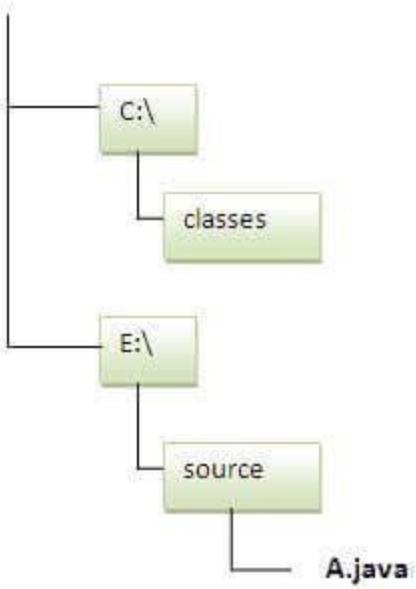
To Compile: javac -d . Simple.java

To Run: java com.javatpoint.core.Simple

```
Output:Hello subpackage
```

How to send the class file to another directory or drive?

There is a scenario, I want to put the class file of A.java source file in classes folder of c: drive. For example:




```
1. //save as Simple.java
2. package mypack;
3. public class Simple{
4.  public static void main(String args[]){
5.    System.out.println("Welcome to package");
6.   }
7. }
```

To Compile:

e:\sources> javac -d c:\classes Simple.java

To Run:

To run this program from e:\source directory, you need to set classpath of the directory where the class file resides.

e:\sources> set classpath=c:\classes;.;

e:\sources> java mypack.Simple

Another way to run this program by -classpath switch of java:

The -classpath switch can be used with javac and java tool.

To run this program from e:\source directory, you can use -classpath switch of java that tells where to look for class file. For example:

e:\sources> java -classpath c:\classes mypack.Simple

Output:Welcome to package

Ways to load the class files or jar files

There are two ways to load the class files temporary and permanent.

- Temporary
  - By setting the classpath in the command prompt
  - By -classpath switch
- Permanent
  - By setting the classpath in the environment variables
  - By creating the jar file, that contains all the class files, and copying the jar file in the jre/lib/ext folder.

Rule: There can be only one public class in a java source file and it must be saved by the public class name.

```
1. //save as C.java otherwise Compilte Time Error
2.
3. class A{}
4. class B{}
5. public class C{}
```

How to put two public classes in a package?

If you want to put two public classes in a package, have two java source files containing one public class, but keep the package name same. For example:

```
1. //save as A.java
```

```
2.
3. package javatpoint;
4. public class A{}
1. //save as B.java
2.
3. package javatpoint;
4. public class B{}
```