Exception Handling in Java

Exception Handling

- 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.

- 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.

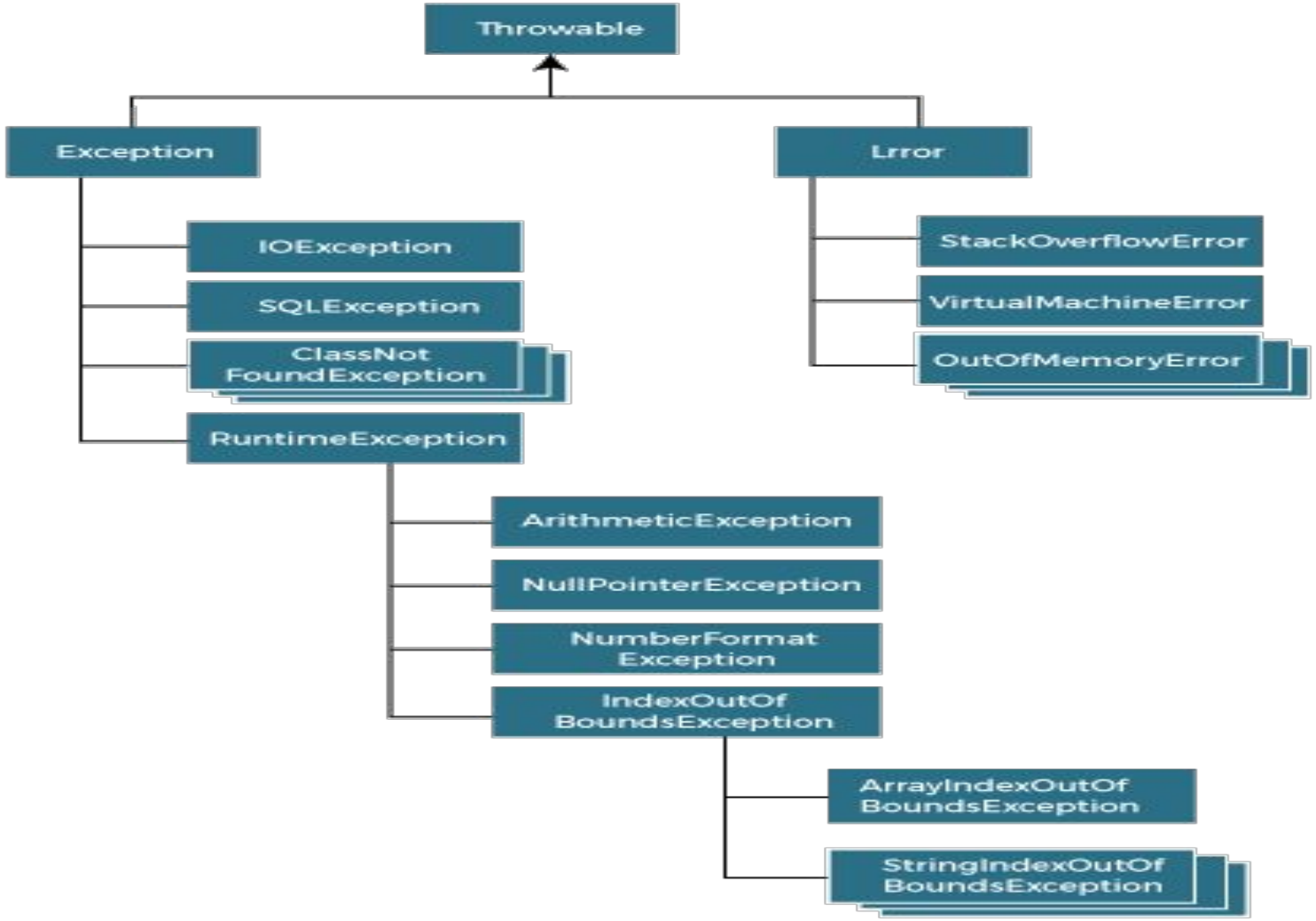
Advantage of Exception Handling

- 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:

- statement 1;
- statement 2;
- statement 3; //exception occurs
- statement 4;
- statement 5;
- statement 6;
- statement 7;
- Suppose there are 7 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

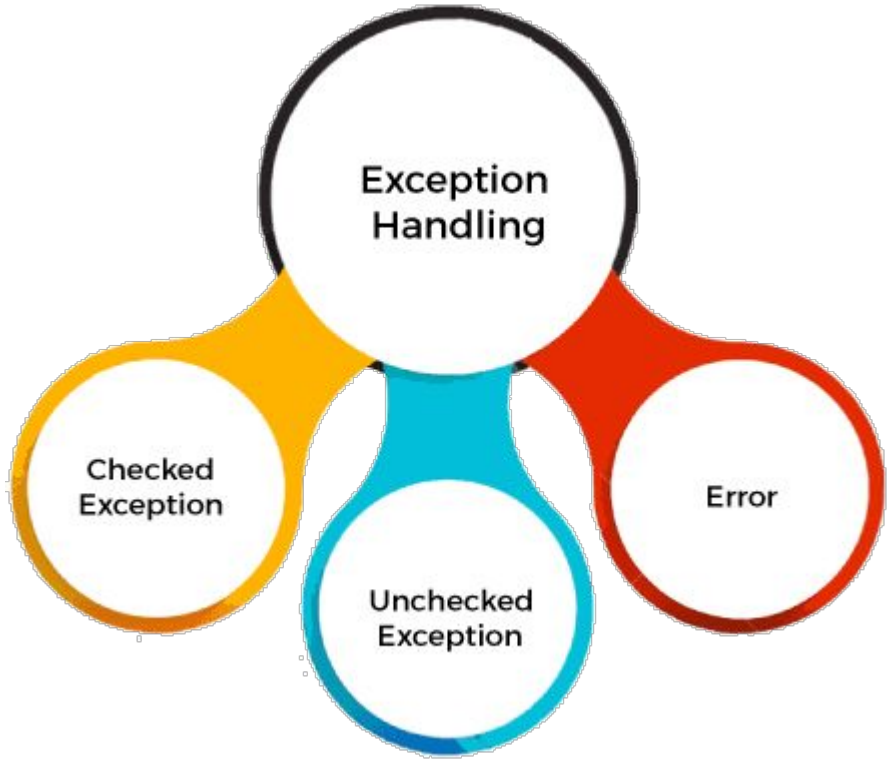
- The java.lang.Throwable class is the root class of Java Exception hierarchy inherited by two subclasses: Exception and Error. The hierarchy of Java Exception classes is given below:



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:

- Checked Exception
- Unchecked Exception
- 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.

- **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

JavaExceptionExample.java

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

Output:

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

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.

```
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.

```
String s=null;
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.

Common Scenarios of Java Exceptions

String s="abc";

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.

int a[]=new int[5];

a[10]=50; //ArrayIndexOutOfBoundsException

Java try-catch 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**

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

Syntax of try-finally block

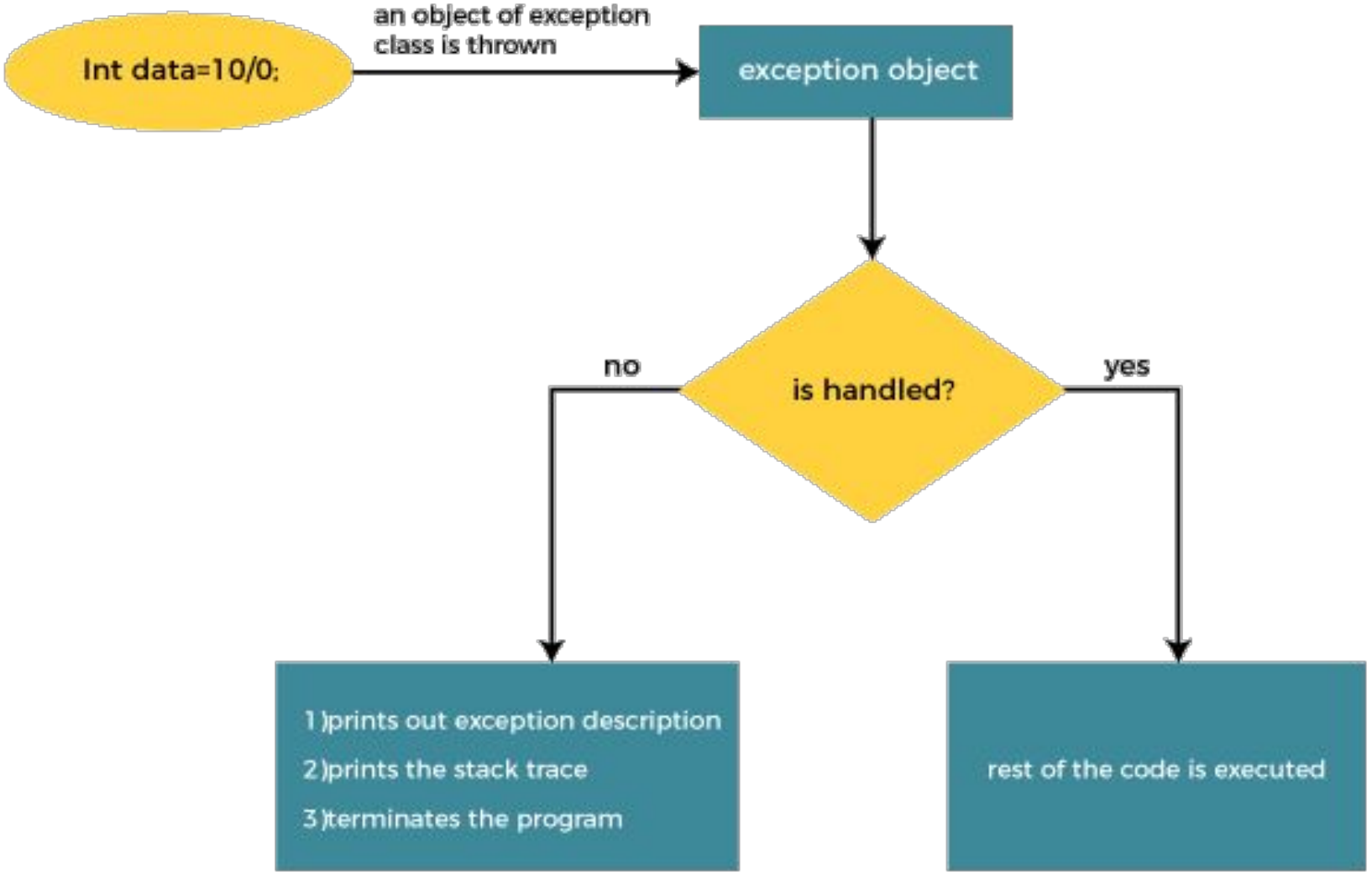
```
try{
//code that may throw an exception
}finally{}
```

Java try-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



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:

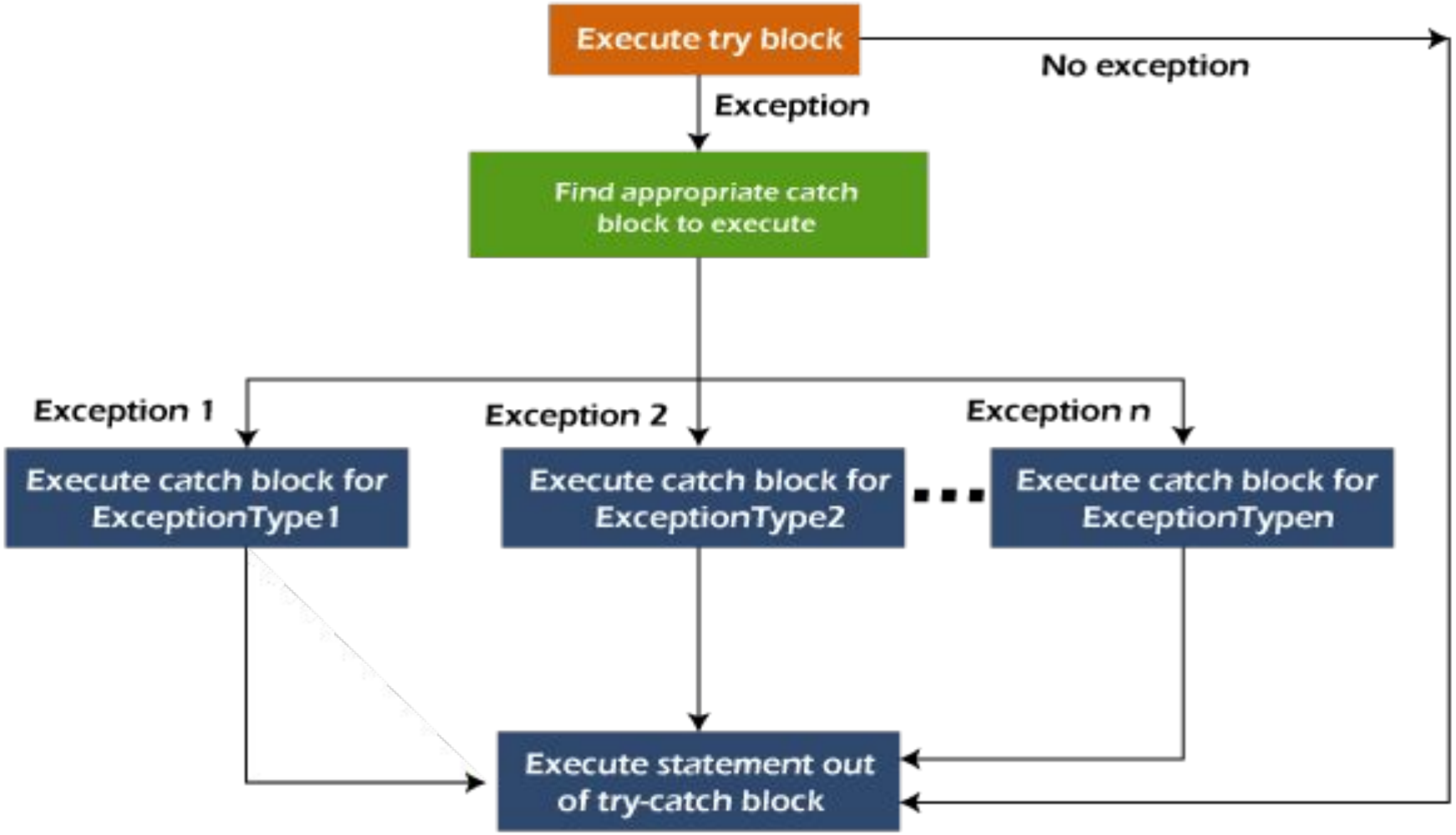
- Prints out exception description.
- Prints the stack trace (Hierarchy of methods where the exception occurred).
- Causes the program to terminate.
- But if the application programmer handles the exception, the normal flow of the application is maintained, i.e., rest of the code is executed.

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

MultipleCatchBlock1.java

```
public class MultipleCatchBlock1 {
    public static void main(String[] args) {
        try{
            int a[]=new int[5];
            a[5]=30/0;
           }
           catch(ArithmeticException e)
             {
              System.out.println("Arithmetic Exception occurs");
             }
           catch(ArrayIndexOutOfBoundsException e)
             {
              System.out.println("ArrayIndexOutOfBounds Exception occurs");
             }
           catch(Exception e)
             {
              System.out.println("Parent Exception occurs");
             }
           System.out.println("rest of the code");
    }
}
```

Test it Now

Output:

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

Java Nested try block

- In Java, using a try block inside another try block is permitted. It is called as nested try block. Every statement that we enter a statement in try block, context of that exception is pushed onto the stack.

- For example, the inner try block can be used to handle ArrayIndexOutOfBoundsException while the outer try block can handle the ArithemeticException (division by zero).

- Why use nested try block
- Sometimes a situation may arise where a part of a block may cause one error and the entire block itself may cause another error. In such cases, exception handlers have to be nested.

Syntax:

```
...
//main try block
try
{
    statement 1;
    statement 2;
//try catch block within another try block
    try
    {
        statement 3;
        statement 4;
//try catch block within nested try block
        catch(Exception e2)
        {
//exception message
        }

    }
    catch(Exception e1)
    {
//exception message
    }
}
//catch block of parent (outer) try block
catch(Exception e3)
{
//exception message
}
....
```

Java Nested try Example

```
public class NestedTryBlock{
 public static void main(String args[]){
 //outer try block
  try{
  //inner try block 1
    try{
      System.out.println("going to divide by 0");
     int b =39/0;
   }
    //catch block of inner try block 1
    catch(ArithmeticException e)
    {
      System.out.println(e);
    }
    //inner try block 2
   try{
   int a[]=new int[5];
   //assigning the value out of array bounds
    a[5]=4;
   }
   //catch block of inner try block 2
   catch(ArrayIndexOutOfBoundsException e)
   {
     System.out.println(e);
   }
   System.out.println("other statement");
}
//catch block of outer try block
  catch(Exception e)
  {
System.out.println("handled the exception (outer catch)");
  }
System.out.println("normal flow..");
 }
}
```

Output:

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

C:\Users\Anurati\Desktop\abcDemo>java NestedTryBlock
going to divide by 0
java.lang.ArithmeticException: / by zero
java.lang.ArrayIndexOutOfBoundsException: Index 5 out of bounds for length 5
other statement
normal flow..
```

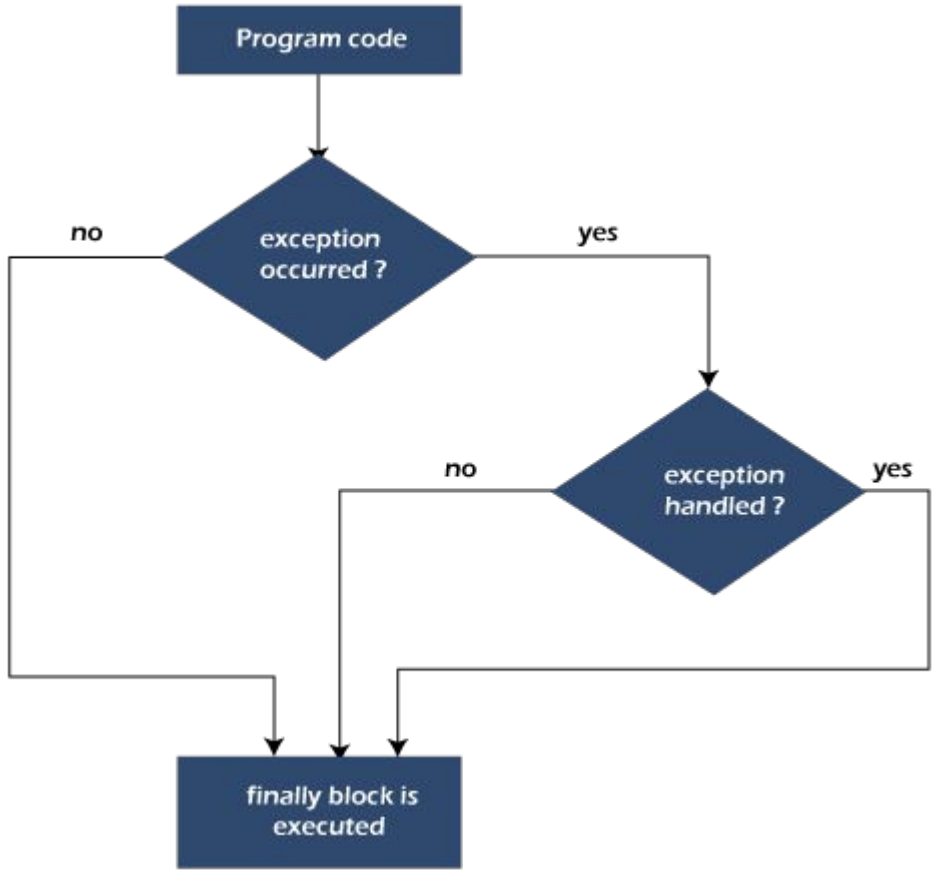
Java finally block

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



Java finally block

- 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.

```
class TestFinallyBlock {

  public static void main(String args[]){

  try{

//below code do not throw any exception

   int data=25/5;

   System.out.println(data);

  }

//catch won't be executed

  catch(NullPointerException e){

System.out.println(e);

}

 //executed regardless of exception occurred or not

 finally {

System.out.println("finally block is always executed");

}

System.out.println("rest of phe code...");

  }

}
```

```
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...
```

Java finally block

- When an exception occurr but not handled by the catch block

- 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.

```
public class TestFinallyBlock1{
public static void main(String args[]){
try {
System.out.println("Inside the try block");

//below code throws divide by zero exception
int data=25/0;
System.out.println(data);
}
//cannot handle Arithmetic type exception
//can only accept Null Pointer type exception
catch(NullPointerException e){
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...");
}
}
```

```
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)
```

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.

- 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.

Java throw Exception

- IThe syntax of the Java throw keyword is given below.

- throw Instance i.e.,

- throw new exception_class("error message");
- Let's see the example of throw IOException.

- 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.

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.

```
public class TestThrow1 {
   //function to check if person is eligible to vote or not
   public static void validate(int age) {
      if(age<18) {
         //throw Arithmetic exception if not eligible to vote
            throw new ArithmeticException("Person is not eligible to vote");
      }
      else {
         System.out.println("Person is eligible to vote!!");
      }
   }
   //main method
   public static void main(String args[]){
      //calling the function
      validate(13);
      System.out.println("rest of the code...");
   }
}
```

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)
```

Example 2: Throwing Checked Exception

```
import java.io.*;
public class TestThrow2 {
    //function to check if person is eligible to vote or not
            public static void method() throws FileNotFoundException {
FileReader file = new FileReader("C:\\Users\\Anurati\\Desktop\\abc.txt");

     BufferedReader fileInput = new BufferedReader(file);
       throw new FileNotFoundException();
   }
   //main method
   public static void main(String args[]){
      try
      {
         method();
      }
      catch (FileNotFoundException e)
      {
         e.printStackTrace();
      }
      System.out.println("rest of the code...");
  }
}
```

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...
```

Throwing User-defined Exception

```
// class represents user-defined exception
class UserDefinedException extends Exception
{
    public UserDefinedException(String str)
    {
        // Calling constructor of parent Exception
        super(str);
    }
}  // Class that uses above MyException
public class TestThrow3
{
    public static void main(String args[])
    {
        try
        {
            // throw an object of user defined exception
                    throw new UserDefinedException("This is
user-defined exception");
        }
        catch (UserDefinedException ude)
        {
            System.out.println("Caught the exception");
            // Print the message from MyException object
            System.out.println(ude.getMessage());
        }
    }
}
```

```
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

```
return_type method_name() throws exception_class_name{
//method code
}
```

Java throws keyword

- 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

```
import java.io.IOException;
class Testthrows1{
  void m()throws IOException{
    throw new IOException("device error");//checked exception
  }
  void n()throws IOException{
    m();    }
  void p(){
   try{
    n();
   }catch(Exception e){System.out.println("exception handled");}    }
  public static void main(String args[]){
   Testthrows1 obj=new Testthrows1();
   obj.p();
   System.out.println("normal flow...");
  }  }
```

Output:

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

Java throws

There are two cases:

Case 1: We have caught the exception i.e. we have handled the exception using try/catch block.

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.

Case 1: Handle Exception Using try-catch block

```
import java.io.*;
class M{
 void method()throws IOException{
  throw new IOException("device error");
 }  }
public class Testthrows2{
   public static void main(String args[]){
    try{
     M m=new M();
     m.method();
    }catch(Exception e){System.out.println("exception handled");}

    System.out.println("normal flow...");
  }  }
```

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.

A) If exception does not occur

```
import java.io.*;
class M{
 void method()throws IOException{
  System.out.println("device operation performed");
 }  }
class Testthrows3{
   public static void main(String args[])throws IOException{//declare exception
     M m=new M();
     m.method();
    System.out.println("normal flow...");
  }  }
```

Output:

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

Case 2: Declare Exception

B) If exception occurs

```
import java.io.*;
class M{
 void method()throws IOException{
  throw new IOException("device error");
 }
}
class Testthrows4{
   public static void main(String args[])throws IOException{//declare exception
     M m=new M();
     m.method();

    System.out.println("normal flow...");
  }
}
```

Output:

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

Case 2: Declare Exception

B) If exception occurs

```
import java.io.*;
class M{
 void method()throws IOException{
  throw new IOException("device error");
 }
}
class Testthrows4{
   public static void main(String args[])throws IOException{//declare exception
     M m=new M();
     m.method();

    System.out.println("normal flow...");
  }
}
```

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

B) If exception occurs

```
import java.io.*;
class M{
 void method()throws IOException{
  throw new IOException("device error");
 }
}
class Testthrows4{
   public static void main(String args[])throws IOException{//declare exception
     M m=new M();
     m.method();

    System.out.println("normal flow...");
  }
}
```

Output:

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