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IT2030 - Object Oriented Programming

Lecture 05

Errors and Exceptions

Introduction

Rarely does a program run successfully at its very first attempt. It is common to make mistakes while developing as well as typing a program. A mistake might lead to an error causing the program to produce unexpected results. ***Errors*** are the wrongs that can make a program go wrong.

An error may produce an incorrect output or may terminate the execution of the program abruptly or even may cause the system to crash. It is therefore important to detect and manage properly all the possible error conditions in the program so that the program will not terminate or crash during execution.

Types of Errors

Errors may broadly be classified into two categories:

- Compile-time errors
- Run-time errors

Compile - Time Errors

All syntax errors will be detected and displayed by the Java compiler and therefore these errors are known as compile time errors. Whenever the compiler displays an error, it will not create the **.class** file. It is therefore necessary that we fix all the errors before we can successfully compile and run the program.

Example : Compile Time Errors

- /* This program contains an error */

```
public class Error1 {

   public static void main(String args[]) {
      System.out.println("Hello Java!")
            // Missing ;
   }
}
```

The Java compiler does a nice job of telling us where the errors are in the program. For example, if we have missed the semicolon at the end of print statement in the above Program, the following message will be displayed in the screen:

```
Error1.java :5: ';' expected System.out.println
("Hello Java! ")

1 error
```

Most of the compile-time errors are due to typing mistakes. The most common problems are:

- Missing semicolons
- Missing (or mismatch of) brackets in classes and methods
- Misspelling of identifiers and keywords
- Missing double quotes in strings
- Use of undeclared variables
- Incompatible types in assignments, initializations.
- Bad references to objects
- Use of = in place of = = operator

Other errors we may encounter are related to directory paths. An error such as

javac: command not found

means that we have not set the path correctly. We must ensure that the path includes the directory where the Java executables are stored. Sometimes, a program may compile successfully creating the .class file but may not run properly. Such programs may produce wrong results due to wrong logic or may terminate due to errors such as stack overflow.

Most common run-time errors are:

- Dividing an integer by zero
- Accessing an element that is out of the bounds of an array
- Trying to store a value into an array of an incompatible class or type
- Trying to cast an instance of a class to one of its subclasses
- Passing a parameter that is not in a valid range or value for a method
- Trying to illegally change the state of a thread
- Attempting to use a negative size for an array
- Using a null object reference as a legitimate object reference to access a method or a variable
- Converting invalid string to a number
- Accessing a character that is out of bounds of a string

Example : Run-Time Errors

```
class Error2 {
        public static void main (String args[ ]) {
                int a = 10;
                int b = 5;
                int c = 5;
                int x = a / (b-c) ; / / Division by zero

                System.out.println("x = " + x) ; int y = a / (b+c);
                System.out.println("y = " + y);
        }
}
```

Error2.java

Program is syntactically correct and therefore does not cause any problem during compilation. However, while executing, it displays the following message and stops without executing further statements.

java. lang.ArithmeticException: / by zero at Error2.main(Error2.java:8)

When Java run-time tries to execute a division by zero, it generates an error condition, which causes the program to stop after displaying an appropriate message.

Coding Exercise

- Create a simple java program that will generate the run time exception for Converting invalid string to an Integer

Hint : You can use Integer.parseInt(String s) method for the conversion

What is an Exception?

An exception is an *abnormal event* that arises during the execution (run time) of the program and disrupts the normal flow of the program.

Java classifies exceptions as

- Errors
- Exceptions
  - Checked Exceptions
  - Unchecked Exceptions

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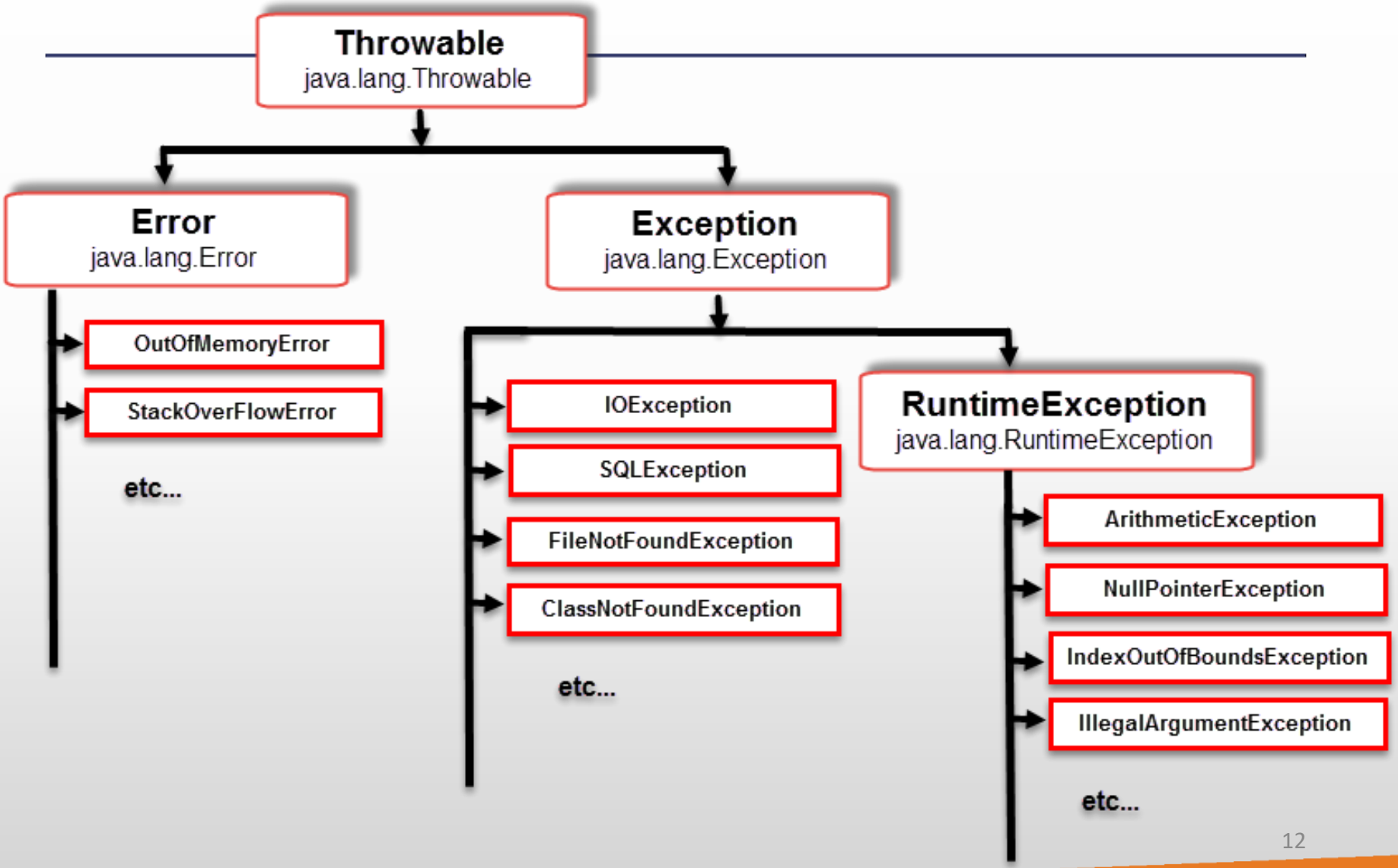
Hierarchy of Java Exception Classes



Error Class

- An Error is a subclass of Throwable that indicates serious problems.
- Errors represent critical errors, once occurs the system is not expected to recover from (irrecoverable).
- Errors can be generated from mistake in program logic or design.
- Most applications should not try to handle it.
  - e.g. OutOfMemoryError, VirtualMachineError, AssertionError

Exception Class

This class represents the exceptional conditions that user must handle or catch.

- A Java exception is an object that describes an exceptional (that is, error) condition that has occurred in a piece of code. When an exceptional condition arises, an object representing that exception is created and *thrown* in the method that caused the error.
- That method may choose to handle the exception itself, or pass it on. Either way, at some point, the exception is *caught* and processed.
- Exceptions can be generated by the Java run-time system, or they can be manually generated by your code.

Checked Exceptions

- Checked Exception in Java is all those Exception which requires being catches and handled during compile time.
- The classes that extend Throwable class except RuntimeException and Error are known as checked exceptions

e.g.IOException, SQLException etc. Checked

Unchecked Exceptions

- Unchecked exceptions are usually caused by incorrect program code or logic such as invalid parameters passed to a method.
- The classes that extend RuntimeException are known as unchecked exceptions.
- Unchecked exceptions are checked at runtime.

e.g. ArithmeticException, NullPointerException, ArrayIndexOutOfBoundsException

Exception Handling

There are two ways to handle Exceptions:

- **Throw out and ignore**

When an Exception occur inside a code of program simply throw it out and ignore that an Exception occur declare the methods as **throws** Exception.

- **Catch and handle**

If a code segment is generating an Exception place it inside a try block. Then mention the way to handle the Exception inside a catch block use **try-catch** blocks

Exception Handling Using try and catch

1. Find the problem (Hit the exception).
2. Inform that an error has occurred (Throw the exception)
3. Receive the error information (Catch the exception)
4. Take corrective actions (Handle the exception)

Provides two benefits.

- Allows you to fix the error.
- Prevents the program from automatically terminating.

- To guard against and handle a run-time error, simply enclose the code that you want to monitor inside a **try** block.
- Immediately following the **try** block, include a **catch** clause that specifies the exception type that you wish to catch.
- Syntax:

```
try {
        statement ; / / generates an exception

} catch ( Exception-type e ) {
        statement ; / / processes the exception
}
```

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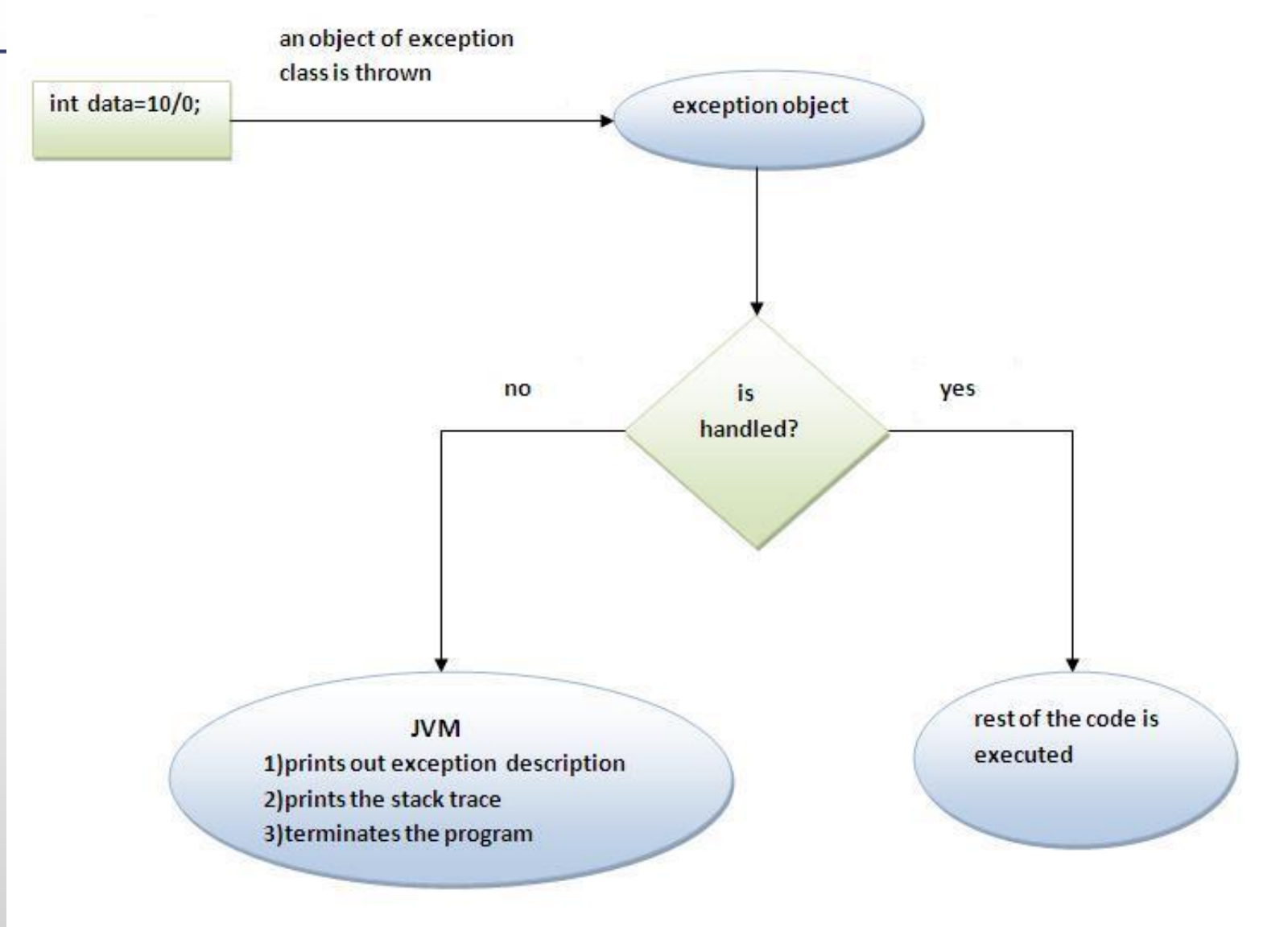
Internal Working of Java try-catch Block



Example: try and catch

```
class Exc2 {

   public static void main(String args[]) {
      int d, a;
      try { // monitor a block of code.
                d = 0;
                a = 42 / d;
                System.out.println("This will not be printed.");
      } catch (ArithmeticException e) { // catch divide-by-zero error
               System.out.println("Exception: " + e);
               System.out.println("Division by zero.");
      }
   }
}
```

Exception.java

Note:

The call to **println( )** inside the **try** block is never executed. Once an exception is thrown, program control transfers out of the **try** block into the **catch** block. Put differently, **catch** is not “called,” so execution never “returns” to the **try** block from a **catch**. Thus, the line "This will not be printed." is not displayed.

Once the **catch** statement has executed, program control continues with the next line in the program following the entire **try / catch** mechanism.

Coding Exercise

You can now catch handle the exception that you generated in the earlier exercise, by displaying a meaningful message.

Multiple catch clauses

- More than one exception could be raised by a single piece of code.
- To handle this type of situation, programmer can specify two or more **catch** clauses, each catching a different type of exception.
- When an exception is thrown, each **catch** statement is inspected in order, and the first one whose type matches that of the exception is executed.
- After one **catch** statement executes, the others are bypassed, and execution continues after the **try /catch** block.

```
try {
        statement ; / / generates an exception

} catch ( Exception1-type e ) {
        statement ; / / processes the exception
} catch ( Exception2-type e ) {
        statement ; / / processes the exception
}
```

Example: Multiple catch clauses

```
class MultipleCatches {

   public static void main(String args[]) {
      try {
                int a = args.length;
                System.out.println("a = " + a);
                int b = 42 / a;
                int c[] = {1};
                c[42] = 99;
      } catch (ArithmeticException e) {
                System.out.println("Divide by 0: " + e);
      } catch (ArrayIndexOutOfBoundsException e) {
                System.out.println("Array index oob: " + e);
      }
            System.out.println("After try/catch blocks.");
   }
}
```

MultiExceptionCatch.java

Catching More Than One Type of Exception with One Exception Handler

- In Java SE 7 and later, a single catch block can handle more than one type of exception. This feature can reduce code duplication and lessen the temptation to catch an overly broad exception.
- In the catch clause, specify the types of exceptions that block can handle, and separate each exception type with a vertical bar (|):

```
catch (IOException | SQLException ex) {
        System.out.println(ex);
 }
```

Note:
If a catch block handles more than one exception type, then the catch parameter is implicitly final. In this example, the catch parameter ex is final and therefore cannot assign any values to it within the catch block.

Nested try Statements

- When a try catch block is present inside another try block then it is called the nested try catch block.
- Each time a try block does not have a catch handler for a particular exception, then the catch blocks of parent try block are inspected for that exception, if match is found that that catch block executes.
- If neither catch block nor parent catch block handles exception then the system generated message would be shown for the exception, similar to what we see when we don't handle exception.

- Syntax:

```
//Main try block
try {
        statement 1;
        statement 2;
        //try-catch block inside another try block
        try {
                statement 3;
                statement 4;
                //try-catch block inside nested try block
                try {
                        statement 5;
                        statement 6;
                } catch(Exception e2) {
                        //Exception Message
                 }
        } catch(Exception e1) {
                        //Exception Message
        }
} catch(Exception e3) {  //Catch of Main(parent) try block
         //Exception Message
}
```

Example: Nested try Statements

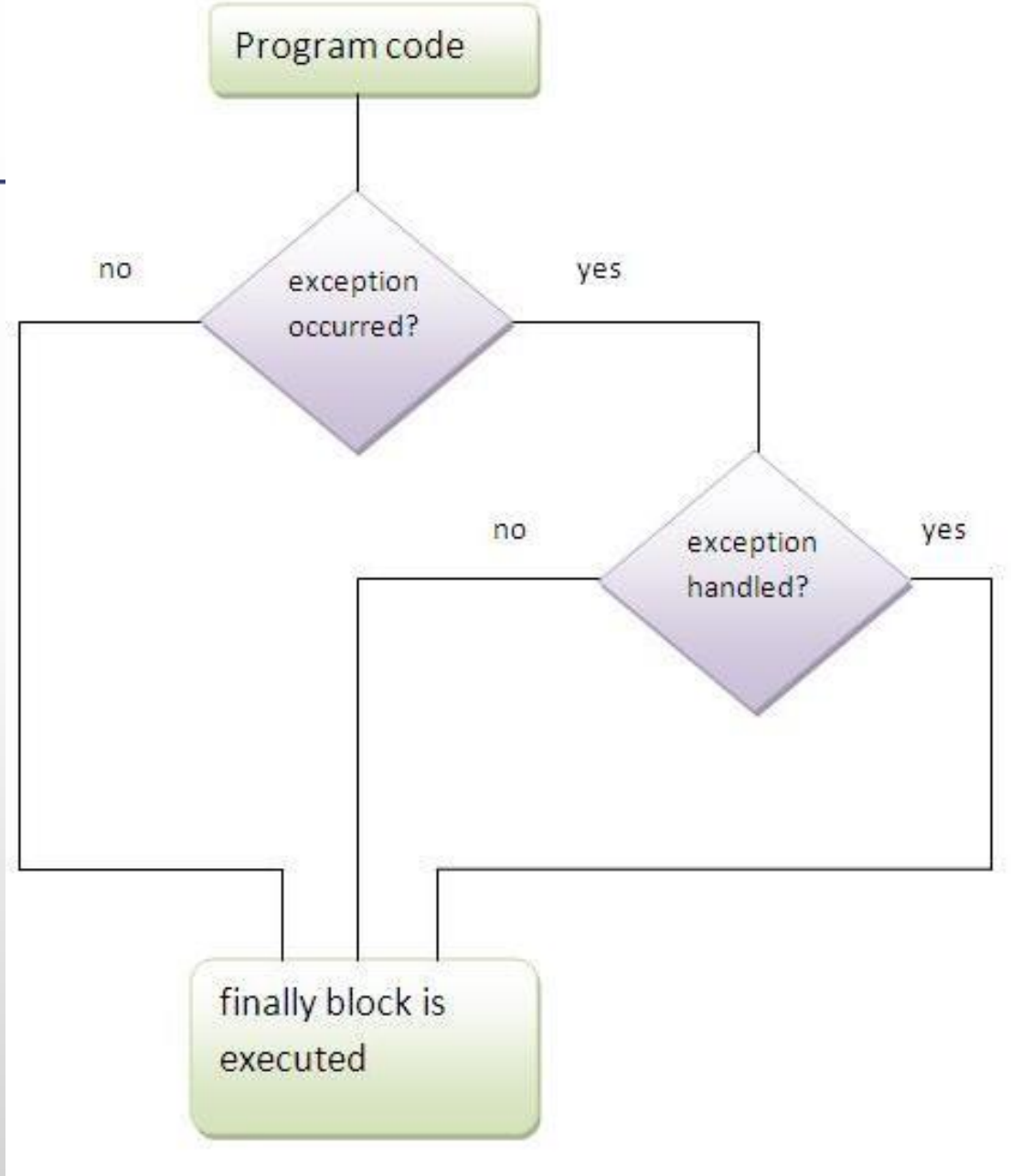
```
public class NestingDemo {

    public static void main(String[] args) {
        try { //try-block2
            try { //try-block3
                try {
                    int arr[] = {1, 2, 3, 4};
                    System.out.println(arr[10]);
                } catch (ArithmeticException e) {
                    System.out.print("Arithmetic Exception");
                    System.out.println(" handled in try-block3");
                }
            } catch (ArithmeticException e) {
                System.out.print("Arithmetic Exception");
                System.out.println(" handled in try-block2");
            }
        } catch (ArithmeticException e3) {
            System.out.print("Arithmetic Exception");
            System.out.println(" handled in main try-block");
        } catch (ArrayIndexOutOfBoundsException e4) {
            System.out.print("ArrayIndexOutOfBoundsException");
            System.out.println(" handled in main try-block");
        } catch (Exception e5) {
            System.out.print("Exception");
            System.out.println(" handled in main try-block");
        }
    }
}
```

Finally Block

- **finally** statement that can be used to handle an exception that is not caught by any of the previous catch statements.
- **finally** block can be used to handle any exception generated within a try block. It may be added immediately after the try block or after the last catch block shown as follows
- When a finally block is defined, this is guaranteed to execute, regardless of whether or not an exception is thrown. As a result, we can use it to perform certain house-keeping operations such as closing files and releasing system resources
- Syntax:

```
try {
        statement ;
} finally{
}
```

```
try {
        statement ;
} catch ( Exception1-type e ) {
        statement ;
} finally{
}
```


Program code
exception occurred?
no
yes
exception handled?
no
yes
finally block is executed

Example: finally block

```
class TestFinallyBlock{
  public static void main(String args[]){
            try{
                        int data=25/0;
                        System.out.println(data);
             } catch(ArithmeticException e){
                        System.out.println(e);
            }   finally{
                        System.out.println("finally block is always executed");}
                        System.out.println("rest of the code...");
            }
   }
}
```

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Coding Exercise

- Add a finally block to the exception that you handled earlier, display the below message.

"End of the operation"

Exception Handling Using throws

- When an Exception occur inside a code of program simply throw it out and ignore.
- **throws** keyword is used for handling checked exceptions . By using throws we can declare multiple exceptions in one go.
- A **throws** clause lists the types of exceptions that a method might throw.
- Syntax

```
type method-name(parameter-list) throws exception-list
{
        // body of method
}
```

Example: throws

```
import java.io.*;


class Error03{
      public static void main(String[] a) throws IOException{
            BufferedReader in = new BufferedReader( new InputStreamReader (System.in));
            String text=""; System.out.print("Enter an integer value : ");
            text = in.readLine(); int num = Integer.parseInt(text);
            System.out.println("You inserted "+num);
     }
 }
```

IOError.java

Coding Exercise

- Create a class MathOp with the two methods to add and divide two integers.
- Write a class with a main method, call the two methods with following parameters

Coding Exercise

- Throw out the ArithmeticException from the divide method.
- Catch it and handle with a try catch block in the main method.

Creating Your Own Exception Subclasses

- There may be times when we would like to throw our own exceptions. We can do this by using the keyword throw as follows:

```
throw new Throwable-subclass;
```

Examples: throw new ArithmeticException( );

throw new NumberFormatException( );

- To define your own exception create a subclass of **Exception** (which is a subclass of **Throwable**).

- The **Exception** class does not define any methods of its own. It inherits those methods provided by **Throwable**. Thus, all exceptions, including those that you create, have the methods defined by **Throwable** available to them.

- **Exception class** defines four public constructors. Two are shown here:
  - Exception( )
  - Exception(String *msg*)

The first form creates an exception that has no description. The second form lets you specify a description of the exception.

Example

```
class MyException extends Exception {
        MyException (String message) {
              super(message);
        }
}

class TestMyException {
       public static void main (String args[ ]) {
             int x = 5, y = 1000;

            try {
                    float z = (float) x / (float) y;
                    if(z < 0.01) {
                     throw new MyException ("Number is too small") ;
             }
            }  catch (MyException e) {
                    System.out.println ("Caught my exception");
                    System.out.println(e.getMessage ());
            } finally {
                    System.out.println ("I am always here") ;
            }
      }
}
```

MyException.java

Commonly Used Exceptions

Exception	Meaning
ArithmeticException	Arithmetic error, such as divide-by-zero.
ArrayIndexOutOfBoundsException	Array index is out-of-bounds.
ArrayStoreException	Assignment to an array element of an incompatible type.
ClassCastException	Invalid cast.
EnumConstantNotPresentException	An attempt is made to use an undefined enumeration value.
IllegalArgumentException	Illegal argument used to invoke a method.
IllegalMonitorStateException	Illegal monitor operation, such as waiting on an unlocked thread.
IllegalStateException	Environment or application is in incorrect state.
IllegalThreadStateException	Requested operation not compatible with current thread state.
IndexOutOfBoundsException	Some type of index is out-of-bounds.
NegativeArraySizeException	Array created with a negative size.
NullPointerException	Invalid use of a null reference.
NumberFormatException	Invalid conversion of a string to a numeric format.
SecurityException	Attempt to violate security.
StringIndexOutOfBounds	Attempt to index outside the bounds of a string.
TypeNotPresentException	Type not found.

Thank you!