Exceptions

Your computer takes exception

- Exceptions are errors in the logic of a program (run-time errors).
- Examples:

```
Exception in thread "main" java.io.FileNotFoundException:
   student.txt (The system cannot find the file specified.)


Exception in thread "main" java.lang.NullPointerException:
   at FileProcessor.main(FileProcessor.java:9)
```

- Question: do all run-time errors cause Exceptions?

Causes of Exceptions

- Most exceptions happen because of "corner cases":
  - your program does something at the boundaries of what Java knows how to handle.
- For example:
  - Java knows how to open files for reading, mostly.
  - But if you tell it to open a file that doesn't exist, it doesn't know how it should behave.
  - It throws an exception, and gives the programmer an opportunity to define how the program should react.

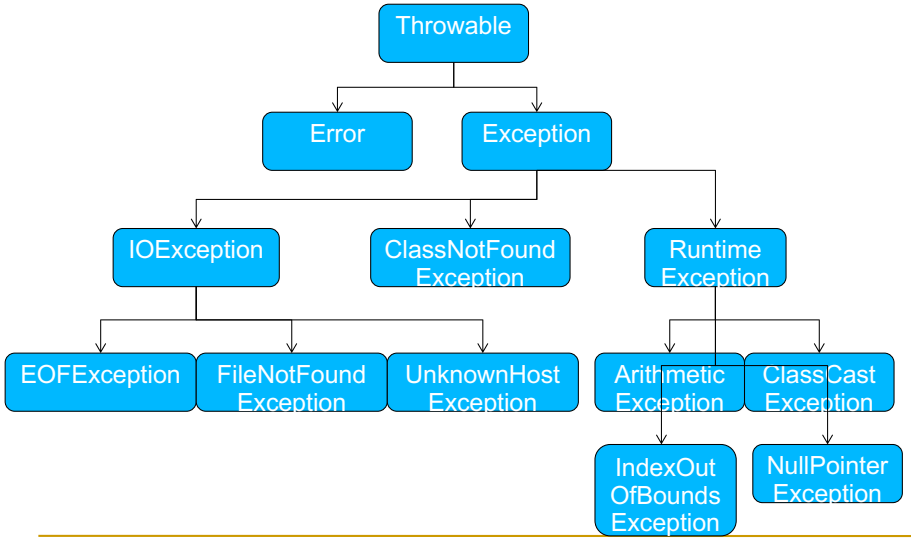
The Exception Class

- As with anything in Java, `Exception` is a class

Method	What it does
void printStackTrace()	Prints the sequence of method calls leading up to the statement that caused the Exception.
String getLocalizedMessage()	Returns a "detail" message.
String toString()	Returns the Exception class name and detail message.

The methods in the `Exception` class can be useful for debugging, as we will see.

The Exception class hierarchy (partial)



Pitch and catch

- When a Java statement causes an Exception (called *throwing* the Exception), by default Java abruptly ends the program.
- To stop this default behavior, you can write code that *catches* the thrown Exception.

Catch: An example

```
import java.util.*;   // For Scanner class
import java.io.*;

public class FileProcessor
{
   public static void main(String [] args)
   {
        try {
             File inputFile = new File("student.txt");
             Scanner input = new Scanner(inputFile);

             while(input.hasNextLine()) {
                  System.out.println("> " + input.nextLine());
             }
        }
        catch(FileNotFoundException exception) {
             System.out.println("Could not find the file 'student.txt'.");
        }
   }
}
```

try/catch syntax

try block indicates that the enclosed statements have exception handlers associated with them.

```
try {
  <statements that might cause an exception>;
}
catch(<ExceptionType1> e1) {
  <statements>
}
...
catch(<ExceptionTypeN> eN) {
  <statements>
}
```

catch block is an exception handler for *one type* of exception.

The type of exception that the catch block handles is indicated with a parameter.

You can have as many catch blocks for one try block as you like. They must each handle a different type of exception.

Control Flow with try/catch

```
try {
    <statements that might cause an exception>;
}
catch(<ExceptionType1> e1) {
    <statements>
}
…
catch(<ExceptionTypeN> eN) {
    <statements>
}
<statements after try/catch>
```

- If no exception occurs during the try block:
  - jump to statements after all the catch blocks.
- If an exception occurs in the try block:
  - jump to the first handler for that type of exception.
  - After the catch finishes, jump to the statement after all the catch blocks.

Catch: An example

```
import java.util.*;   // For Scanner class
import java.io.*;

public class FileProcessor
{
    public static void main(String [] args)
    {
        try {
            File inputFile = new File("student.txt");
            Scanner input = new Scanner(inputFile);

            while(input.hasNextLine()) {
                System.out.println("> " + input.nextLine());
            }
        }
        catch(FileNotFoundException exception) {
            System.out.println("Could not find the file 'student.txt'.");
        }
    }
}
```

finally

```
try {
    <statements that might cause an exception>;
}
catch(<ExceptionType1> e1) {
    <statements>
}
…
catch(<ExceptionTypeN> eN) {
    <statements>
} finally {
    <statements in here are done whether
     an exception occurred or not>
}
```

Remember

- When an exception occurs
  - you jump to the appropriate catch block
  - you do not ever jump back to the try block
- If you absolutely must complete the try block
  - you need to put it inside a loop

Example

```
String filename = null;
Scanner inFromFile = null;
try {
  Scanner inFromKbd = new Scanner(System.in);
  System.out.print("Enter file name> ");
  filename = inFromKbd.nextLine();
  inFromFile = new Scanner(new File(filename));
} catch (FileNotFoundException e) {
  System.out.println("Error opening file " +
                     filename);
}
/* but the file might not be open */
```

Example

```
String filename = null;
Scanner inFromFile = null;
boolean successfulOpen=false;
do {
  try {
    Scanner inFromKbd = new Scanner(System.in);
    System.out.print("Enter file name> ");
    filename = inFromKbd.nextLine();
    inFromFile = new Scanner(new File(filename));
    successfulOpen=true;
  } catch (FileNotFoundException e) {
    System.out.println("Error opening file " + filename);
  }
} while (!successfulOpen);
/* if we get this far, the file is open */
```

Stack Traces

- How do you know what went wrong?
- All exceptions have methods that return information about the cause of the Exception:

Method	Description
getLocalizedMessage()	Returns a String containing a description of the error
getStackTrace()	Returns an array of StackTraceElement objects, each of which contains info about where the error occurred
printStackTrace()	Displays the Stack Trace on the console.

Displaying the stack trace info

```
import java.util.*; // For Scanner class
import java.io.*;

public class FileProcessor
{
    public static void main(String [] args)
    {
          try {
               File inputFile = new File("student.txt");
               Scanner input = new Scanner(inputFile);

               while(input.hasNextLine()) {
                    System.out.println("> " + input.nextLine());
               }
          }
          catch(FileNotFoundException exception) {
               System.out.println("Could not find the file 'student.txt'.");
               System.out.println(exception.getLocalizedMessage());
               exception.printStackTrace();
          }
    }
}
```

Multiple catch blocks

```
import java.util.*;   // For Scanner class
import java.io.*;

public class FileProcessor
{
   public static void main(String [] args)
   {
        try {
            File inputFile = new File("student.txt");
            Scanner input = new Scanner(inputFile);
            PrintWriter pw = new PrintWriter(new File("quoted.txt"));

            while(input.hasNextLine()) {
                pw.println("> " + input.nextLine());
            }
        }
        catch(FileNotFoundException exception) {
            System.out.println("Could not find the file 'student.txt'.");
        }
        catch(IOException exception) {
            System.out.println("Could not write to file 'quoted.txt'.");
        }
   }
}
```

Multiple catch blocks

```
import java.util.*;   // For Scanner class
import java.io.*;

public class FileProcessor
{
   public static void main(String [] args)
   {
        try {
            File inputFile = new File("student.txt");
            Scanner input = new Scanner(inputFile);
            PrintWriter pw = new PrintWriter(new File("quoted.txt"));

            while(input.hasNextLine()) {
                pw.println("> " + input.nextLine());
            }
        }
        catch(FileNotFoundException exception) {
            System.out.println("Could not find the input file.");
            System.out.println(exception.getLocalizedMessage());
            exception.printStackTrace();
        }
        catch(IOException exception) {
            System.out.println("Could not write to file 'quoted.txt'.");
        }
   }
}
```

Checked and Unchecked Exceptions

- Exceptions happen while the program is running
- For most kinds of Exceptions, the compiler is happy to let the programmer make mistakes that could lead to an exception at run-time.

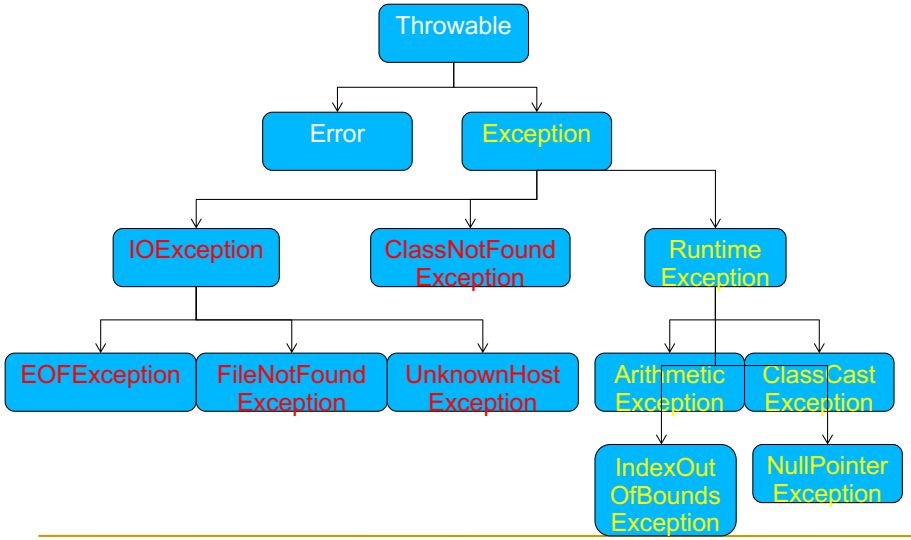
- Unchecked (by the compiler) Exceptions
  - They are caused by programmer error.
  - The compiler lets the programmer screw up.
  - *e.g.*, NullPointerException, IndexOutOfBoundsException

Checked and Unchecked Exceptions

- Exceptions happen while the program is running
- For most kinds of Exceptions, the compiler is happy to let the programmer make mistakes that could lead to an exception at run-time.
- But, for certain kinds of exceptions, the compiler will ***check*** to see if your code ***might*** cause an exception at run-time.

- Checked (by the compiler) Exceptions:
  - They are caused by things outside of the programmer's control (*eg*, a file doesn't exist).
  - The compiler requires that the programmer declare what to do if the Exception occurs.

Checked and Unchecked Exceptions



Options for Checked Exceptions

If the compiler detects that a statement might cause a Checked Exception, it requires the programmer to do either of the following:

1. Catch the Exception
2. Declare that crashing is acceptable
   - Use the `throws` clause in the method signature

Otherwise, the program will not compile.

Throws: An example

```
import java.util.*;    // For Scanner class
import java.io.*;

public class FileProcessor
{
   public static void main(String [] args)
        throws FileNotFoundException
   {
        File inputFile = new File("student.txt");
        Scanner input = new Scanner(inputFile);

        while(input.hasNextLine()) {
            System.out.println("> " + input.nextLine());
        }
   }
}
```

Catch or throw?

When should you catch an exception, and when should you declare that it can be thrown?

- Usually, if your catch block is not going to do anything besides print an error message and quit the program, it's better to just throw the exception
- You should only catch an exception if you're really going to handle the error so that it won't affect the rest of the program.

Causing a ruckus

- Guess what … you can create your very own Exceptions, any time you want!

- The `throw` keyword:

  (note: NOT the same as the `throws` keyword!)

  - Use it to make your code throw an exception

  ```
  throw new Exception();
  ```

  - Mainly useful for passing messages between methods that aren't easily done with returns