Advanced Java

LESSON 2: EXCEPTIONS AND IO

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Agenda

- Exceptions
- Throws
- Text I-O

Exceptions

Handling Exceptions

- An exception is an object that is generated as the result of an error or an unexpected event.
- Exception are said to have been “thrown.”
- It is the programmers responsibility to write code that detects and handles exceptions.
- Unhandled exceptions will crash a program.

Example: BadArray.java

- Java allows you to create exception handlers.

Handling Exceptions

- An exception handler is a section of code that gracefully responds to exceptions.
- The process of intercepting and responding to exceptions is called exception handling.
- The default exception handler deals with unhandled exceptions.
- The default exception handler prints an error message and crashes the program.

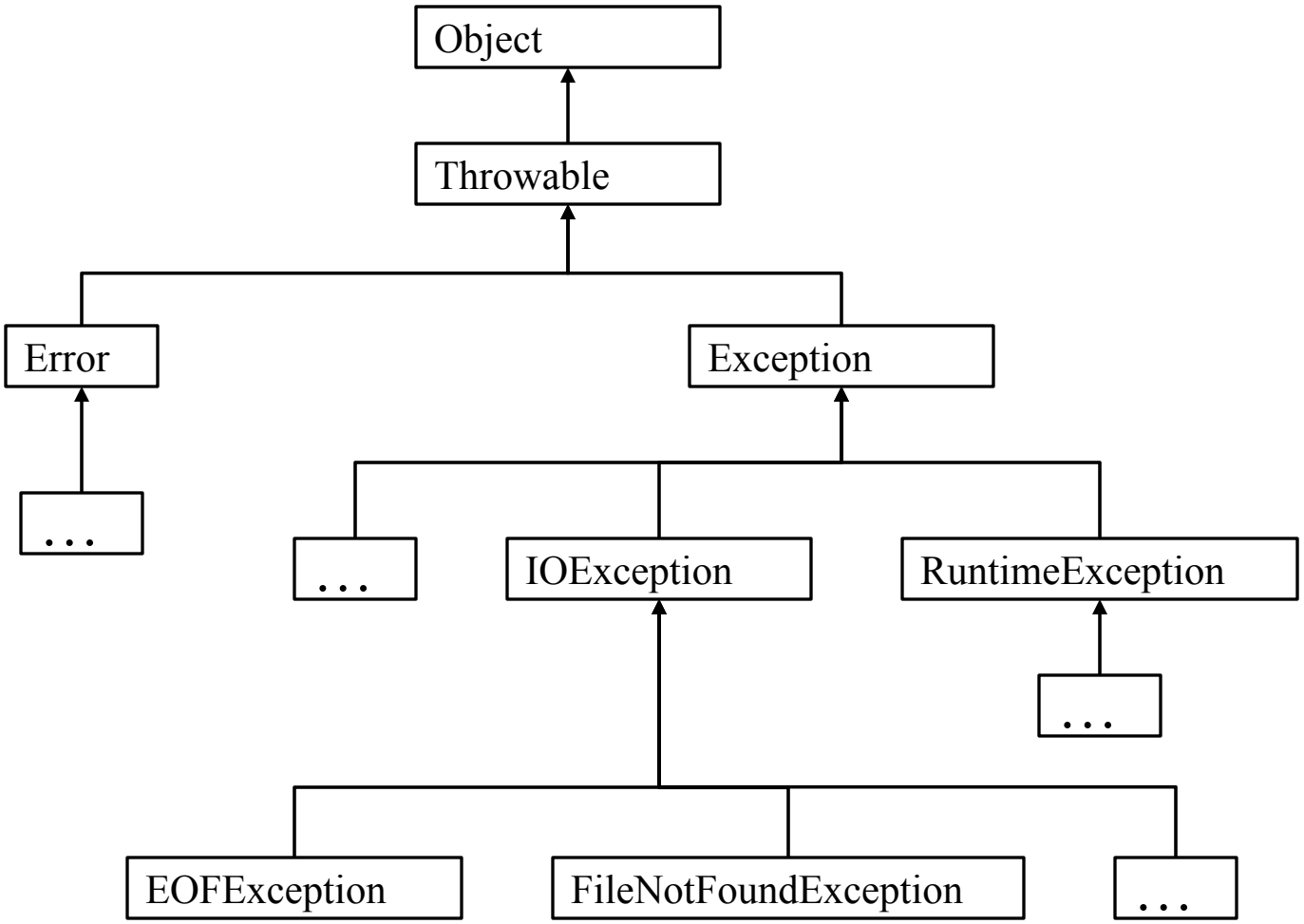
Exception Classes

- An exception is an object.
- Exception objects are created from classes in the Java API hierarchy of exception classes.
- All of the exception classes in the hierarchy are derived from the `Throwable` class.
- `Error` and `Exception` are derived from the `Throwable` class.

Exception Classes

- Classes that are derived from `Error`:
  - are for exceptions that are thrown when critical errors occur. (i.e.)
    - an internal error in the Java Virtual Machine, or
    - running out of memory.
- Applications should not try to handle these errors because they are the result of a serious condition.
- Programmers should handle the exceptions that are instances of classes that are derived from the `Exception` class.

Exception Classes



Handling Exceptions

To handle an exception, you use a *try* statement.

```
try
{
   (try block statements...)
}
catch (ExceptionType ParameterName)
{
   (catch block statements...)
}
```

First the keyword `try` indicates a block of code will be attempted (the curly braces are required).

This block of code is known as a *try block*.

Handling Exceptions

A *try block* is:

- one or more statements that are executed, and
- can potentially throw an exception.

The application will not halt if the try block throws an exception.

After the try block, a `catch` clause appears.

Handling Exceptions

A catch clause begins with the key word `catch`:

- **`catch (ExceptionType ParameterName)`**
- *`ExceptionType`* is the name of an exception class and
- *`ParameterName`* is a variable name which will reference the exception object if the code in the try block throws an exception.

The code that immediately follows the catch clause is known as a *catch block* (the curly braces are required).

The code in the catch block is executed if the try block throws an exception.

Handling Exceptions

This code is designed to handle a `FileNotFoundException` if it is thrown.

```
try
{
   File file = new File ("MyFile.txt");
   Scanner inputFile = new Scanner(file);
}
catch (FileNotFoundException e)
{
   System.out.println("File not found.");
}
```

The Java Virtual Machine searches for a `catch` clause that can deal with the exception.

Example: OpenFile.java

Handling Exceptions

- The parameter must be of a type that is compatible with the thrown exception's type.
- After an exception, the program will continue execution at the point just past the catch block.

Default Error Message

Each exception object has a method named getMessage that can be used to retrieve the default error message for the exception.

Example:

- ExceptionMessage.java
- ParseIntError.java

Polymorphic References To Exceptions

- When handling exceptions, you can use a polymorphic reference as a parameter in the catch clause.
- Most exceptions are derived from the Exception class.
- A catch clause that uses a parameter variable of the Exception type is capable of catching any exception that is derived from the Exception class.

Polymorphic References To Exceptions

```
try
{
  number = Integer.parseInt(str);
}
catch (Exception e)
{
System.out.println("The following error occurred: "
                   + e.getMessage());
}
```

The `Integer` class's `parseInt` method throws a `NumberFormatException` object.

The `NumberFormatException` class is derived from the `Exception` class.

Handling Multiple Exceptions

- The code in the try block may be capable of throwing more than one type of exception.
- A catch clause needs to be written for each type of exception that could potentially be thrown.
- The JVM will run the first compatible catch clause found.
- The catch clauses must be listed from most specific to most general.
- Example: SalesReport.java, SalesReport2.java

Exception Handlers

There can be many polymorphic catch clauses.

A try statement may have only one `catch` clause for each specific type of exception.

```
try
{
  number = Integer.parseInt(str);
}
catch (NumberFormatException e)
{
  System.out.println("Bad number format.");
}
catch (NumberFormatException e) // ERROR!!!
{
  System.out.println(str + " is not a number.");
}
```

Exception Handlers

The `NumberFormatException` class is derived from the `IllegalArgumentException` class.

```
try
{
  number = Integer.parseInt(str);
}
catch (IllegalArgumentException e)
{
  System.out.println("Bad number format.");
}
catch (NumberFormatException e) // ERROR!!!
{
  System.out.println(str + " is not a number.");
}
```

Exception Handlers

The previous code could be rewritten to work, as follows, with no errors:

```
try
{
  number = Integer.parseInt(str);
}
catch (NumberFormatException e)
{
  System.out.println(str
                     + " is not a number.");
}
catch (IllegalArgumentException e) // OK
{
  System.out.println("Bad number format.");
}
```

The `finally` Clause

The try statement may have an optional `finally` clause.

If present, the `finally` clause must appear after all of the `catch` clauses.

```
try
{
   (try block statements...)
}
catch (ExceptionType ParameterName)
{
   (catch block statements...)
}
finally
{
   (finally block statements...)
}
```

The finally Clause

The *finally block* is one or more statements,

- that are always executed after the try block has executed and
- after any catch blocks have executed if an exception was thrown.

The statements in the finally block execute whether an exception occurs or not.

The Stack Trace

- The *call stack* is an internal list of all the methods that are currently executing.
- A *stack trace* is a list of all the methods in the call stack.

It indicates:

- the method that was executing when an exception occurred and
- all of the methods that were called in order to execute that method.

Example: StackTrace.java

Uncaught Exceptions

- When an exception is thrown, it cannot be ignored.
- It must be handled by the program, or by the default exception handler.
- When the code in a method throws an exception:
  - normal execution of that method stops, and
  - the JVM searches for a compatible exception handler inside the method.

Uncaught Exceptions

- If there is no exception handler inside the method:
  - control of the program is passed to the previous method in the call stack.
  - If that method has no exception handler, then control is passed again, up the call stack, to the previous method.
- If control reaches the main method:
  - the main method must either handle the exception, or
  - the program is halted and the default exception handler handles the exception.

Checked and Unchecked Exceptions

- There are two categories of exceptions:
  - unchecked
  - checked.
- Unchecked exceptions are those that are derived from the Error class or the RuntimeException class.
- Exceptions derived from Error are thrown when a critical error occurs, and should not be handled.
- RuntimeException serves as a superclass for exceptions that result from programming errors.

Checked and Unchecked Exceptions

- These exceptions can be avoided with properly written code.
- Unchecked exceptions, in most cases, should not be handled.
- All exceptions that are not derived from Error or RuntimeException are checked exceptions.

Checked and Unchecked Exceptions

- If the code in a method can throw a checked exception, the method:
  - must handle the exception, or
  - it must have a throws clause listed in the method header.
- The throws clause informs the compiler what exceptions can be thrown from a method.

Checked and Unchecked Exceptions

```
// This method will not compile!
public void displayFile(String name)
{
   // Open the file.
   File file = new File(name);
   Scanner inputFile = new Scanner(file);
   // Read and display the file's contents.
   while (inputFile.hasNext())
   {
     System.out.println(inputFile.nextLine());
   }
   // Close the file.
   inputFile.close();
}
```

Checked and Unchecked Exceptions

- The code in this method is capable of throwing checked exceptions.
- The keyword throws can be written at the end of the method header, followed by a list of the types of exceptions that the method can throw.

```
public void displayFile(String name)
    throws FileNotFoundException
```

In-Class Activity

1. Download “Animals” from Blackboard and open in IntelliJ.
2. Add a class for user input.
3. Replace the code in the Main class between the comments with instantiation of the User Input Class and a call to the method that accepts input. (hint: pass the list to the IO Object)
4. Using Decisions and Exceptions, verify all the data entered by the user is of the correct data type.

Throws

Throwing Exceptions

- You can write code that:
  - throws one of the standard Java exceptions, or
  - an instance of a custom exception class that you have designed.
- The `throw` statement is used to manually throw an exception.

```
throw new ExceptionType(MessageString);
```

- The `throw` statement causes an exception object to be created and thrown.

Throwing Exceptions

- The *MessageString* argument contains a custom error message that can be retrieved from the exception object's `getMessage` method.
- If you do not pass a message to the constructor, the exception will have a null message.

```
throw new Exception("Out of fuel");
```

Note: Don't confuse the `throw` statement with the `throws` clause.

Example:

- InventoryItem.java
- InventoryDemo.java

Creating Exception Classes

- You can create your own exception classes by deriving them from the `Exception` class or one of its derived classes.

  Example:
  - BankAccount.java
  - NegativeStartingBalance.java
  - AccountTest.java

Creating Exception Classes

- Some examples of exceptions that can affect a bank account:
  - A negative starting balance is passed to the constructor.
  - A negative interest rate is passed to the constructor.
  - A negative number is passed to the deposit method.
  - A negative number is passed to the withdraw method.
- The amount passed to the withdraw method exceeds the account's balance.
- We can create exceptions that represent each of these error conditions.

In-Class Activity

1. Create a class, “InputTypeVerifier” in “Animals” that checks for correct datatype and throws an exception if incorrect. (hint: always pass user input as a String and return as the correct datatype)
2. Modify “Animals” to use “InputTypeVerifier” inside of a try/catch block .
3. Add a loop that accepts user input, adds to the ArrayList which then follows by adding to the output file.
4. Test the InputVerifier to the program.

I-O

Readers, Writers, and Streams

- Input and output in Java is accomplished by classes called streams
- Input streams provide ways to move bytes of data from an input device to a program
- Output streams move the data in the opposite direction

Predefined Streams

- **`System.in`**
  - InputStream object, usually for the keyboard
- **`System.out`**
  - a buffered PrintStream object, usually the screen or an active window
- **`System.err`**
  - an unbuffered PrintStream object usually associated with the screen or console window

Wrapping Classes

- **`InputStream`** class provides methods for reading bytes only
  - to read at a higher level we must "wrap" System.in with another class

  Example:

```
BufferedReader inFile =
    new BufferedReader (
    new InputStreamReader(System.in));
```

- Now we can send inFile either
  - the **`.read()`** message for a single char value or …
  - the **`.readLine()`** message for an entire line of text

Using a Reader

- Wrap **`FileReader`** in **`BufferedReader`** class

```
BufferedReader inFile =
    new BufferedReader (
    new FileReader (inputFilename) );
```

- Now the **`BufferedReader`** object (inFile) can be sent a **`.readLine()`** message
- A **`BufferedReader`** is so named because it buffers the input
  - this improves program performance

Using a Reader

- How to know when all the data in a file has been read?
  - the **`readLine()`** method returns the value null

```
String line = inFile.readLine():
while (line != null)
   {    … // process valueString
     line = inFile.readLine();  }
```

- Also possible to check for other things such as an empty line with no text

```
if (line.equals("")) continue;
```

Using a Reader

Steps for processing text input

1. Build a **`BufferedReader`** by wrapping one around a **`FileReader`**
2. Use an input loop to read lines of text from the **`BufferedReader`**
   - Convert those lines to numeric values if necessary
3. Close the **`BufferedReader`**

Using a Writer

- When writing values to a text file, author suggests use a Writer class
  - increase **`FileWriter`** capabilities by wrapping it in **`BufferedWriter`** and **`PrintWriter`** classes

```
PrintWriter outFile = new PrintWriter(
    new BufferedWriter (
    new FileWriter (file_name) ) );
```

Classes

- **`FileWriter`**
  - A convenience class for writing character files.
- **`BufferedWriter`**
  - Writes text to a character-output stream, buffering characters so as to provide for the efficient writing of single characters, arrays, and strings.
- **`BufferedReader`**
  - reads text from a character-input stream, buffering characters so as to provide for the efficient reading of characters, arrays, and lines.
- **`FileReader`**
  - A convenience class for writing character files.

In-Class Activity

1. Add all JavaDoc comments to “Animals”.
2. Create Online Documentation and show instructor.
3. Create Unit tests.
4. Run and show instructor.