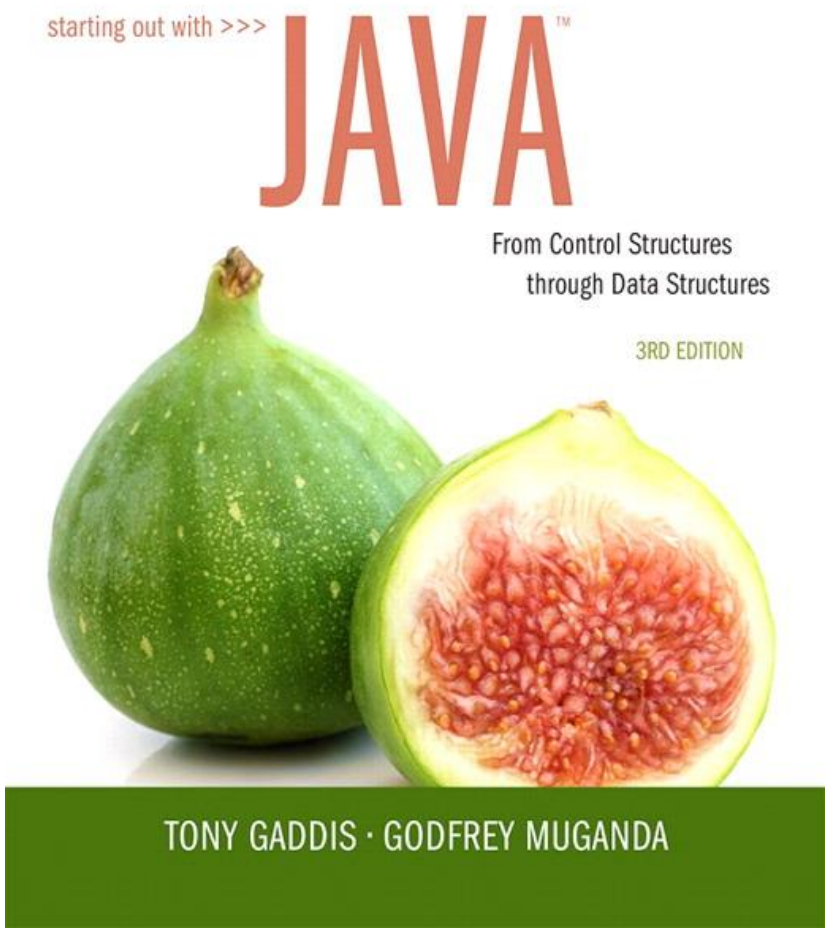
CHAPTER 11

Exceptions and Advanced File I/O



Chapter Topics

Chapter 11 discusses the following main topics:

- Handling Exceptions
- Throwing Exceptions
- More about Input/Output Streams
- Advanced Topics:
  - Binary Files,
  - Random Access Files, and
  - Object Serialization

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.

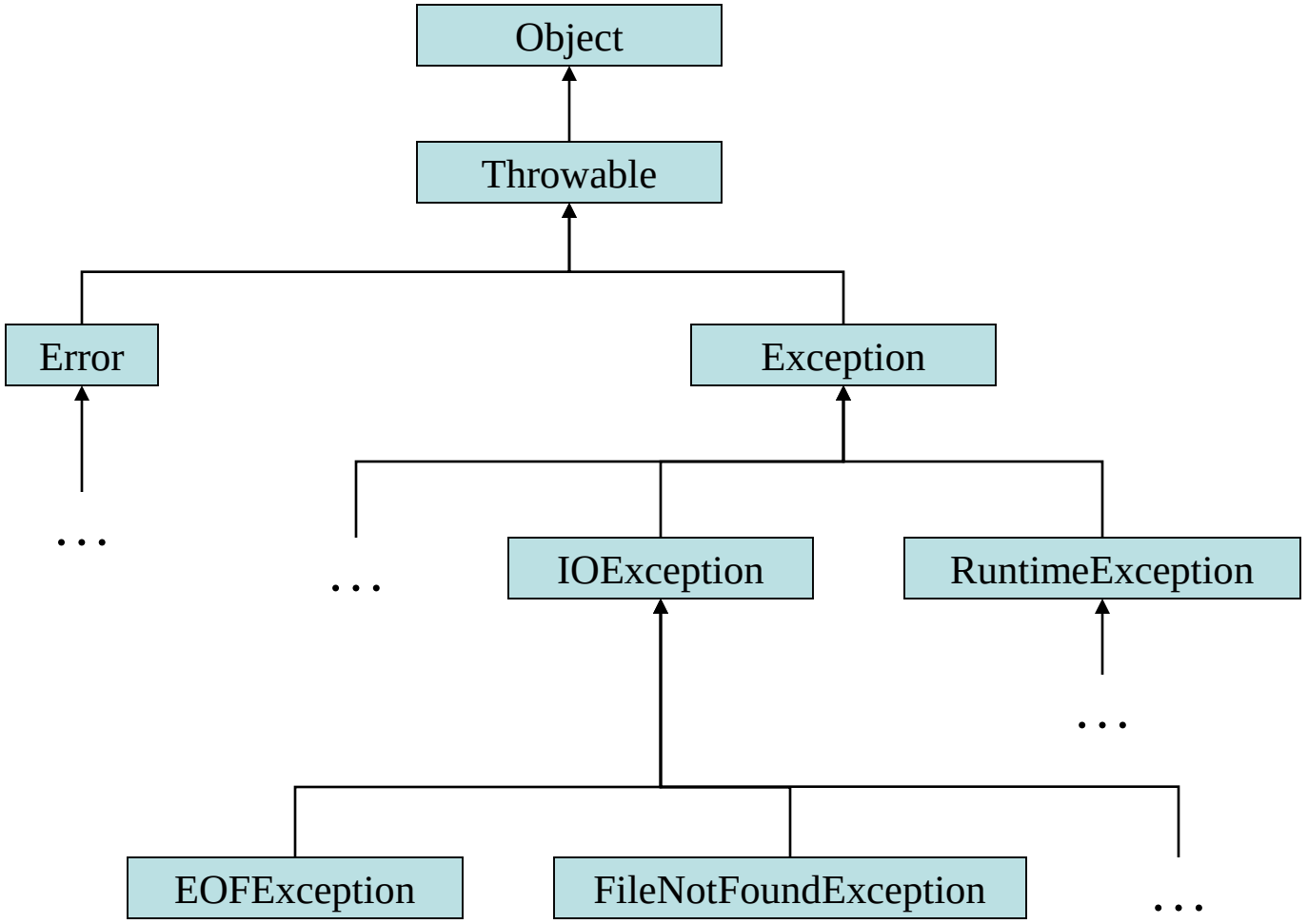
Exception Classes

- 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.

Handling Exceptions

- 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

Multi-Catch (Java 7)

- Beginning in Java 7, you can specify more than one exception in a `catch` clause:

```
try
{
}
catch(NumberFormatException | InputMismatchException ex)
{
}
```

Separate the exceptions with the `|` character.

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
```

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: DieExceptionDemo.java