Chapter 17

More on Exception Handling

Lecture slides for:

Java Actually: A Comprehensive Primer in Programming

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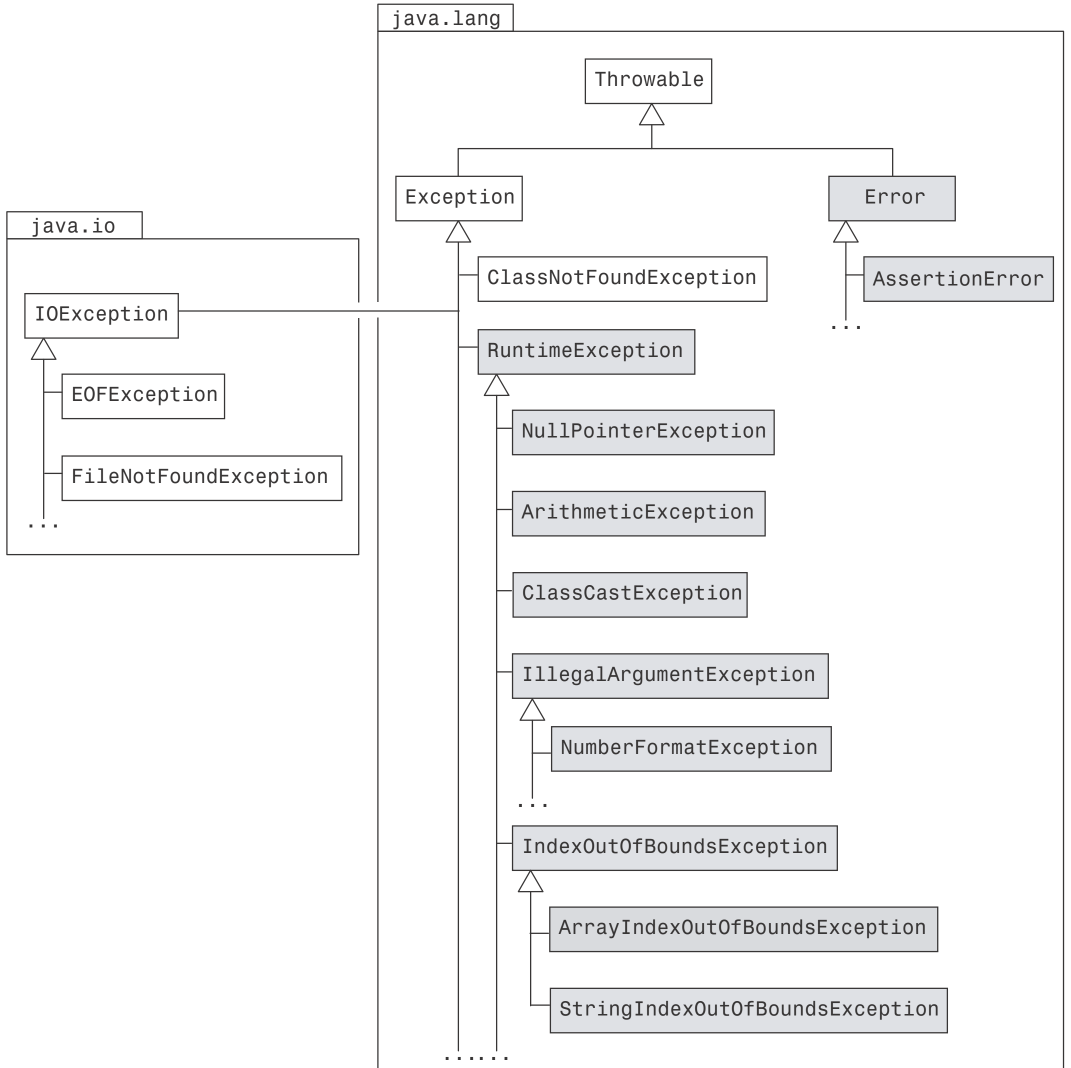
Overview

- Overview of exception classes
- Explicitly throwing an exception: the `throw` clause
- `try` block with multiple `catch` blocks
- Typical programming errors in exception handling
- Executing the finally block

Partial hierarchy of exception classes (Figure 18.1)



The grey-coloured classes (and their subclasses) represent unchecked exceptions.

Selected methods from the `Throwable` class (Table 18.1)

Method	Description
`String getMessage()`	Returns the string in the exception. The string provides more explanation of the exception.
`void printStackTrace()`	Prints on the terminal the stack trace at the time the exception was thrown.

Class `Exception` and checked exceptions

- Exceptions of the type `Exception` class and its subclasses, with the exception of subclasses of `RuntimeException` class, are called *checked exceptions*.
  - The compiler checks that a method that throws a checked exception, also explicitly handles the exception.

Class `RuntimeException` and unchecked exceptions

- The class `RuntimeException` and its subclasses represent exceptions that represent typical unforeseen errors, such as *programming errors*.
- Exceptions that are defined by the class `RuntimeException` and its subclasses is called *unchecked exceptions*.
  - It is not necessary that they be caught in the program, but the cause of the error must be corrected in the program.

Class `Error`

- The subclass `AssertionError` is used to signal that an assertion does not hold during the execution.
  - Such exceptions should not be caught.

Explicitly throwing an exception

- A program can explicitly throw an exception with the `throw` statement:

```
throw new ArithmeticException ("Distance and time cannot be < 0");
```

- Executing a `throw` statement interrupts the normal execution of the program, and the exception is propagated.
- It is common to use an appropriate exception class to define an error situation and provide supplementary information about the exception in the constructor call.
- In Program 18.1, the program execution will result in an `ArithmeticException` being thrown in the method `calculateSpeed()`, (4).
  – This exception will propagate and will be handled by the `catch` block in `main()` method.
  – From this point, normal execution of the program will continue.

Throwing an exception programmatically (Program 18.1)

```
public class Speed4 {

  public static void main(String[] args) {
    System.out.println("Entering main().");
    try {
      printSpeed(-100, 10);                     // (1) Distance < 0.
    }
    catch (ArithmeticException exception) {     // (2)
      System.out.println(exception + " (handled in main())");
    }
    System.out.println("Returning from main().");
  }

  private static void printSpeed(int kilometers, int hours) {
    System.out.println("Entering printSpeed().");
    int speed = calculateSpeed(kilometers, hours);
    System.out.println("Speed = " +
                       kilometers + "/" + hours + " = " + speed);
    System.out.println("Returning from printSpeed().");
  }
  private static int calculateSpeed(int distance, int time) {
    System.out.println("Calculating speed.");
    if (distance < 0 || time < 0)                              // (3)
      throw new ArithmeticException("distance and time" +
                                    " cannot be < 0");         // (4)
    return distance/time;
  }
}
```

- Output from the program:

```
Entering main().
Entering printSpeed().
Calculating speed.
java.lang.ArithmeticException: distance and time cannot be < 0 (handled in main())
Returning from main().
```

Handling several types of exceptions

- If the code in a `try` block can throw different types of exceptions, we can specify one `catch` block for each type of exception after the `try` block (Program 18.2).
- Indexing in the string array `args`, (3) and (4), can throw an unchecked `ArrayIndexOutOfBoundsException` unless at least two strings are specified on the command line.
- Converting to integer with the `parseInt()` method, (3) and (4), can throw an unchecked `NumberFormatException` if any of the strings contain characters that can not be part of an integer.

`try` block with several `catch` blocks (Program 18.2)

```
public class Speed5 {

  public static void main(String[] args) {
    System.out.println("Entering main().");
    int arg1, arg2;                                          // (1)
    try {                                                    // (2)
      arg1 = Integer.parseInt(args[0]);                      // (3)
      arg2 = Integer.parseInt(args[1]);                      // (4)
    }
    catch (ArrayIndexOutOfBoundsException exception) {      // (5)
      System.out.println("Specify both kilometers and hours.");
      System.out.println("Usage: java Speed5 <kilometers> <hours>");
      System.out.println(exception  + " (handled in main())");
      return;
    }
    catch (NumberFormatException exception) {               // (6)
      System.out.println("Kilometers and hours must be integers.");
      System.out.println("Usage: java Speed5 <kilometers> <hours>");
      System.out.println(exception  + " (handled in main())");
      return;
    }
    printSpeed(arg1, arg2);                                  // (7)
    System.out.println("Returning from main().");
  }
  private static void printSpeed(int kilometers, int hours) {
    System.out.println("Entering printSpeed().");
    try {
      int speed = calculateSpeed(kilometers, hours);
      System.out.println("Speed = " +
                         kilometers + "/" + hours + " = " + speed);
    }
    catch (ArithmeticException exception) {
      System.out.println(exception  + " (handled in printSpeed())");
    }
    System.out.println("Returning from printSpeed().");
  }

  private static int calculateSpeed(int distance, int time) {
    System.out.println("Calculating speed.");
    if (distance < 0 || time < 0)
      throw new ArithmeticException("distance and time cannot be < 0");
    return distance/time;
  }
}
```

- Output from the program:

```
> java Speed5 100
Entering main().
Specify both kilometers and hours.
Usage: java Speed5 <kilometers> <hours>
java.lang.ArrayIndexOutOfBoundsException: 1 (handled in main())
> java Speed5 200 4u
Entering main().
Kilometers and hours must be integers.
Usage: java Speed5 <kilometers> <hours>
java.lang.NumberFormatException: For input string: "4u" (handled in main())
> java Speed5 200 -10
Entering main().
Entering printSpeed().
Calculating speed.
java.lang.ArithmeticException: distance and time cannot be < 0 (handled in printSpeed())
Returning from printSpeed().
Returning from main().
> java Speed5 200 0
Entering main().
Entering printSpeed().
Calculating speed.
java.lang.ArithmeticException: / by zero (handled in printSpeed())
Returning from printSpeed().
Returning from main().
```

Typical programming errors in exception handling

- A parameter type in a `catch` block can shadow other exception types in the subsequent `catch` blocks.
  - For example, the superclass `RuntimeException` in the `catch` block (1) shadows the subclass `ArithmeticException` in the `catch` block (2):

```
try { ... }
catch (RuntimeException    exception1) { ... }        // (1)
catch (ArithmeticException exception2) { ... }        // (2)
```

  - Exceptions of type `ArithmeticException` are caught by the catch block (1) and never by the catch block (2), since objects of subclasses can be assigned to a superclass reference.
  - The compiler will warn of such cases.
- Do not catch all exceptions in one catch block by using more general exception classes, such as `Exception` and `RuntimeException`.
  - Using specific exception classes, often with multiple catch blocks, are recommended in the `try-catch` construct to improve program understanding.

Defining new exceptions

- It is recommended to define new subclasses of the class `Exception`.
- The new exception is then automatically checked by the compiler.

```
class SpeedCalculationException extends Exception {
  SpeedCalculationException(String str) {
    super(str);
  }
}
```

- It is usually sufficient to define only a constructor that takes a string parameter.

Executing the `finally` block

- A `finally` block can occur with a `try` block.
  - A `catch` block does not necessarily need to be specified.
- The code in the `finally` block is always executed if the `try` block is executed.
  - It does not matter if an exception was thrown or not.
- "Cleanup Code" may be put in a `finally` block so it will always be executed.
- The class Speed7 illustrates executing a `finally` block.
  - A `finally` block is specified at (4), with the corresponding try block at (1).
  - Printout shows that the code in the `finally` block will always be executed if the `try` block is executed.

```
public class Speed7 {

  public static void main(String[] args) {
    System.out.println("Entering main().");
    try {                                                      //(1)
//    printSpeed(100, 20);                                     //(2a)
      printSpeed(-100,20);                                     //(2b)
    }
    catch (SpeedCalculationException exception) {              //(3)
      System.out.println(exception + " (handled in main())");
    }
    finally {                                                  //(4)
      System.out.println("Command to use: java Speed7");
    }
    System.out.println("Returning from main().");
  }
  private static void printSpeed(int kilometers, int hours)
                    throws SpeedCalculationException {         //(5)
    System.out.println("Entering printSpeed().");
    double speed = calculateSpeed(kilometers, hours);
    System.out.println("Speed = " +
        kilometers + "/" + hours + " = " + speed);
    System.out.println("Returning from printSpeed().");
  }

  private static int calculateSpeed(int distance, int time)
                   throws SpeedCalculationException {          //(6)
    System.out.println("Calculating speed.");
    if (distance < 0 || time <= 0)
      throw new SpeedCalculationException("distance and time " +
                                           "must be > 0");     //(7)
    return distance/time;
  }
}
```

- Running the program with the code line (2a):

  ```
  printSpeed(100, 20);                          // (2a)
  ```

  gives the following output:

  ```
  Entering main().
  Entering printSpeed().
  Calculating speed.
  Speed = 100/20 = 5.0
  Returning from printSpeed().
  Command to use: java Speed7
  Returning from main().
  ```

- Running the program with the code line (2b):

  ```
  printSpeed(100, 0);                           // (2b)
  ```

  gives the following output:

  ```
  Entering main().
  Entering printSpeed().
  Calculating speed.
  SpeedCalculationException: distance and time must be > 0 (handled in main())
  Command to use: java Speed7
  Returning from main().
  ```

  – Note that the execution of the method `printSpeed()` was stopped *after* the `finally` block was executed.

Exception handling and inheritance

- A method in the subclass can only specify in its `throws` clause *a subset of the exception types* specified in the `throws` clause of the method it is overriding from a superclass.

```
// Class A
 public void methodWithManyExceptions() throws Exception1, Exception2, Exception3 {...}
 ...

// In subclass B which extends superclass A
 public void methodWithManyExceptions() throws Exception1, Exception3 {...}
```

Summary of exception handling

- "*Throw and catch*" rule for checked exceptions:
  - A method can catch the exceptions it throws, and handle them in `catch` blocks.
  - The checked exceptions that a method can throw and not catch, must be declared in a `throws` clause of the method.
- A method can programmatically throw an exception using the `throw` statement.

```
... methodName(...) throws Exception1, Exception2, ... , Exceptionn {
        ...
        try { // code resulting in one of the following exceptions being thrown:
              // Exception1, ... , Exceptionn og Exceptiona, ..., Exceptionm
            throw new Exceptioni(); // throws an exception of type Exceptioni
        }
        catch (Exceptionj ej) { // catches exception of type Exceptionj
            // code to handle Exception ej
        }
        ...
        catch (Exceptionk ek) { // catches exception of type Exceptionk
            // code to handle Exception ek
        }
        finally { ... } // Code that is always executed if try block is executed.
        ...
}
```

`try-catch-finally` **block**