Exceptions

Introduction

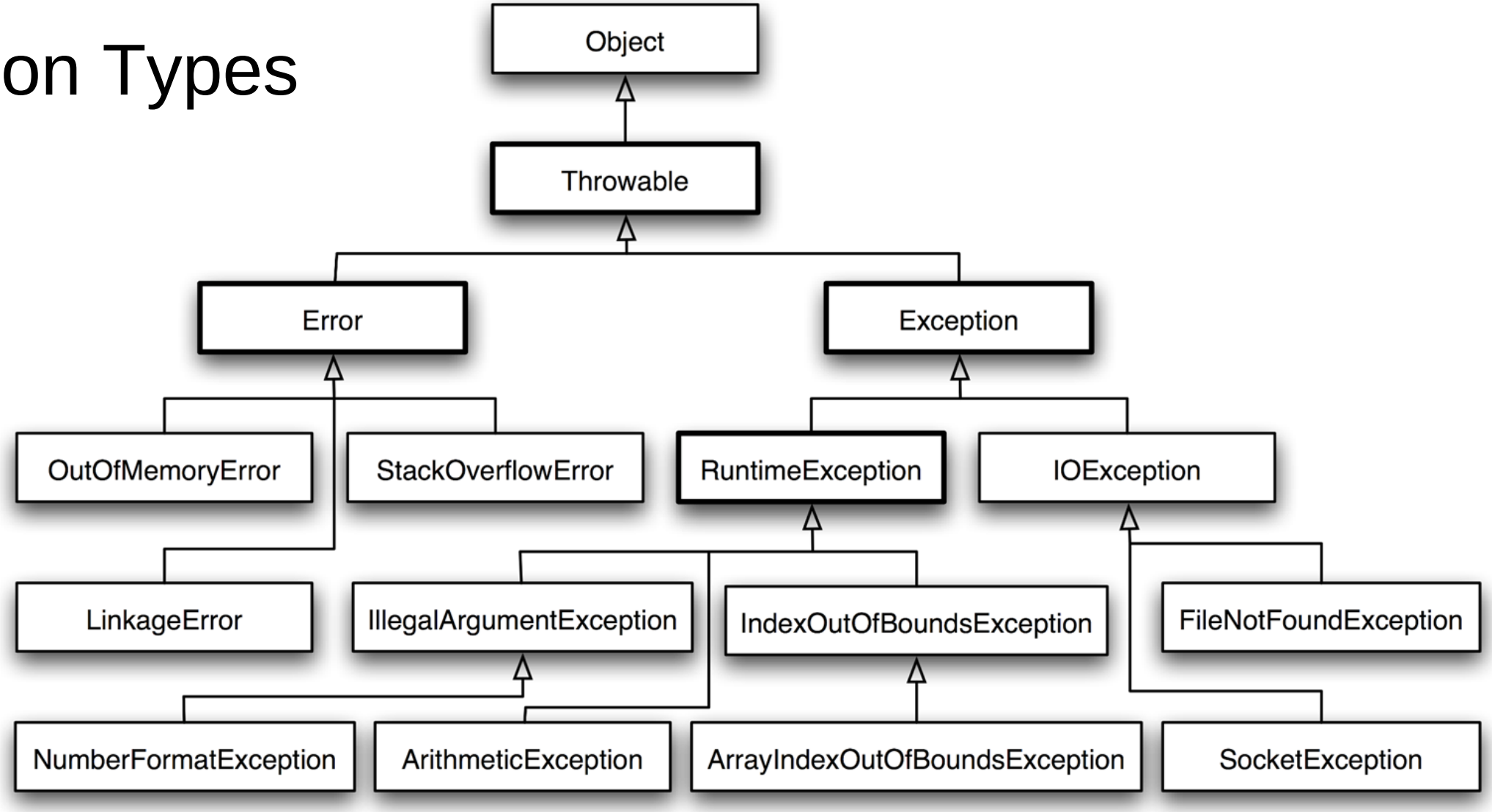
- When executing, abnormal situations (or *exceptions*) may happen, due to:
  - Coding errors made by the programmer:
  - Errors caused by wrong input
  - Unforeseen external conditions (network disconnected, data file deleted,…)
- On these cases, Java by default will stop and generate an error message
  - ```
    int[] values = {1, 2, 4};
    System.out.println(values[10]);
    System.out.println("Task done!");    // unreachable
    ```
  - ```
    Exception in thread "main" java.lang.ArrayIndexOutOfBoundsException:
    Index 10 out of bounds for length 3
    ```

Exception Handling

- Technically said: Java will *throw an exception*
  - One can handle these situations to change the default behavior by *catching the exception*
- Example:
  - ```
    try {
        int[] values = {1, 2, 4};
        System.out.println(values[10]);
        System.out.println("Success!"); // unreachable
    } catch(ArrayIndexOutOfBoundsException e) {
        System.err.println("Error: " + e.getMessage());
        System.out.println("Error recovered");
    }

    System.out.println("Task done!");   // reachable
    ```
  - ```
    Error: Index 10 out of bounds for length 3
    Error recovered
    Task done!
    ```

Exception Types



- This are just some most used ones of the built-in exception types!

Exception Objects

- An exception object is an instance of an exception class
  - Can be thrown with the `throw` keyword
  - Any uncaught exception will cause the program to stop
- Inside the `catch` block, one may re-throw the caught exception object, or throw another new exception if necessary
- Example:
  - ```
    static String date2String(int day, int month, int year) {
        if (day <= 0 || day > 31)
            throw new IllegalArgumentException("Invalid day value");
        if (month <= 0 || month > 12)
            throw new IllegalArgumentException("Invalid month value");
        if (List.of(2, 4, 6, 9, 11).indexOf(month) >= 0 && day == 31)
            throw new IllegalArgumentException("Invalid day value for the given month");

        return String.format("%02d/%02d/%04d", day, month, year);
    }
    ```
    ```

Handling Multiple Exceptions

- One code may throw different types of exceptions. There are several ways to handle (choose one to use depending on situation):
  - Multiple nested `try … catch`
  - Multiple sequential `try … catch`
  - A single `try` with multiple `catch`
    - ```
      try {
          doSomething1(); // may throw FileNotFoundException
          doSomething2(); // may throw FileAlreadyExistsException
      }
      catch(FileNotFoundException e) { //... }
      catch(FileAlreadyExistsException e) { //... }
      ```
  - A single `try … catch` with piped classes
    - ```
      try { // ... }
      catch(FileNotFoundException | FileAlreadyExistsException e) { //... }
      ```
  - A single `try … catch` with a super exception class
    - ```
      try { // ... }
      catch(IOException e) { //... }
      ```
      ```

Checked and Unchecked Exceptions

- Checked exceptions are the ones that are checked at compile-time, and *need to be explicitly handled in code*
  - Examples: `IOException`, `FileNotFoundException`, `ClassNotFoundException`,…
  - A method may leave the handling of some of its checked exceptions to the callers with the `throws` keyword
    - ```
      MyData loadData(String filepath)
          throws FileNotFoundException, FileAlreadyExistsException
      { // ... }
      ```
- Unchecked exceptions are the other ones
  - Examples: `NullPointerException`, `ArrayIndexOutOfBoundException`, `ArithmeticException`,…
      ```

User-defined Exceptions

- One may create his own types of exceptions for capturing additional information by extending the `Exception` class
- Example:
  - ```
    class DateException extends Exception {
        private int day, month, year;

        DateException(String message, int day, int month, int year) {
            super(message);
            this.day = day;
            this.month = month;
            this.year = year;
        }

        // ...
    }
    ```
  - ```
    throw new DateException("Invalid day value", day, month, year);
    ```

`finally` Block

- The `finally` block always executes when the `try` block exits, even when an exception occurs
  - It is useful for cleanup code to avoid being accidentally bypassed by a `return`, `continue`, `break` or an exception
  - Good practice to put cleanup code in a `finally` block, even when no exceptions are anticipated.
- Example:

```
int safeFunction() {
    SomeResource rc = acquireResource();
    try {
        doGoodThing();  // may throw GoodException
        doBadThing();   // may throw BadException
        return 0;
    } catch(GoodException e) {
        return 1;
    } catch(BadException e) {
        return 2;
    } finally {
        rc.release();
    }
}
```

Assertions

- An `assert` statement is used to declare an expected `boolean` condition in a program, which is checked at runtime (the program must be running with assertions enabled)
  - If the condition is false, the Java will throw an `AssertionError` exception
  - To run a program with assertions enabled:
    - `java -ea <Program>`
- Programmers usually use `assert` for program testing and verification purposes, and try to ensure that assertions never fail in production programs
  - Enable assertions only in development time
- Example:
  - ```
    MyData data = loadData(dataFilePath);
    assert data != null;
    ```
    ```

Exercise

- Write a program to repeatedly ask the user for a numerator and a divisor, and print the division result, but the invalid-user-input and division-by-zero situations must be handled correctly by your own exception class(es)