Exceptions

It enables a method to throw an exception to its caller. Without this capability, a method must handle the exception or terminate the program.

Example

```
import java.util.Scanner;
public class QuotientWithException {
  public static int quotient(int number1, int number2) {
    if (number2 == 0)
      throw new ArithmeticException("Divisor cannot be zero");
    return number1 / number2;
  }
  public static void main(String[] args) {
    Scanner input = new Scanner(System.in);

    // Prompt the user to enter two integers
    System.out.print("Enter two integers: ");
    int number1 = input.nextInt();
    int number2 = input.nextInt();

    try {
      int result = quotient(number1, number2);
      System.out.println(number1 + " / " + number2 + " is "
        + result);
    }
    catch (ArithmeticException ex) {
      System.out.println("Exception: an integer " +
        "cannot be divided by zero ");
    }

    System.out.println("Execution continues ...");
  }
}
```

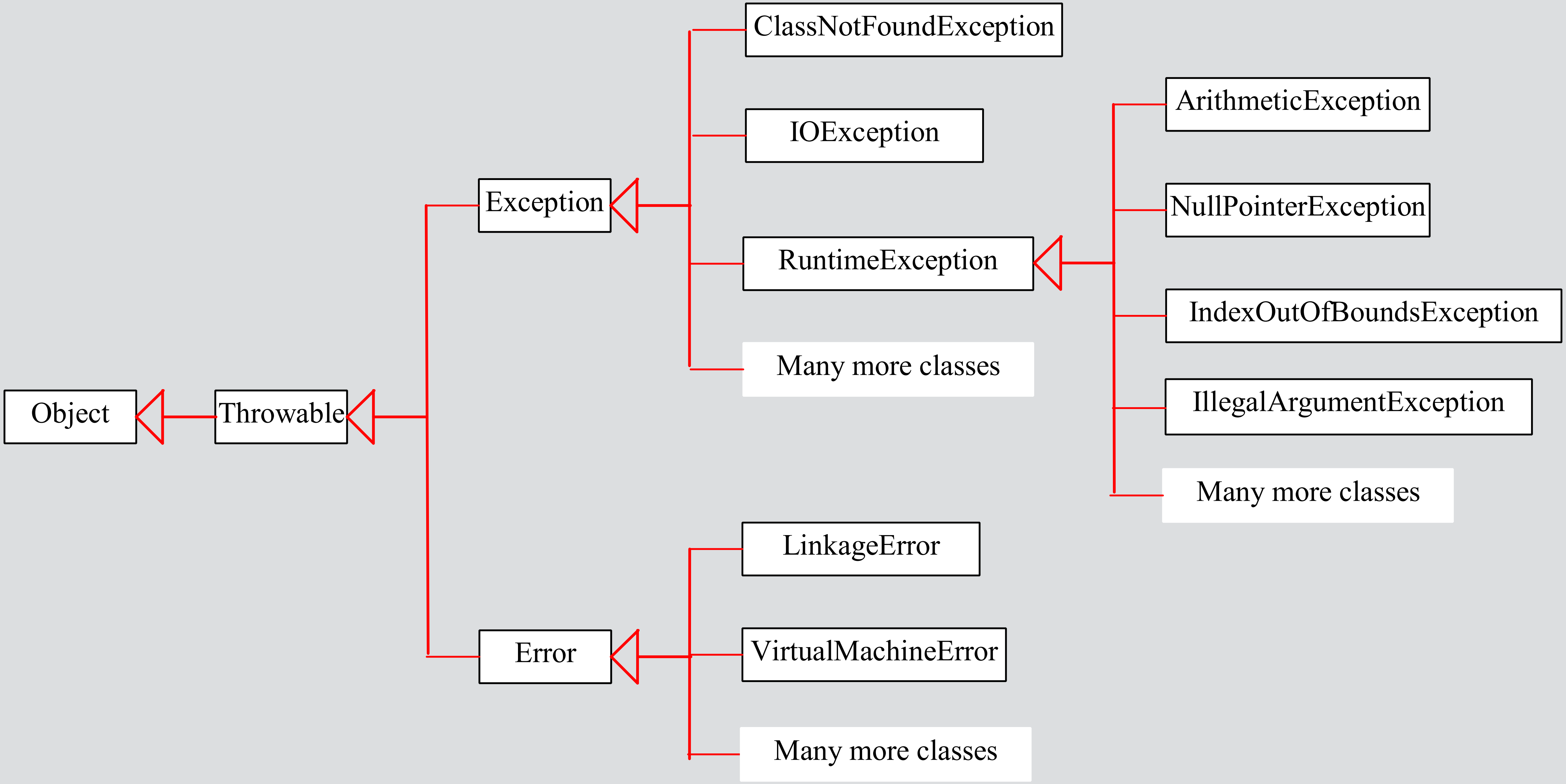
Handling InputMismatchException

By handling InputMismatchException, your program will continuously read an input until it is correct.

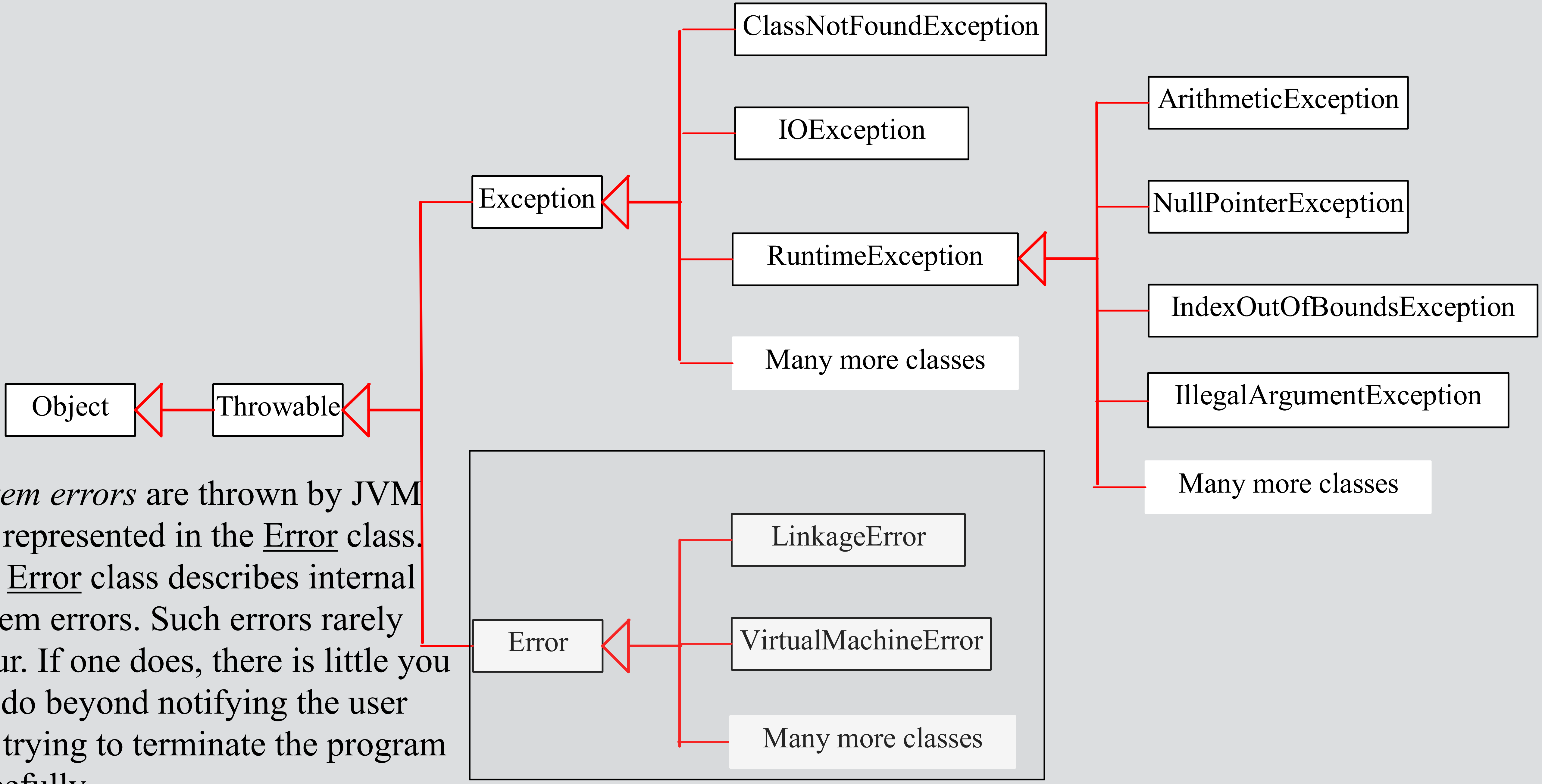
Example

```
import java.util.*;
public class InputMismatchExceptionDemo {
  public static void main(String[] args) {
    Scanner input = new Scanner(System.in);
    boolean continueInput = true;
    do {
      try {
        System.out.print("Enter an integer: ");
        int number = input.nextInt();
        // Display the result
        System.out.println("The number entered is " + number);
        continueInput = false;
      }
      catch (InputMismatchException ex) {
        System.out.println("Try again. (" +
          "Incorrect input: an integer is required)");
        input.nextLine(); // discard input
      }
    } while (continueInput);
  }
}
```

Exception Types



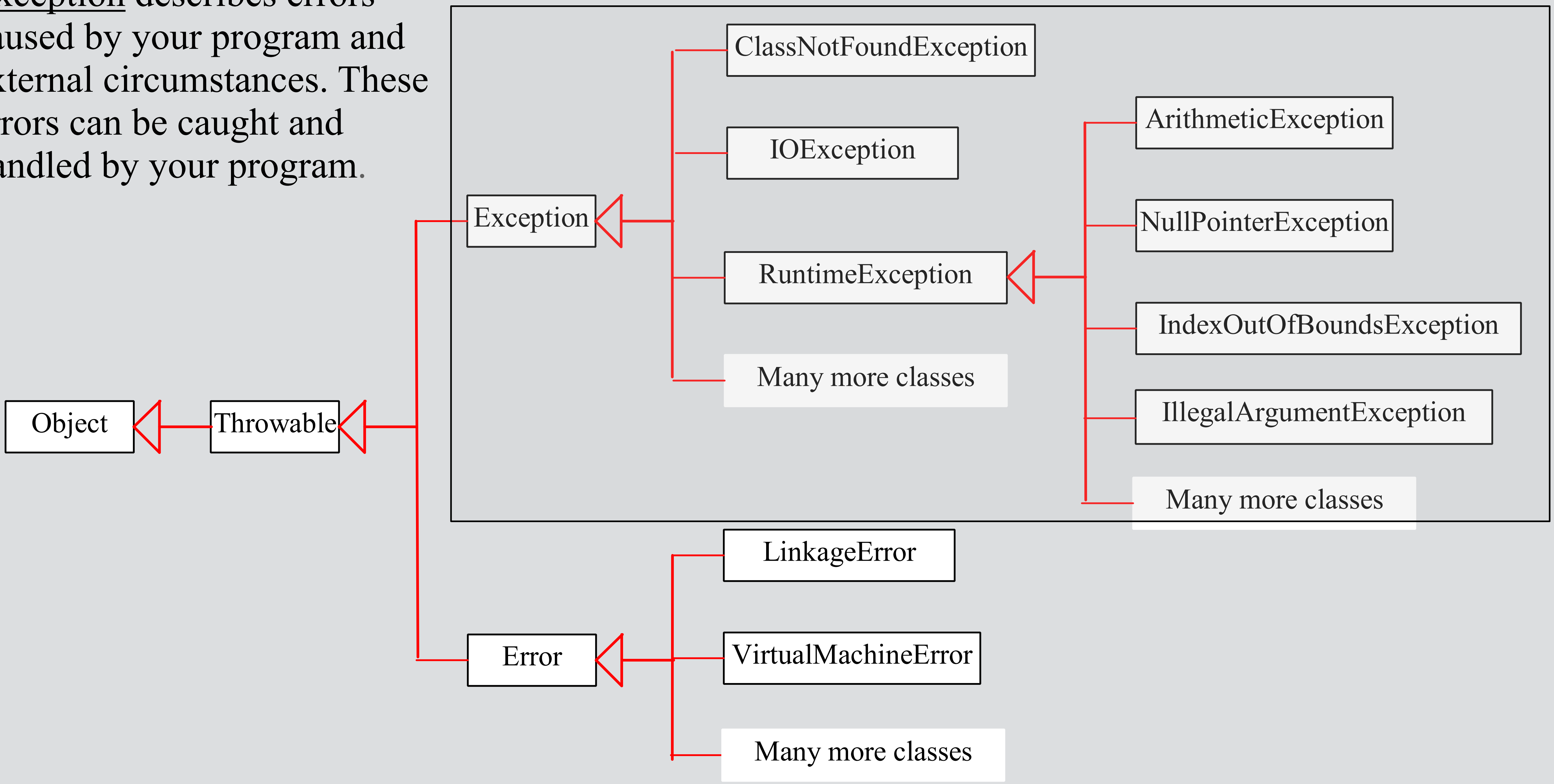
System Errors



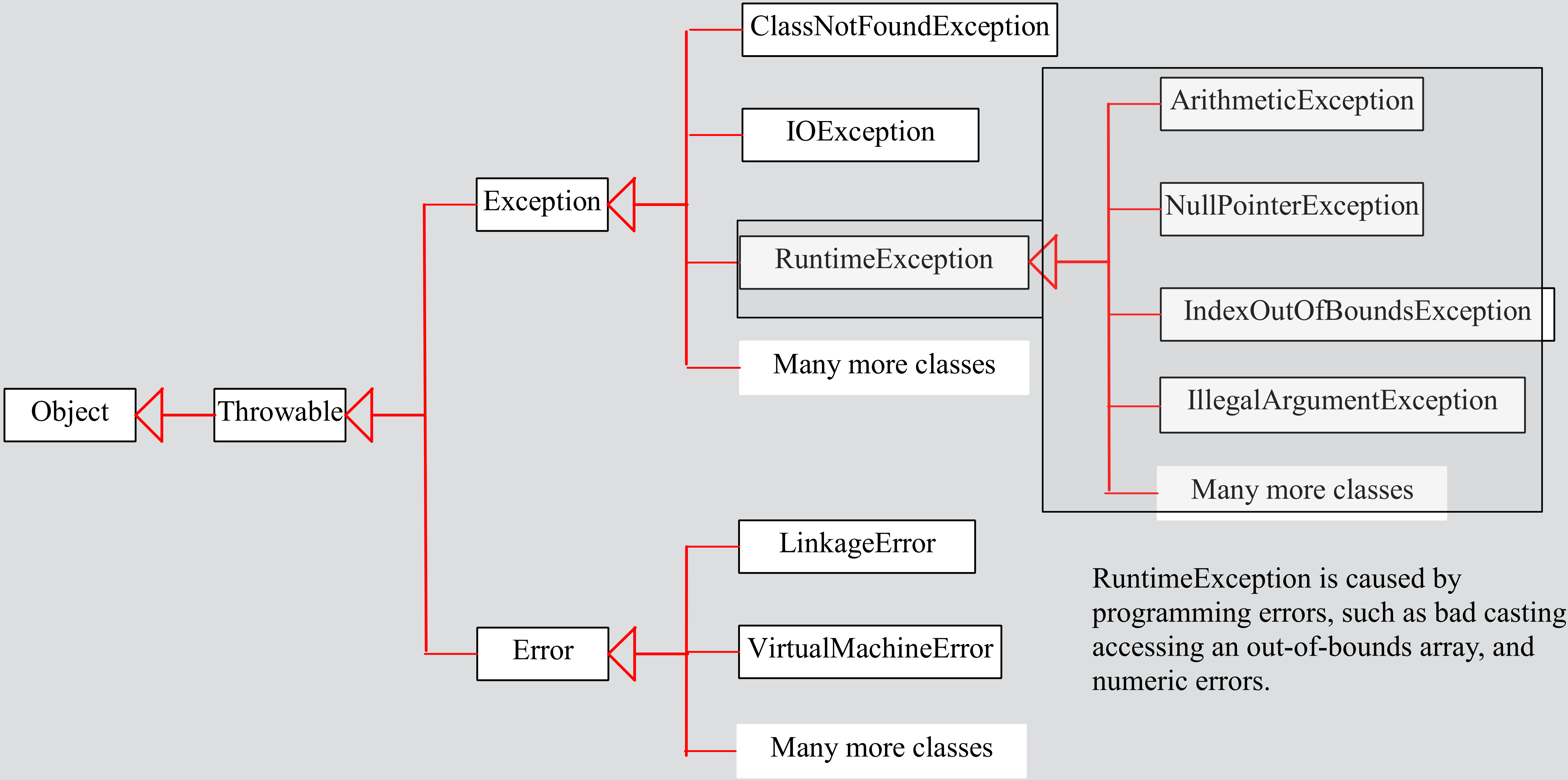
System errors are thrown by JVM and represented in the Error class. The Error class describes internal system errors. Such errors rarely occur. If one does, there is little you can do beyond notifying the user and trying to terminate the program gracefully.

Exceptions

Exception describes errors caused by your program and external circumstances. These errors can be caught and handled by your program.



Runtime Exceptions



RuntimeException is caused by programming errors, such as bad casting, accessing an out-of-bounds array, and numeric errors.

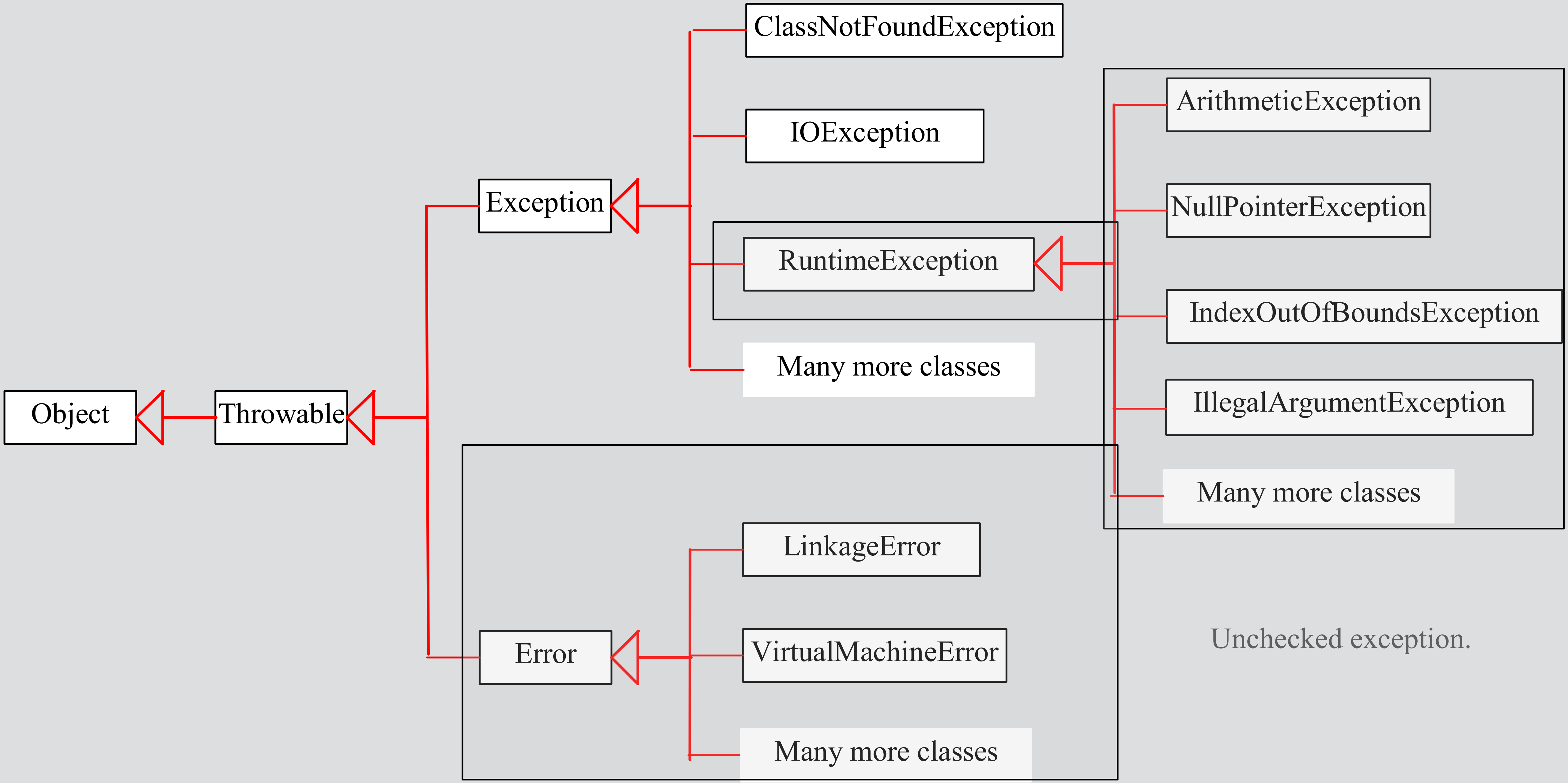
Checked Exceptions vs. Unchecked Exceptions

RuntimeException, Error and their subclasses are known as *unchecked exceptions*. All other exceptions are known as *checked exceptions*, meaning that the compiler forces the programmer to check and deal with the exceptions.

Unchecked Exceptions

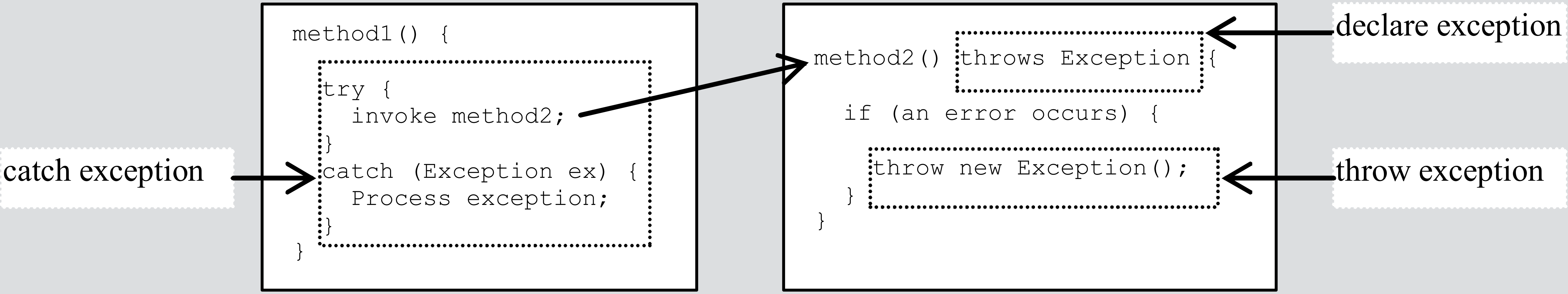
In most cases, unchecked exceptions reflect programming logic errors that are not recoverable. For example, a NullPointerException is thrown if you access an object through a reference variable before an object is assigned to it; an IndexOutOfBoundsException is thrown if you access an element in an array outside the bounds of the array. These are the logic errors that should be corrected in the program. Unchecked exceptions can occur anywhere in the program. To avoid cumbersome overuse of try-catch blocks, Java does not mandate you to write code to catch unchecked exceptions.

Unchecked Exceptions



Unchecked exception.

Declaring, Throwing, and Catching Exceptions



```
method1() {

  try {
    invoke method2;
  }
  catch (Exception ex) {
    Process exception;
  }
}
```

```
method2() throws Exception {

  if (an error occurs) {

    throw new Exception();
  }
}
```

catch exception

declare exception

throw exception

Declaring Exceptions

Every method must state the types of checked exceptions it might throw. This is known as *declaring exceptions*.

```
public void myMethod()
   throws IOException

public void myMethod()
   throws IOException, OtherException
```

Throwing Exceptions

When the program detects an error, the program can create an instance of an appropriate exception type and throw it. This is known as *throwing an exception*. Here is an example,

```
throw new TheException();
```

```
TheException ex = new TheException();
throw ex;
```

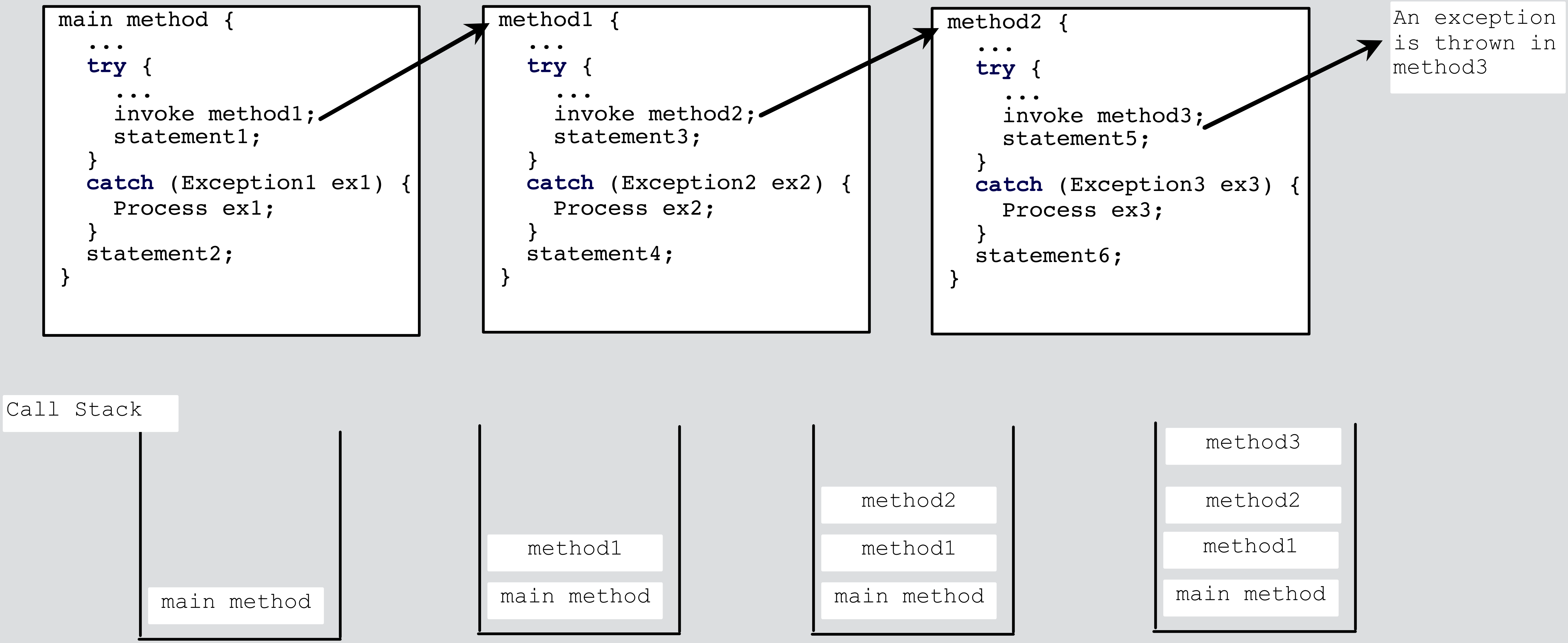
Throwing Exceptions Example

```
   /** Set a new radius */
public void setRadius(double newRadius)
    throws IllegalArgumentException {
  if (newRadius >= 0)
    radius =  newRadius;
  else
    throw new IllegalArgumentException(
      "Radius cannot be negative");
}
```

Catching Exceptions

```
try {
  statements;  // Statements that may throw exceptions
}
catch (Exception1 exVar1) {
  handler for exception1;
}
catch (Exception2 exVar2) {
  handler for exception2;
}
...
catch (ExceptionN exVar3) {
  handler for exceptionN;
}
```

Catching Exceptions



```
main method {
  ...
  try {
    ...
    invoke method1;
    statement1;
  }
  catch (Exception1 ex1) {
    Process ex1;
  }
  statement2;
}
```

```
method1 {
  ...
  try {
    ...
    invoke method2;
    statement3;
  }
  catch (Exception2 ex2) {
    Process ex2;
  }
  statement4;
}
```

```
method2 {
  ...
  try {
    ...
    invoke method3;
    statement5;
  }
  catch (Exception3 ex3) {
    Process ex3;
  }
  statement6;
}
```

An exception is thrown in method3

Call Stack

main method

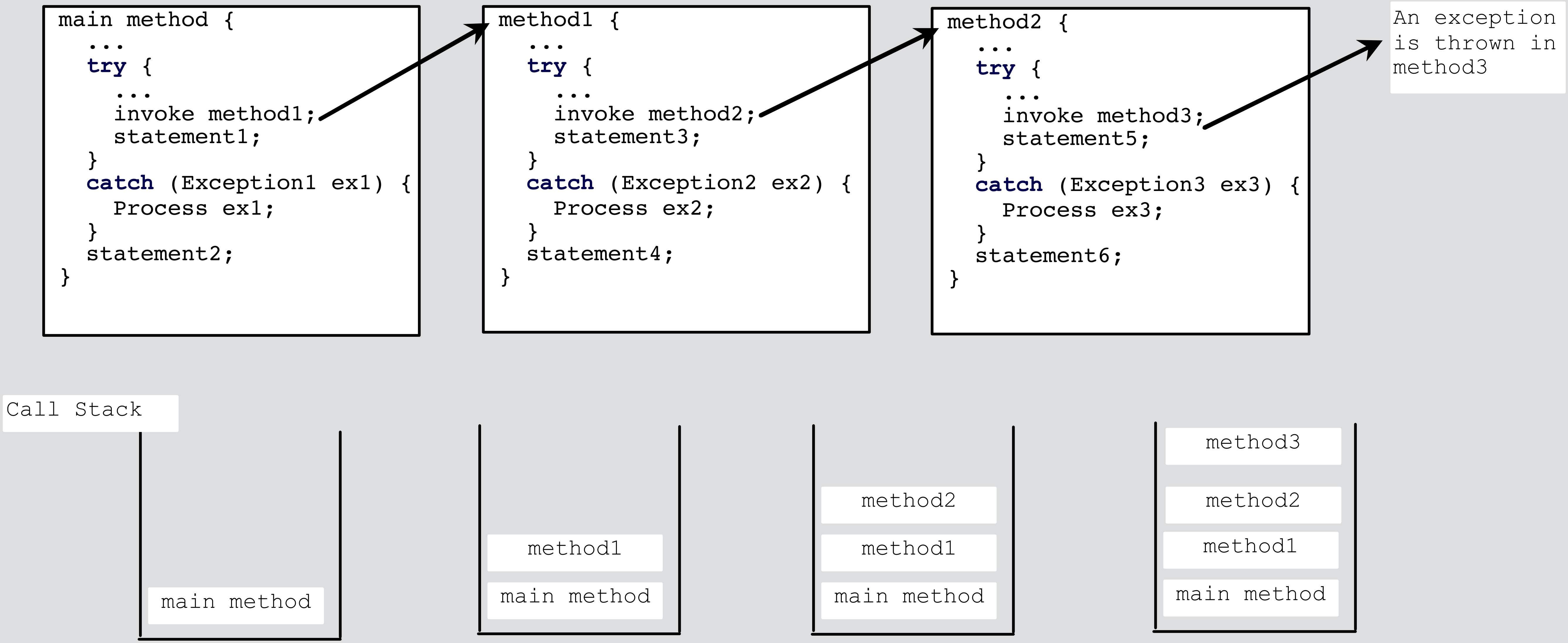
method1
main method

method2
method1
main method

method3
method2
method1
main method

Suppose the **main** method invokes **method1**, **method1** invokes **method2**, **method2** invokes **method3**, and **method3** throws an exception

Catching Exceptions



```
main method {
  ...
  try {
    ...
    invoke method1;
    statement1;
  }
  catch (Exception1 ex1) {
    Process ex1;
  }
  statement2;
}
```

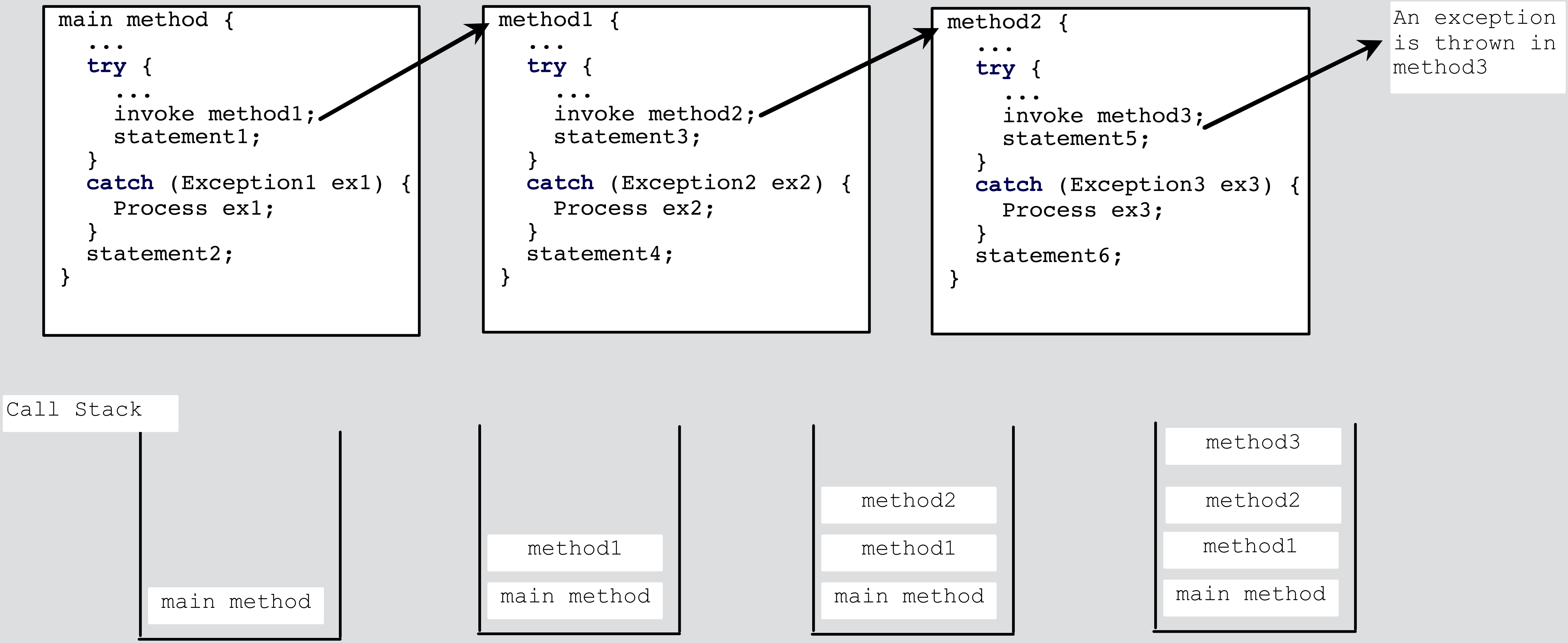
```
method1 {
  ...
  try {
    ...
    invoke method2;
    statement3;
  }
  catch (Exception2 ex2) {
    Process ex2;
  }
  statement4;
}
```

```
method2 {
  ...
  try {
    ...
    invoke method3;
    statement5;
  }
  catch (Exception3 ex3) {
    Process ex3;
  }
  statement6;
}
```

An exception is thrown in method3

If the exception type is **Exception3**, it is caught by the **catch** block for handling exception **ex3** in **method2**. **statement5** is skipped, and **statement6** is executed.

Catching Exceptions



```
main method {
  ...
  try {
    ...
    invoke method1;
    statement1;
  }
  catch (Exception1 ex1) {
    Process ex1;
  }
  statement2;
}
```

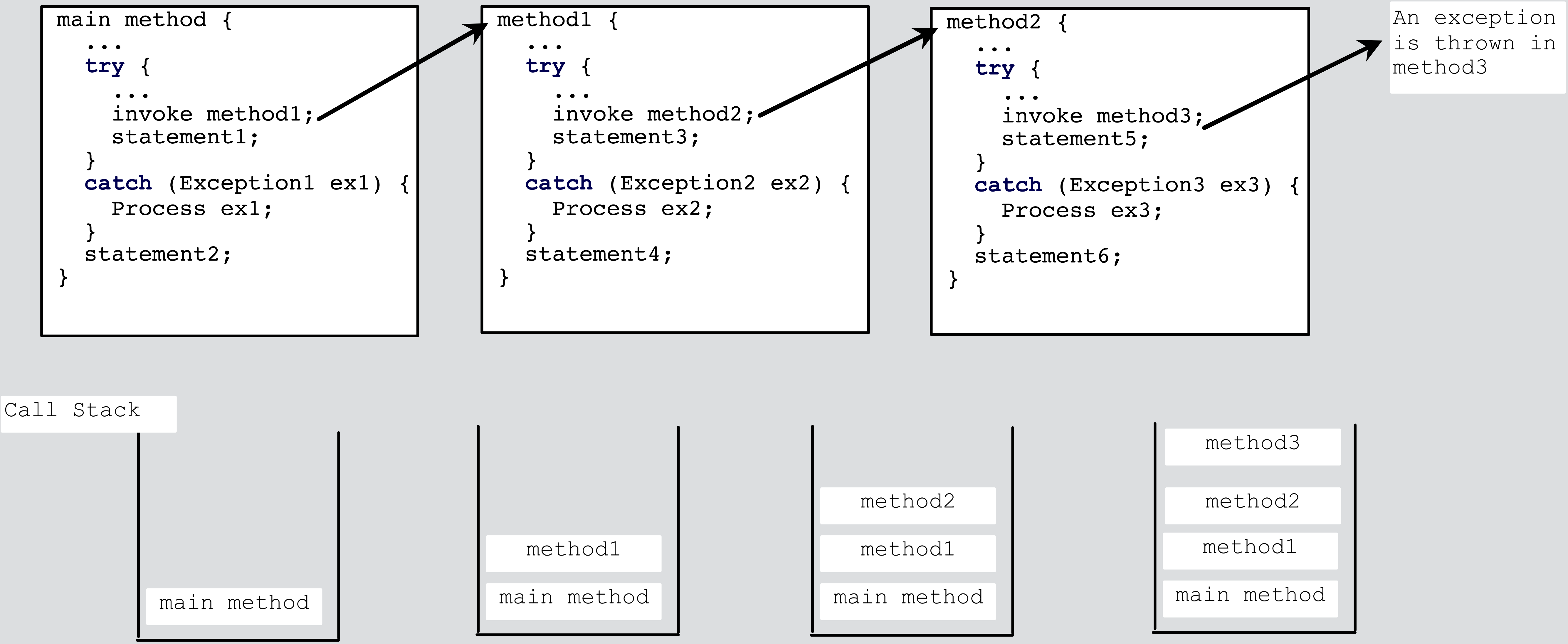
```
method1 {
  ...
  try {
    ...
    invoke method2;
    statement3;
  }
  catch (Exception2 ex2) {
    Process ex2;
  }
  statement4;
}
```

```
method2 {
  ...
  try {
    ...
    invoke method3;
    statement5;
  }
  catch (Exception3 ex3) {
    Process ex3;
  }
  statement6;
}
```

An exception is thrown in method3

If the exception type is Exception2, method2 is aborted, the control is returned to method1, and the exception is caught by the catch block for handling exception ex2 in method1. statement3 is skipped, and statement4 is executed.

Catching Exceptions



```
main method {
  ...
  try {
    ...
    invoke method1;
    statement1;
  }
  catch (Exception1 ex1) {
    Process ex1;
  }
  statement2;
}
```

```
method1 {
  ...
  try {
    ...
    invoke method2;
    statement3;
  }
  catch (Exception2 ex2) {
    Process ex2;
  }
  statement4;
}
```

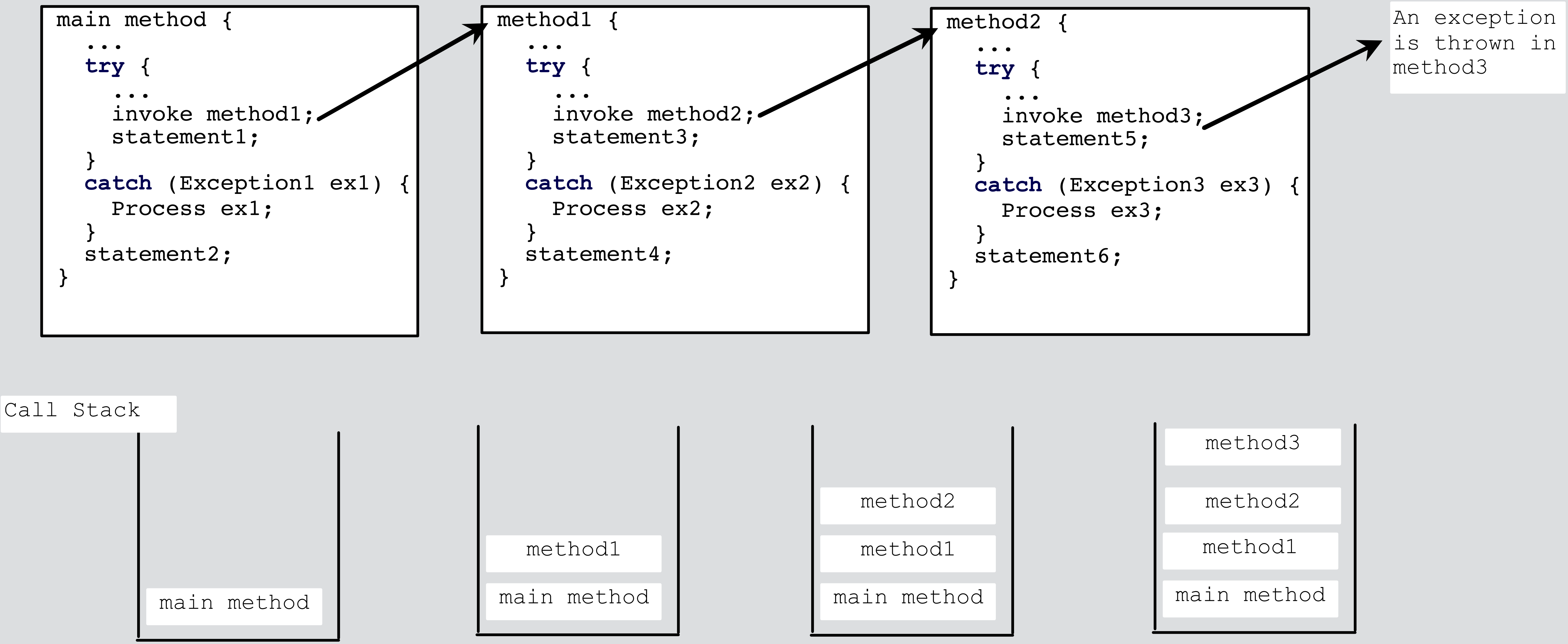
```
method2 {
  ...
  try {
    ...
    invoke method3;
    statement5;
  }
  catch (Exception3 ex3) {
    Process ex3;
  }
  statement6;
}
```

An exception is thrown in method3

Call Stack

If the exception type is **Exception1**, **method1** is aborted, the control is returned to the **main** method, and the exception is caught by the **catch** block for handling exception **ex1** in the **main** method. **statement1** is skipped, and **statement2** is executed.

Catching Exceptions



```
main method {
  ...
  try {
    ...
    invoke method1;
    statement1;
  }
  catch (Exception1 ex1) {
    Process ex1;
  }
  statement2;
}
```

```
method1 {
  ...
  try {
    ...
    invoke method2;
    statement3;
  }
  catch (Exception2 ex2) {
    Process ex2;
  }
  statement4;
}
```

```
method2 {
  ...
  try {
    ...
    invoke method3;
    statement5;
  }
  catch (Exception3 ex3) {
    Process ex3;
  }
  statement6;
}
```

An exception is thrown in method3

If the exception type is not caught in **method2**, **method1**, or **main**, the program terminates, and **statement1** and **statement2** are not executed.

Catch or Declare Checked Exceptions

Suppose p2 is defined as follows:

```
void p2() throws IOException {
  if (a file does not exist) {
     throw new IOException("File does not exist");
  }

  ...
}
```

Catch or Declare Checked Exceptions

Java forces you to deal with checked exceptions. If a method declares a checked exception (i.e., an exception other than Error or RuntimeException), you must invoke it in a try-catch block or declare to throw the exception in the calling method. For example, suppose that method p1 invokes method p2 and p2 may throw a checked exception (e.g., IOException), you have to write the code as shown in (a) or (b).

```
void p1() {
  try {
    p2();
  }
  catch (IOException ex) {
    ...
  }
}
```

(a)

```
void p1() throws IOException {

  p2();

}
```

(b)

Example

```
public class CircleWithException {
  private double radius;
  private static int numberOfObjects = 0;
  public CircleWithException() {
    this(1.0);
  }
 public CircleWithException(double newRadius) {
    setRadius(newRadius);
    numberOfObjects++;
  }
 public double getRadius() {
    return radius;
  }

  /** Set a new radius */
  public void setRadius(double newRadius) throws IllegalArgumentException {
    if (newRadius >= 0)
      radius = newRadius;
    else
      throw new IllegalArgumentException("Radius cannot be negative");
  }

 public static int getNumberOfObjects() {
    return numberOfObjects;
  }

 public double findArea() {
    return radius * radius * 3.14159;
  }
}
```

Example

```
public class TestCircleWithException {
  public static void main(String[] args) {
    try {
      CircleWithException c1 = new CircleWithException(5);
      CircleWithException c2 = new CircleWithException(-5);
      CircleWithException c3 = new CircleWithException(0);
    }
    catch (IllegalArgumentException ex) {
      System.out.println(ex);
    }

    System.out.println("Number of objects created: " +
      CircleWithException.getNumberOfObjects());
  }
}
```

Rethrowing Exceptions

```
try {
  statements;
}
catch(TheException ex) {
  perform operations before exits;
  throw ex;
}
```

The `finally` Clause

```
try {
  statements;
}
catch(TheException ex) {
  handling ex;
}
finally {
  finalStatements;
}
```

Trace a Program Execution

Suppose no exceptions in the statements

```
try {
  statements;
}
catch(TheException ex) {
  handling ex;
}
finally {
  finalStatements;
}

Next statement;
```

Trace a Program Execution

```
try {
  statements;
}
catch(TheException ex) {
  handling ex;
}
finally {
  finalStatements;
}

Next statement;
```

The final block is always executed

Trace a Program Execution

```
try {
  statements;
}
catch(TheException ex) {
  handling ex;
}
finally {
  finalStatements;
}

Next statement;
```

Next statement in the method is executed

Trace a Program Execution

```
try {
  statement1;
  statement2;
  statement3;
}
catch(Exception1 ex) {
  handling ex;
}
finally {
  finalStatements;
}

Next statement;
```

Suppose an exception of type Exception1 is thrown in statement2

Trace a Program Execution

```
try {
  statement1;
  statement2;
  statement3;
}
catch(Exception1 ex) {
  handling ex;
}
finally {
  finalStatements;
}

Next statement;
```

The exception is handled.

Trace a Program Execution

```
try {
  statement1;
  statement2;
  statement3;
}
catch(Exception1 ex) {
  handling ex;
}
finally {
  finalStatements;
}

Next statement;
```

The final block is always executed.

Trace a Program Execution

```
try {
  statement1;
  statement2;
  statement3;
}
catch(Exception1 ex) {
  handling ex;
}
finally {
  finalStatements;
}

Next statement;
```

The next statement in the method is now executed.

Trace a Program Execution

```
try {
  statement1;
  statement2;
  statement3;
}
catch(Exception1 ex) {
  handling ex;
}
catch(Exception2 ex) {
  handling ex;
  throw ex;
}
finally {
  finalStatements;
}

Next statement;
```

statement2 throws an exception of type Exception2.

Trace a Program Execution

```
try {
  statement1;
  statement2;
  statement3;
}
catch(Exception1 ex) {
  handling ex;
}
catch(Exception2 ex) {
  handling ex;
  throw ex;
}
finally {
  finalStatements;
}

Next statement;
```

Handling exception

Trace a Program Execution

```
try {
  statement1;
  statement2;
  statement3;
}
catch(Exception1 ex) {
  handling ex;
}
catch(Exception2 ex) {
  handling ex;
  throw ex;
}
finally {
  finalStatements;
}

Next statement;
```

Execute the final block

Trace a Program Execution

```
try {
  statement1;
  statement2;
  statement3;
}
catch(Exception1 ex) {
  handling ex;
}
catch(Exception2 ex) {
  handling ex;
  throw ex;
}
finally {
  finalStatements;
}

Next statement;
```

Rethrow the exception and control is transferred to the caller

Cautions When Using Exceptions

- Exception handling separates error-handling code from normal programming tasks, thus making programs easier to read and to modify. Be aware, however, that exception handling usually requires more time and resources because it requires instantiating a new exception object, rolling back the call stack, and propagating the errors to the calling methods.

When to Throw Exceptions

- An exception occurs in a method. If you want the exception to be processed by its caller, you should create an exception object and throw it. If you can handle the exception in the method where it occurs, there is no need to throw it.

When to Use Exceptions

When should you use the try-catch block in the code? You should use it to deal with unexpected error conditions. Do not use it to deal with simple, expected situations. For example, the following code

```
try {
  System.out.println(refVar.toString());
}
catch (NullPointerException ex) {
  System.out.println("refVar is null");
}
```

When to Use Exceptions

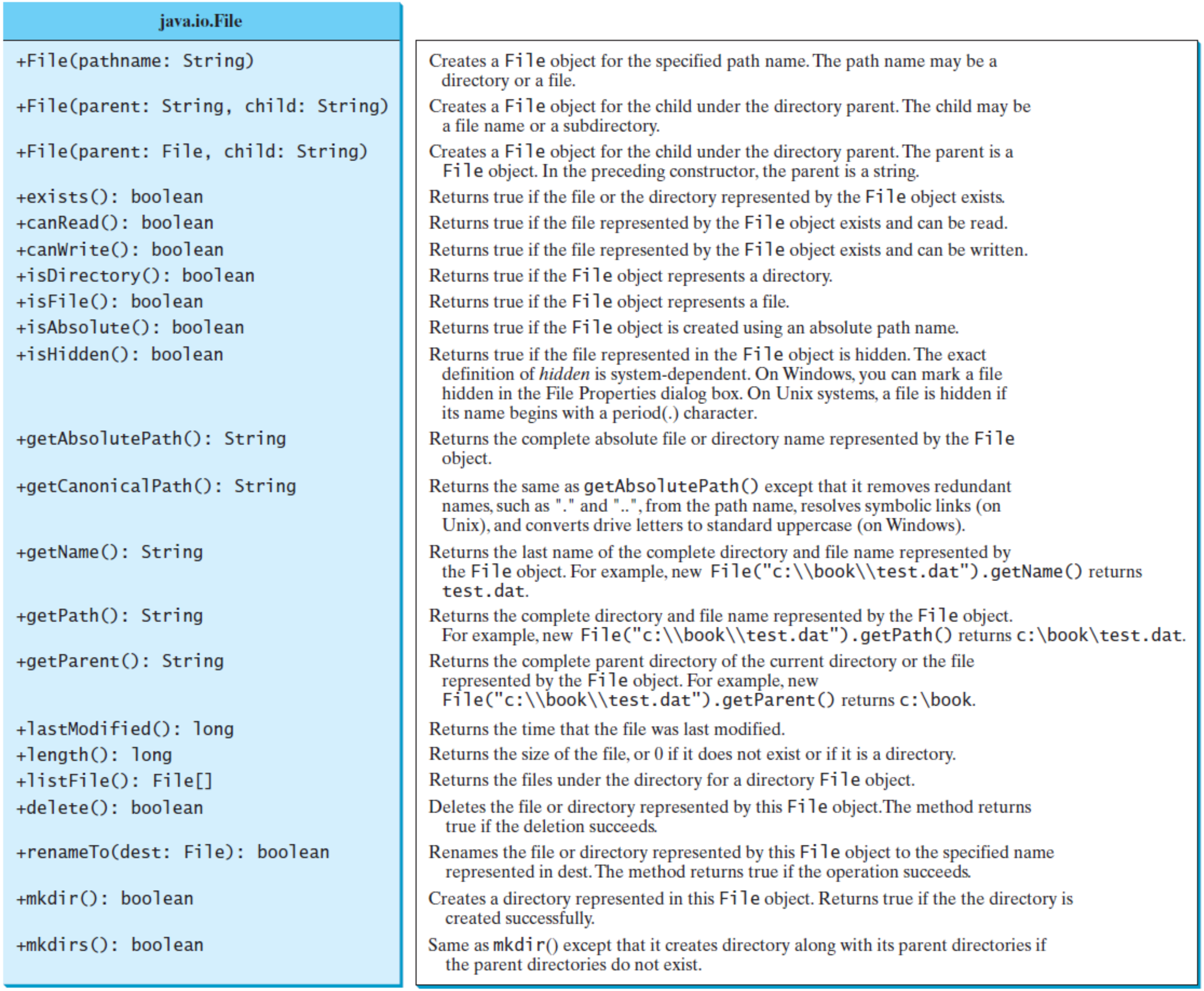
is better to be replaced by

```
if (refVar != null)
  System.out.println(refVar.toString());
else
  System.out.println("refVar is null");
```

When to Use Exceptions

File System and I/O

Obtaining file properties and manipulating file



java.io.File	
+File(pathname: String)	Creates a File object for the specified path name. The path name may be a directory or a file.
+File(parent: String, child: String)	Creates a File object for the child under the directory parent. The child may be a file name or a subdirectory.
+File(parent: File, child: String)	Creates a File object for the child under the directory parent. The parent is a File object. In the preceding constructor, the parent is a string.
+exists(): boolean	Returns true if the file or the directory represented by the File object exists.
+canRead(): boolean	Returns true if the file represented by the File object exists and can be read.
+canWrite(): boolean	Returns true if the file represented by the File object exists and can be written.
+isDirectory(): boolean	Returns true if the File object represents a directory.
+isFile(): boolean	Returns true if the File object represents a file.
+isAbsolute(): boolean	Returns true if the File object is created using an absolute path name.
+isHidden(): boolean	Returns true if the file represented in the File object is hidden. The exact definition of *hidden* is system-dependent. On Windows, you can mark a file hidden in the File Properties dialog box. On Unix systems, a file is hidden if its name begins with a period(.) character.
+getAbsolutePath(): String	Returns the complete absolute file or directory name represented by the File object.
+getCanonicalPath(): String	Returns the same as getAbsolutePath() except that it removes redundant names, such as "." and "..", from the path name, resolves symbolic links (on Unix), and converts drive letters to standard uppercase (on Windows).
+getName(): String	Returns the last name of the complete directory and file name represented by the File object. For example, new File("c:\\book\\test.dat").getName() returns test.dat.
+getPath(): String	Returns the complete directory and file name represented by the File object. For example, new File("c:\\book\\test.dat").getPath() returns c:\book\test.dat.
+getParent(): String	Returns the complete parent directory of the current directory or the file represented by the File object. For example, new File("c:\\book\\test.dat").getParent() returns c:\book.
+lastModified(): long	Returns the time that the file was last modified.
+length(): long	Returns the size of the file, or 0 if it does not exist or if it is a directory.
+listFile(): File[]	Returns the files under the directory for a directory File object.
+delete(): boolean	Deletes the file or directory represented by this File object.The method returns true if the deletion succeeds.
+renameTo(dest: File): boolean	Renames the file or directory represented by this File object to the specified name represented in dest. The method returns true if the operation succeeds.
+mkdir(): boolean	Creates a directory represented in this File object. Returns true if the the directory is created successfully.
+mkdirs(): boolean	Same as mkdir() except that it creates directory along with its parent directories if the parent directories do not exist.

File Properties

```
public class TestFileClass {
  public static void main(String[] args) {
    java.io.File file = new java.io.File("us.gif");
    System.out.println("Does it exist? " + file.exists());
    System.out.println("The file has " + file.length() + " bytes");
    System.out.println("Can it be read? " + file.canRead());
    System.out.println("Can it be written? " + file.canWrite());
    System.out.println("Is it a directory? " + file.isDirectory());
    System.out.println("Is it a file? " + file.isFile());
    System.out.println("Is it absolute? " + file.isAbsolute());
    System.out.println("Is it hidden? " + file.isHidden());
    System.out.println("Absolute path is " +
      file.getAbsolutePath());
    System.out.println("Last modified on " +
      new java.util.Date(file.lastModified()));
  }
}
```

Text I/O

A File object encapsulates the properties of a file or a path, but does not contain the methods for reading/writing data from/to a file. In order to perform I/O, you need to create objects using appropriate Java I/O classes. The objects contain the methods for reading/writing data from/to a file. This section introduces how to read/write strings and numeric values from/to a text file using the Scanner and PrintWriter classes.

Writing Data Using PrintWriter

java.io.PrintWriter	
+PrintWriter(filename: String)	Creates a PrintWriter for the specified file.
+print(s: String): void	Writes a string.
+print(c: char): void	Writes a character.
+print(cArray: char[]): void	Writes an array of character.
+print(i: int): void	Writes an int value.
+print(l: long): void	Writes a long value.
+print(f: float): void	Writes a float value.
+print(d: double): void	Writes a double value.
+print(b: boolean): void	Writes a boolean value.
Also contains the overloaded println methods.	A println method acts like a print method; additionally it prints a line separator. The line separator string is defined by the system. It is \r\n on Windows and \n on Unix.
Also contains the overloaded printf methods.	The printf method was introduced in §4.6, “Formatting Console Output and Strings.”

PrintWriter

```java
public class WriteData {
  public static void main(String[] args) throws java.io.IOException {
    java.io.File file = new java.io.File("scores.txt");
    if (file.exists()) {
      System.out.println("File already exists");
      System.exit(0);
    }

    // Create a file
    java.io.PrintWriter output = new java.io.PrintWriter(file);

    // Write formatted output to the file
    output.print("John T Smith ");
    output.println(90);
    output.print("Eric K Jones ");
    output.println(85);

    // Close the file
    output.close();
  }
}
```

PrintWriter

```
public class WriteDataWithAutoClose {
  public static void main(String[] args) throws Exception {
    java.io.File file = new java.io.File("scores.txt");
    if (file.exists()) {
      System.out.println("File already exists");
      System.exit(0);
    }

    try (
      // Create a file
      java.io.PrintWriter output = new java.io.PrintWriter(file);
    ) {
      // Write formatted output to the file
      output.print("John T Smith ");
      output.println(90);
      output.print("Eric K Jones ");
      output.println(85);
    }
  }
}
```

You don’t have to close the PrintWriter if you put it between try()

Reading Data Using Scanner

java.util.Scanner	
+Scanner(source: File)	Creates a Scanner object to read data from the specified file.
+Scanner(source: String)	Creates a Scanner object to read data from the specified string.
+close()	Closes this scanner.
+hasNext(): boolean	Returns true if this scanner has another token in its input.
+next(): String	Returns next token as a string.
+nextByte(): byte	Returns next token as a byte.
+nextShort(): short	Returns next token as a short.
+nextInt(): int	Returns next token as an int.
+nextLong(): long	Returns next token as a long.
+nextFloat(): float	Returns next token as a float.
+nextDouble(): double	Returns next token as a double.
+useDelimiter(pattern: String): Scanner	Sets this scanner's delimiting pattern.

ReadData Run

Scanner

```
import java.util.Scanner;

public class ReadData {
  public static void main(String[] args) throws Exception {
    // Create a File instance
    java.io.File file = new java.io.File("scores.txt");

    // Create a Scanner for the file
    Scanner input = new Scanner(file);

    // Read data from a file
    while (input.hasNext()) {
      String firstName = input.next();
      String mi = input.next();
      String lastName = input.next();
      int score = input.nextInt();
      System.out.println(
        firstName + " " + mi + " " + lastName + " " + score);
    }

    // Close the file
    input.close();
  }
}
```

Problem: Replacing Text

Write a class named ReplaceText that replaces a string in a text file with a new string. The filename and strings are passed as command-line arguments as follows:

```
java ReplaceText sourceFile targetFile oldString newString
```

For example, invoking

```
java ReplaceText FormatString.java t.txt StringBuilder StringBuffer
```

replaces all the occurrences of StringBuilder by StringBuffer in FormatString.java and saves the new file in t.txt.

ReplaceText Run

Problem: Replacing Text

```java
import java.io.*;
import java.util.*;

public class ReplaceText {
 public static void main(String[] args) throws Exception {
  // Check command line parameter usage
    System.out.println("Write the source file name:");
    Scanner fileNameScanner = new Scanner(System.in);
    String sourceFileName = fileNameScanner.next();
  // Check if source file exists
    File sourceFile = new File(sourceFileName);
  if (!sourceFile.exists()) {
   System.out.println("Source file " + sourceFileName + " does not exist");
   System.exit(2);
  }

  // Check command line parameter usage
    System.out.println("Write the target file name:");
    String targetFileName = fileNameScanner.next();
    fileNameScanner.close();
  // Check if target file exists
  File targetFile = new File(targetFileName);
  if (targetFile.exists()) {
   System.out.println("Target file " + targetFileName + " already exists");
   System.exit(3);
  }

  //You don't have to call close if you put the Scanner and PrintWriter between try ()
  try (
   // Create input and output files
   Scanner input = new Scanner(sourceFile);
   PrintWriter output = new PrintWriter(targetFile);
  ) {
   while (input.hasNext()) {
    String s1 = input.nextLine();
    String s2 = s1.replaceAll("winter", "summer");
    output.println(s2);
   }
  }
 }
}
```

Reading Data from the Web

Just like you can read data from a file on your computer, you can read data from a file on the Web.

Reading Data from the Web

```
URL url = new URL("www.google.com/index.html");
```

After a **URL** object is created, you can use the **openStream()** method defined in the **URL** class to open an input stream and use this stream to create a **Scanner** object as follows:

```
Scanner input = new Scanner(url.openStream());
```

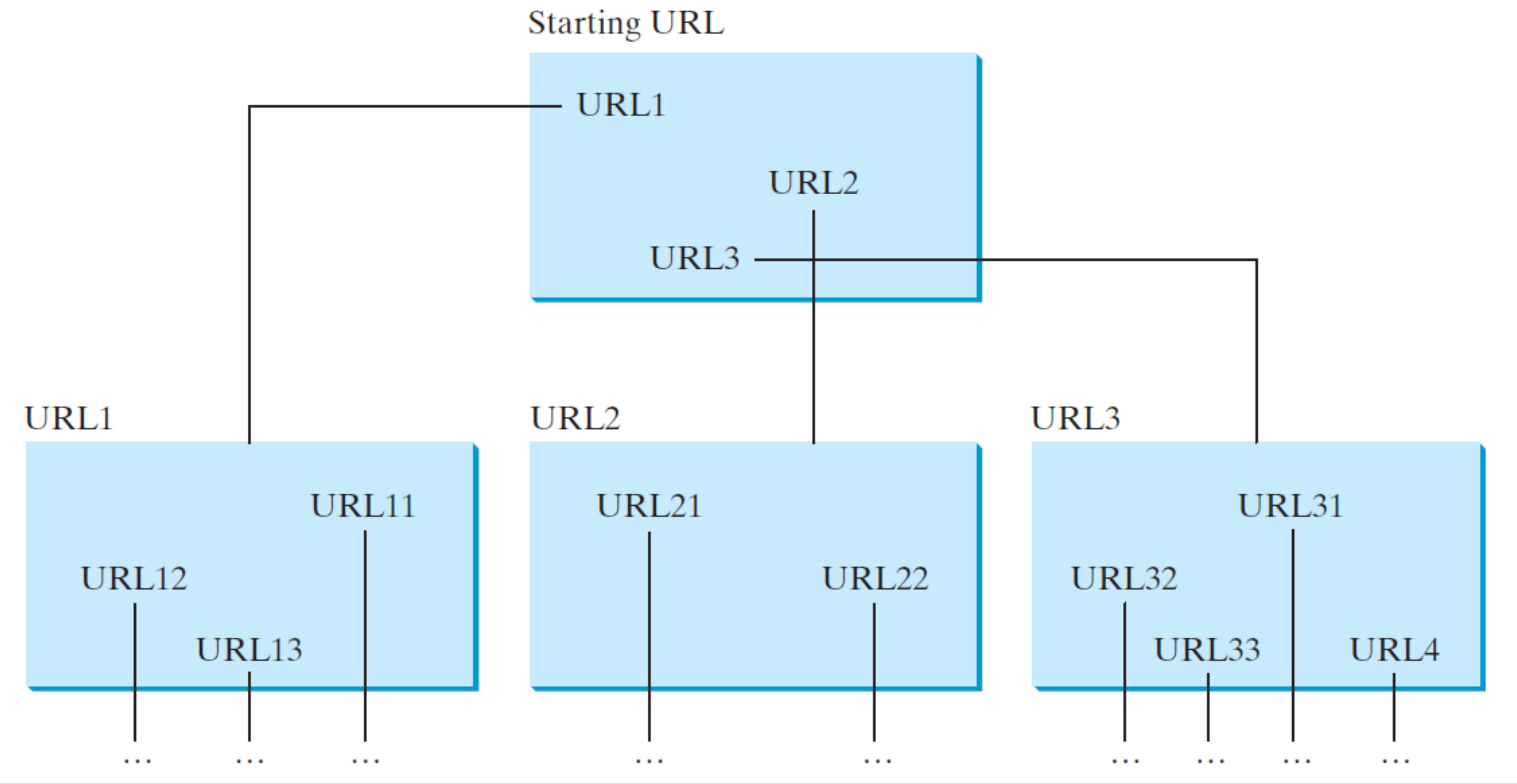
ReadFileFromURL Run

Reading Data from the Web

```java
import java.util.Scanner;

public class ReadFileFromURL {
  public static void main(String[] args) {
    System.out.print("Enter a URL: ");
    String URLString = new Scanner(System.in).next();

    try {
      java.net.URL url = new java.net.URL(URLString);
      int count = 0;
      Scanner input = new Scanner(url.openStream());
      while (input.hasNext()) {
        String line = input.nextLine();
        count += line.length();
      }

      System.out.println("The file size is " + count + " characters");
    }
    catch (java.net.MalformedURLException ex) {
      System.out.println("Invalid URL");
    }
    catch (java.io.IOException ex) {
      System.out.println("IO Errors");
    }
  }
}
```

Case Study: Web Crawler

This case study develops a program that travels the Web by following hyperlinks.



Case Study: Web Crawler

The program follows the URLs to traverse the Web. To avoid that each URL is traversed only once, the program maintains two lists of URLs. One list stores the URLs pending for traversing and the other stores the URLs that have already been traversed. The algorithm for this program can be described as follows:

Case Study: Web Crawler

```
Add the starting URL to a list named listOfPendingURLs;
while listOfPendingURLs is not empty {
    Remove a URL from listOfPendingURLs;
    if this URL is not in listOfTraversedURLs {
     Add it to listOfTraversedURLs;
     Display this URL;
     Exit the while loop when the size of S is equal to 100.
     Read the page from this URL and for each URL contained in the page {
      Add it to listOfPendingURLs if it is not is listOfTraversedURLs;
     }
   }
 }
```

WebCrawler   Run