

Exception Handling and Text IO

Liang, Introduction to Java Programming, Tenth Edition, (c) 2015 Pearson Education, Inc. All



Runtime Error?

```
import java.util.Scanner;

public class Quotient {
    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();

        System.out.println(number1 + " / " + number2 + " is " +
            (number1 / number2));
    }
}
```

Enter two integers: 3 0

Exception in thread "main" java.lang.ArithmeticException: / by zero
at Quotient.main(Quotient.java:11)

Fix it Using an **if** Statement

```
import java.util.Scanner;

public class QuotientWithIf {
    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();

        if (number2 != 0)
            System.out.println(number1 + " / " + number2 + " is " +
                               (number1 / number2));
        else
            System.out.println("Divisor cannot be zero ");
    }
}
```

Suppose there is another method that can throw the exception

```
3 public class QuotientWithMethod {
4     public static int quotient(int number1, int number2) {
5         if (number2 == 0) {
6             System.out.println("Divisor cannot be zero");
7             System.exit(1);
8         }
9
10        return number1 / number2;
11    }
12
13    public static void main(String[] args) {
14        Scanner input = new Scanner(System.in);
15
16        // Prompt the user to enter two integers
17        System.out.print("Enter two integers: ");
18        int number1 = input.nextInt();
19        int number2 = input.nextInt();
20
21        int result = quotient(number1, number2);
22        System.out.println(number1 + " / " + number2 + " is "
23            + result);
24    }
25 }
```



Better handling using exceptions

```

3 public class QuotientWithException {
4     public static int quotient(int number1, int number2) {
5         if (number2 == 0)
6             throw new ArithmeticException("Divisor cannot be zero");
7
8         return number1 / number2;
9     }
10
11     public static void main(String[] args) {
12         Scanner input = new Scanner(System.in);
13
14         // Prompt the user to enter two integers
15         System.out.print("Enter two integers: ");
16         int number1 = input.nextInt();
17         int number2 = input.nextInt();
18
19         try {
20             int result = quotient(number1, number2);
21             System.out.println(number1 + " / " + number2 + " is "
22                 + result);
23         }
24         catch (ArithmeticException ex) {
25             System.out.println("Exception: an integer " +
26                 "cannot be divided by zero ");
27         }
28
29         System.out.println("Execution continues ...");
30     }
31 }

```

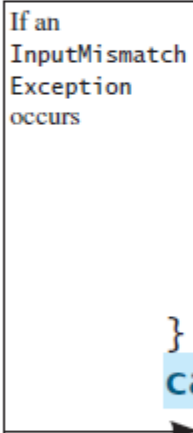
If an
Arithmetic
Exception
occurs



Handling an exception and continuing program execution

```
3 public class InputMismatchExceptionDemo {
4     public static void main(String[] args) {
5         Scanner input = new Scanner(System.in);
6         boolean continueInput = true;
7
8         do {
9             try {
10                 System.out.print("Enter an integer: ");
11                 int number = input.nextInt();
12
13                 // Display the result
14                 System.out.println(
15                     "The number entered is " + number);
16
17                 continueInput = false;
18             }
19             catch (InputMismatchException ex) {
20                 System.out.println("Try again. (" +
21                     "Incorrect input: an integer is required)");
22                 input.nextLine(); // Discard input
23             }
24         } while (continueInput);
25     }
```

If an InputMismatch Exception occurs



Exception Handling

- ❖ Exception handling technique enables a method to **throw** an exception to its caller.
- ❖ Without this capability, a method must handle the exception or terminate the program.

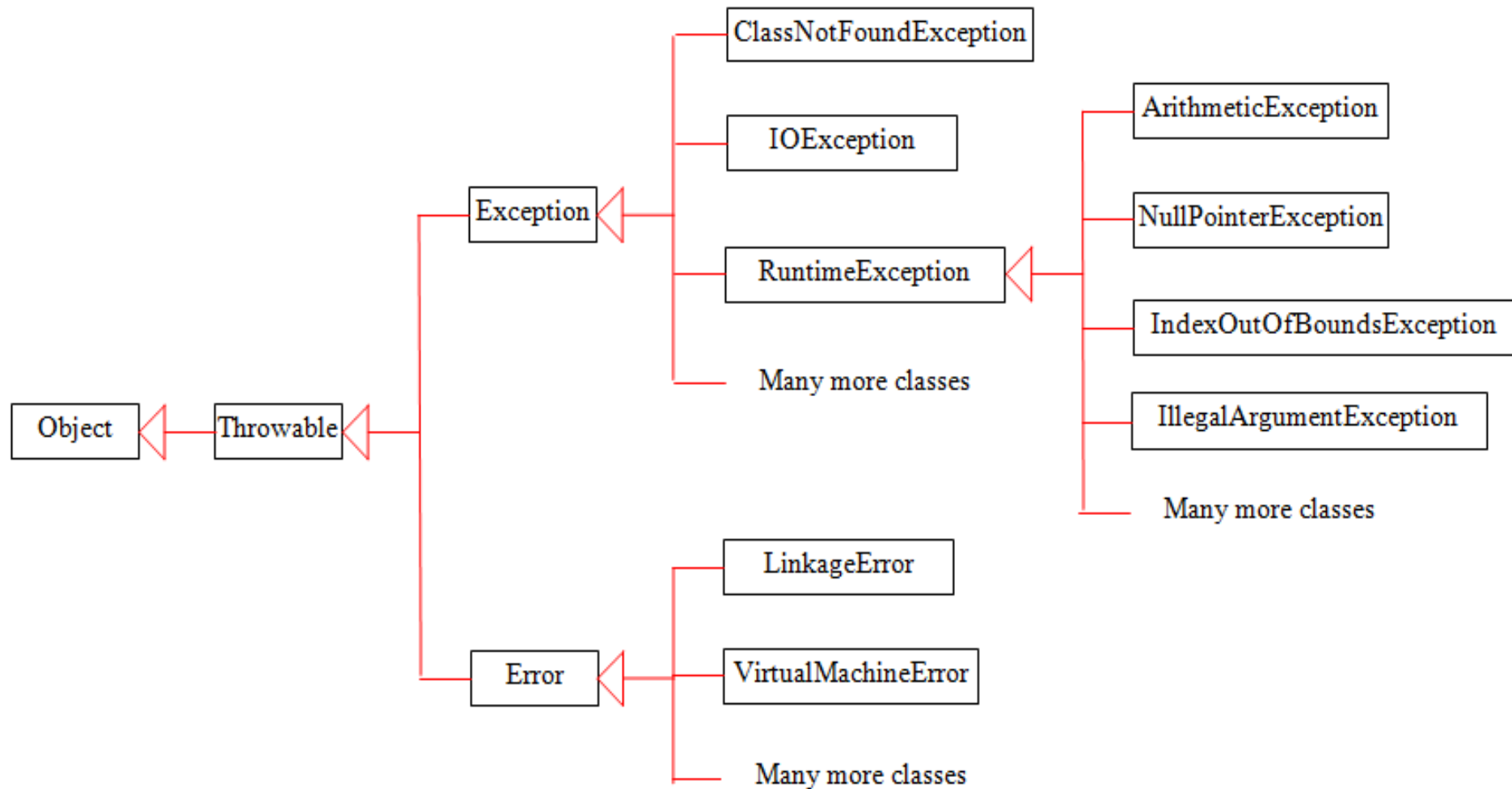
ex·cep·tion  *noun* \ɪk-'sep-shən\

: someone or something that is different from others :
someone or something that is not included

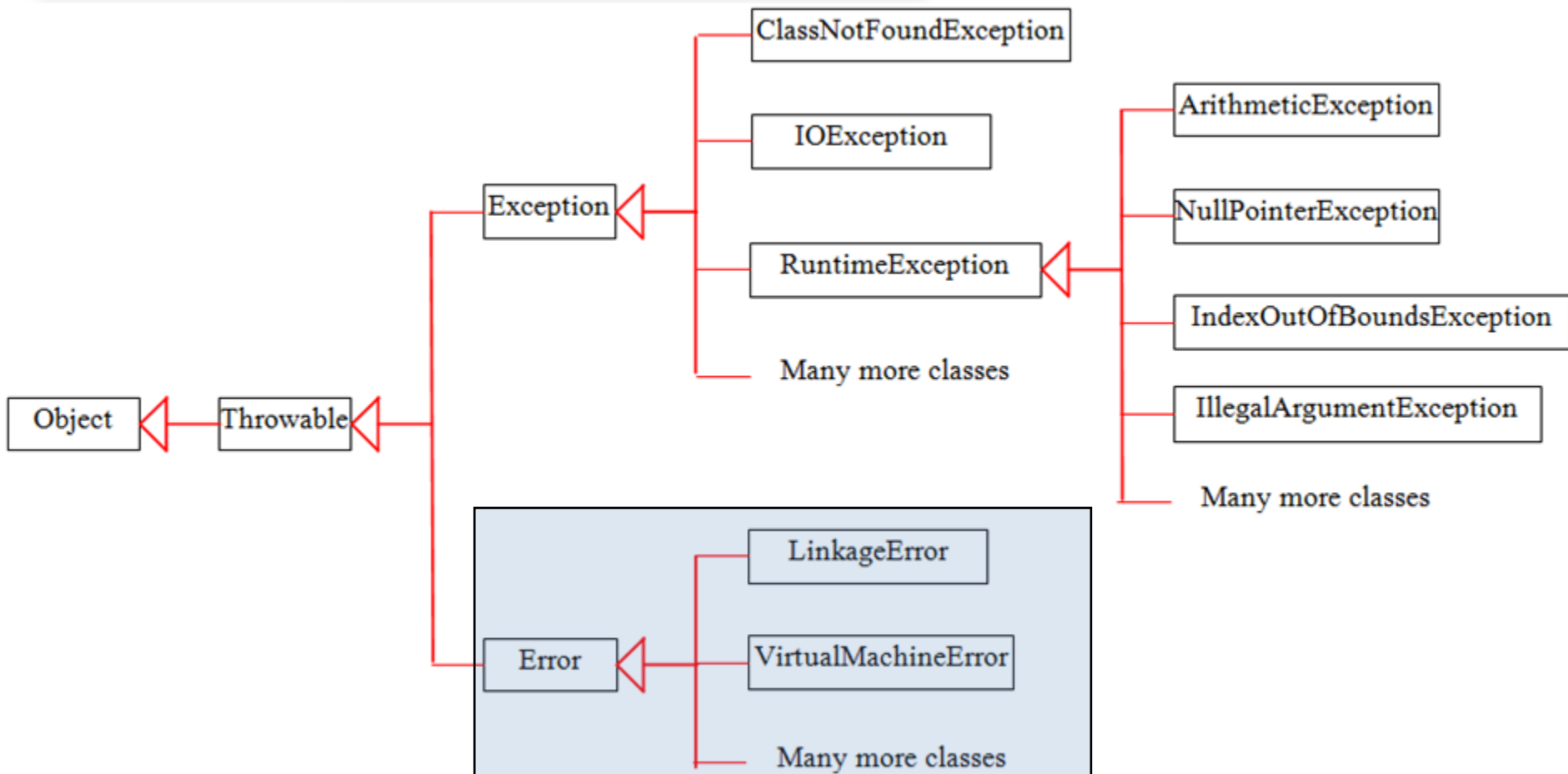
a case where a rule does not apply



Exception Types

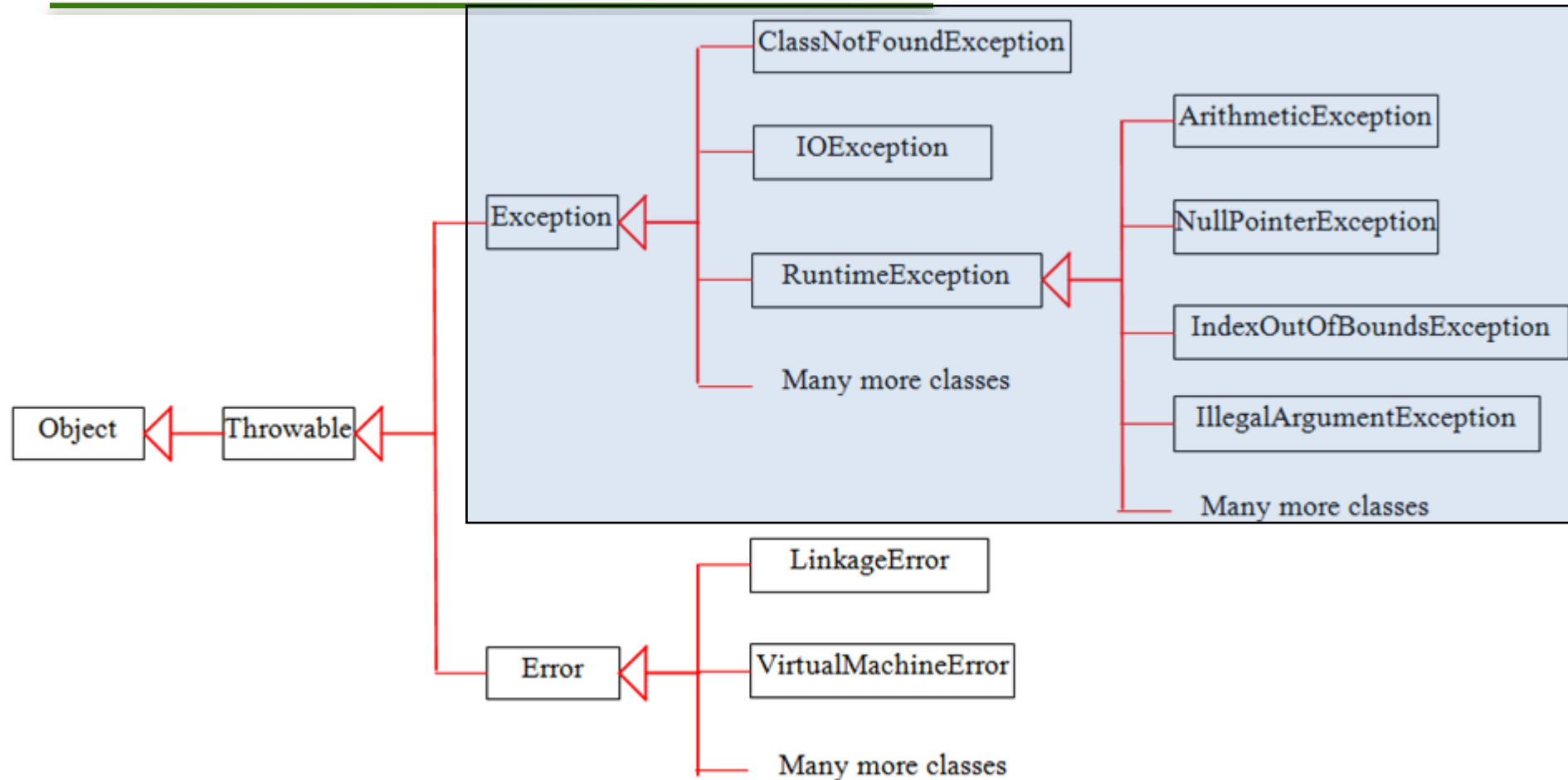


System Errors



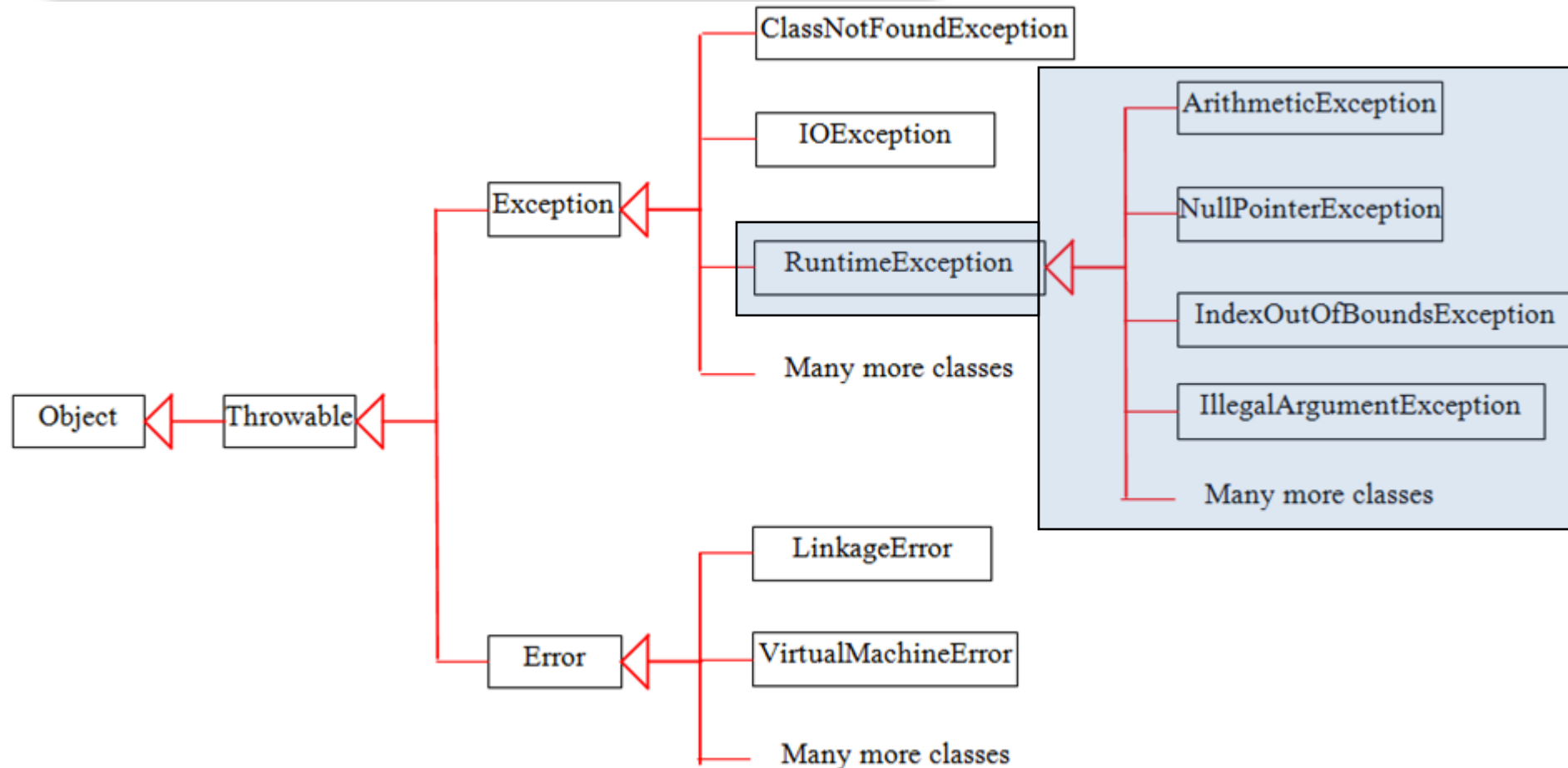
System errors are thrown by **JVM** and represented in the **Error** class. The Error class describes internal system errors.

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.

Declaring, Throwing, and Catching Exceptions

```
method2() throws Exception {  
    if (an error occurs) {  
        throw new Exception();  
    }  
}
```

← declare exception

← throw exception

catch exception →

```
method1() {  
    try {  
        invoke method2;  
    }  
    catch (Exception ex) {  
        Process exception;  
    }  
}
```

Declaring Exceptions

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

```
public void x() throws IOException
```

```
public void y() 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**.

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

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

Throwing Exceptions Example

```
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;  
}
```



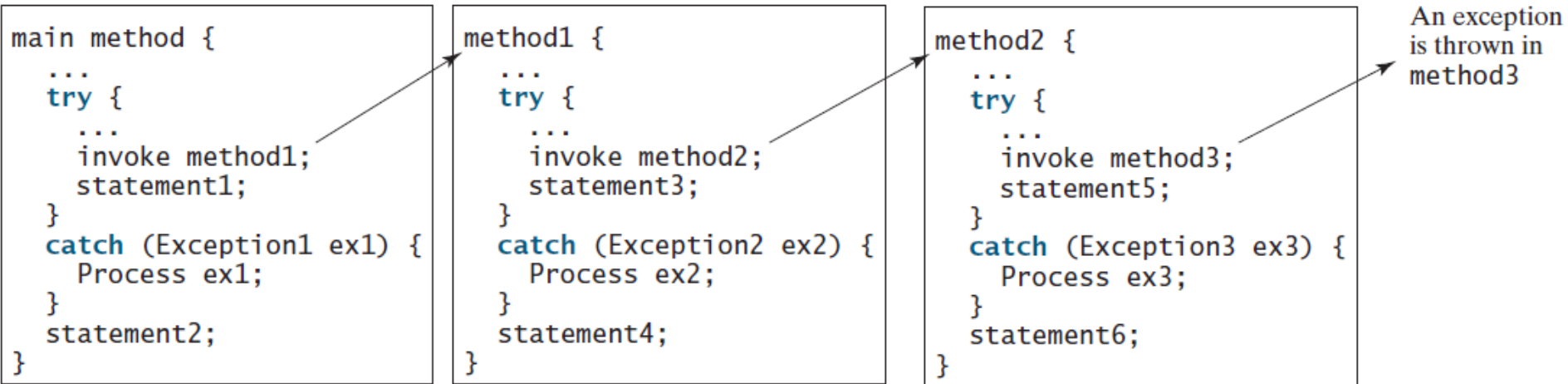
Catch or Declare Checked Exceptions

- ❖ Java forces you to deal with checked exceptions.
- ❖ 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 follow:

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

```
void p1() throws IOException {  
    p2();  
}
```

Important Example



```
1  public class CircleWithException {
2      /** The radius of the circle */
3      private double radius;
4
5      /** The number of the objects created */
6      private static int numberOfObjects = 0;
7
8      /** Construct a circle with radius 1 */
9      public CircleWithException() {
10         this(1.0);
11     }
12
13     /** Construct a circle with a specified radius */
14     public CircleWithException(double newRadius) {
15         setRadius(newRadius);
16         numberOfObjects++;
17     }
18
19     /** Return radius */
20     public double getRadius() {
21         return radius;
22     }
}
```

throws IllegalArgumentException

```

24  /** Set a new radius */
25  public void setRadius(double newRadius)
26      throws IllegalArgumentException {
27      if (newRadius >= 0)
28          radius = newRadius;
29      else
30          throw new IllegalArgumentException(
31              "Radius cannot be negative");
32  }
33
34  /** Return numberOfObjects */
35  public static int getNumberOfObjects() {
36      return numberOfObjects;
37  }
38
39  /** Return the area of this circle */
40  public double findArea() {
41      return radius * radius * 3.14159;
42  }

```

```
1 public class TestCircleWithException {
2     public static void main(String[] args) {
3         try {
4             CircleWithException c1 = new CircleWithException(5);
5             CircleWithException c2 = new CircleWithException(-5);
6             CircleWithException c3 = new CircleWithException(0);
7         }
8         catch (IllegalArgumentException ex) {
9             System.out.println(ex);
10        }
11
12        System.out.println("Number of objects created: " +
13            CircleWithException.getNumberOfObjects());
14    }
15 }
```


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

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

Next statement;

Suppose no
exceptions in
the statements

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

- ❖ 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");
```

Defining Custom Exception Classes

- ❖ Use the exception classes in the **API** whenever possible.
- ❖ Define custom exception classes if the predefined classes are not sufficient.
- ❖ Define custom exception classes by extending `Exception` or a subclass of `Exception`.

Custom Exception Class Example

```
1  public class InvalidRadiusException extends Exception {
2      private double radius;
3
4      /** Construct an exception */
5      public InvalidRadiusException(double radius) {
6          super("Invalid radius " + radius);
7          this.radius = radius;
8      }
9
10     /** Return the radius */
11     public double getRadius() {
12         return radius;
13     }
14 }
```

```
    /** Set a new radius */
    public void setRadius(double newRadius)
        throws InvalidRadiusException {
        if (newRadius >= 0)
            radius = newRadius;
        else
            throw new InvalidRadiusException(newRadius);
    }
```



The **File** Class

- ❖ The **File** class is intended to provide an abstraction that deals with most of the machine-dependent complexities of files and path names in a machine-independent fashion.
- ❖ The filename is a string.
- ❖ The **File** class is a wrapper class for the file name and its directory path.

File class

java.io.File

+File(pathname: String)

+File(parent: String, child: String)

+File(parent: File, child: String)

+exists(): boolean

+canRead(): boolean

+canWrite(): boolean

+isDirectory(): boolean

+isFile(): boolean

+isAbsolute(): boolean

+isHidden(): boolean

Creates a **File** object for the specified path name. The path name may be a directory or a file.

Creates a **File** object for the child under the directory parent. The child may be a file name or a subdirectory.

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.

Returns true if the file or the directory represented by the **File** object exists.

Returns true if the file represented by the **File** object exists and can be read.

Returns true if the file represented by the **File** object exists and can be written.

Returns true if the **File** object represents a directory.

Returns true if the **File** object represents a file.

Returns true if the **File** object is created using an absolute path name.

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.

File class

+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.

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.

PrintWriter class

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 §3.6, “Formatting Console Output and Strings.”

Scanner class

`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):`

Sets this scanner's delimiting pattern.

`Scanner`



Read / Write from/to File

```
File f = new File("C:\\Users\\Ahmad\\Desktop\\h.txt");  
Scanner sc = new Scanner(f);  
while (sc.hasNextLine()) {  
    System.out.println(sc.nextLine());  
}
```

```
PrintWriter pw = new  
PrintWriter("C:\\Users\\Ahmad\\Desktop\\h.txt");  
pw.println("Welcome");  
pw.close();
```

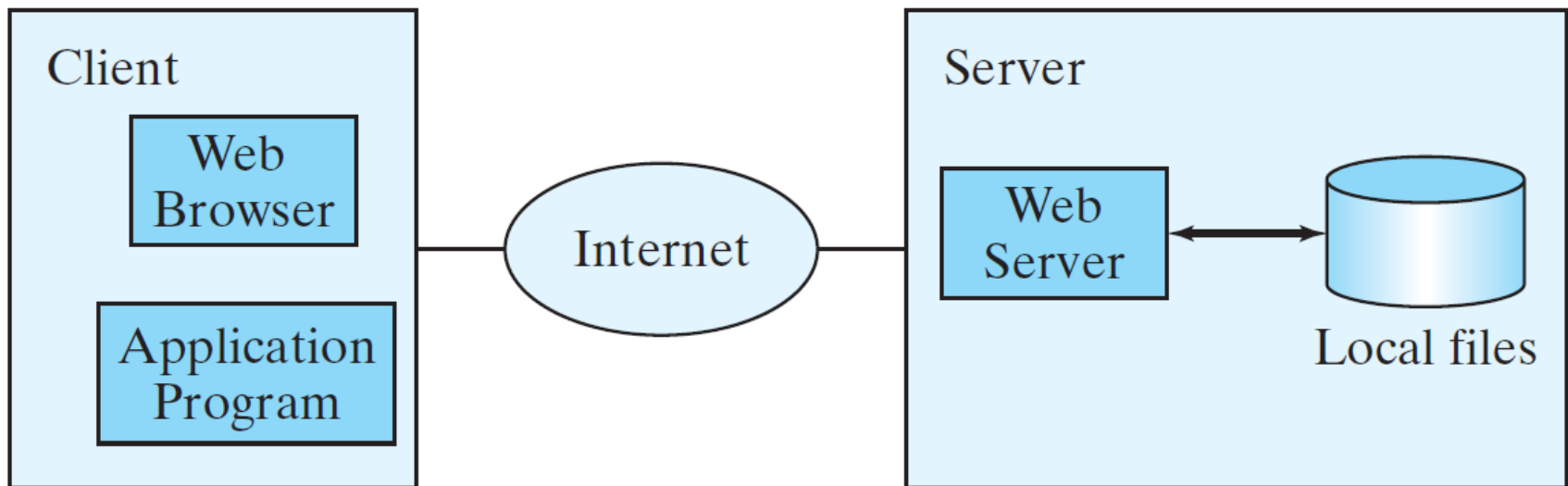
Problem: Replacing Text

- ❖ 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**

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());
```

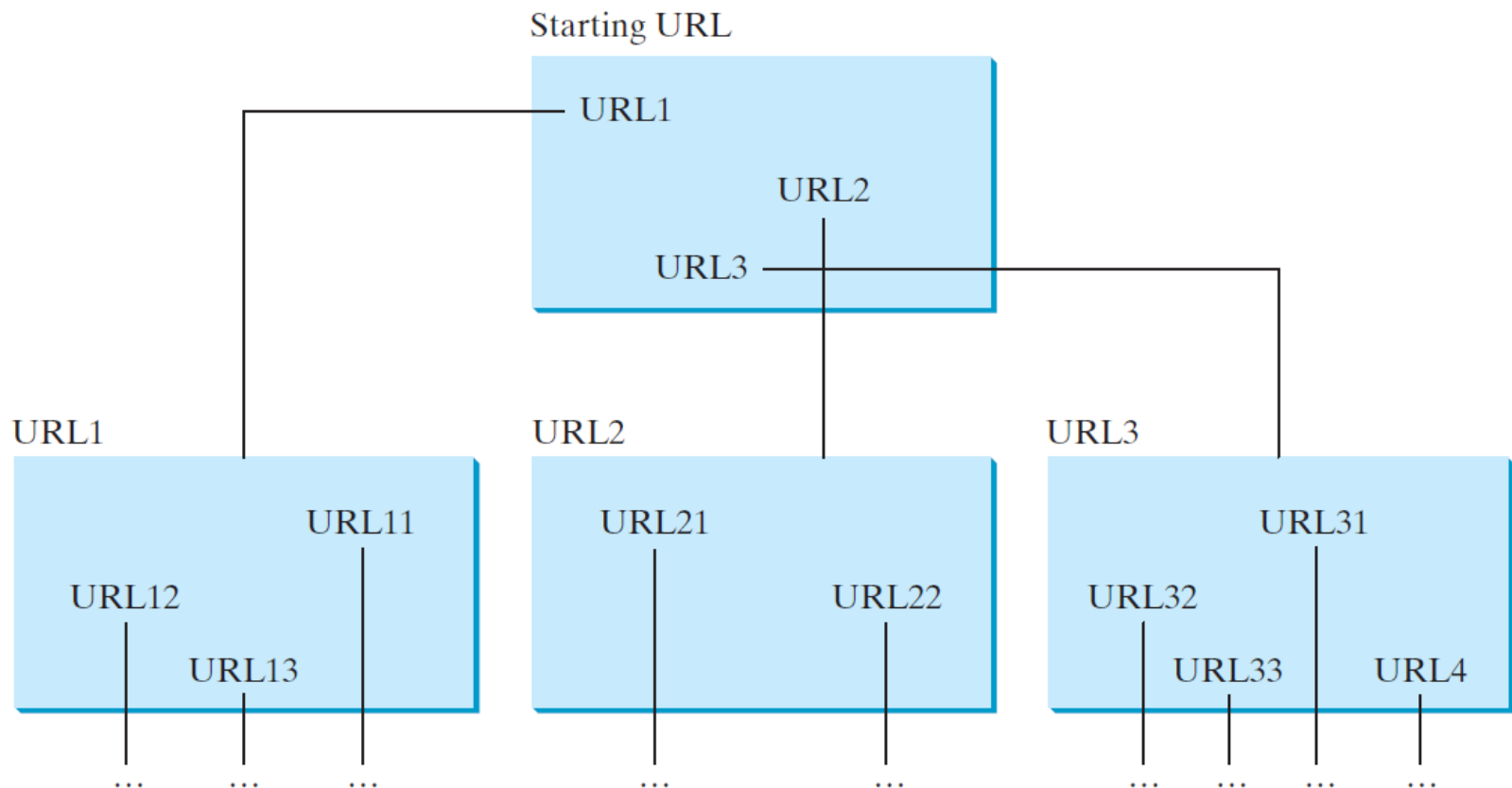
Read webpage

```
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 in listOfTraversedURLs;

 }

 }

}

Web Crawler program

```
import java.util.Scanner; import java.util.ArrayList; public class WebCrawler { public static
void main(String[] args) { Scanner input = new Scanner(System.in);
System.out.print("Enter a URL: "); String url = input.nextLine(); crawler(url); // Traverse
the Web from the a starting url } public static void crawler(String startingURL) {
ArrayList<String> listOfPendingURLs = new ArrayList<>(); ArrayList<String>
listOfTraversedURLs = new ArrayList<>(); listOfPendingURLs.add(startingURL); while
(!listOfPendingURLs.isEmpty() && listOfTraversedURLs.size() <= 100) { String urlString =
listOfPendingURLs.remove(0); listOfTraversedURLs.add(urlString);
System.out.println("Crawl " + urlString); for (String s: getSubURLs(urlString)) { if
(!listOfTraversedURLs.contains(s) && !listOfPendingURLs.contains(s))
listOfPendingURLs.add(s); } } } public static ArrayList<String> getSubURLs(String urlString)
{ ArrayList<String> list = new ArrayList<>(); try { java.net.URL url = new
java.net.URL(urlString); Scanner input = new Scanner(url.openStream()); int current = 0;
while (input.hasNext()) { String line = input.nextLine(); current = line.indexOf("http:",
current); while (current > 0) { int endIndex = line.indexOf("\\", current); if (endIndex > 0)
{ // Ensure that a correct URL is found list.add(line.substring(current, endIndex)); current
= line.indexOf("http:", endIndex); } else current = -1; } } } catch (Exception ex) {
System.out.println("Error: " + ex.getMessage()); } return list; } }
```