Exception Handling

SE306: Object Oriented Concept II

Errors

Syntax errors

- arise because the rules of the language have not been followed.
- detected by the compiler.

Logic errors

- leads to wrong results and detected during testing.
- arise because the logic coded by the programmer was not correct.

Runtime errors

- Occur when the program is running and the environment detects an operation that is impossible to carry out.

Errors

Code errors

- Divide by zero
- Array out of bounds
- Integer overflow
- Accessing a null pointer (reference)

Programs *crash* when an exception goes untrapped, i.e., not handled by the program.

Runtime Errors

```
1
2
3
4
5
6
7
8
9
10
11
12
13
```

```
import java.util.Scanner;

public class ExceptionDemo {
  public static void main(String[] args) {
    Scanner scanner = new Scanner(System.in);
    System.out.print("Enter an integer: ");
    int number = scanner.nextInt();

    // Display the result
    System.out.println(
      "The number entered is " + number);
  }
}
```

If an exception occurs on this line, the rest of the lines in the method are skipped and the program is terminated.

Terminated.

Exception

An *exception* is an event, which occurs during the execution of a program, that disrupts the normal flow of the program's instructions.

Exception = Exceptional Event

Exception Handling

Java exception handling is a mechanism for handling exception by *detecting* and *responding* to exceptions in a systematic, uniform and reliable manner.

Any exceptions not specifically handled within a Java program are caught by the Java run time environment

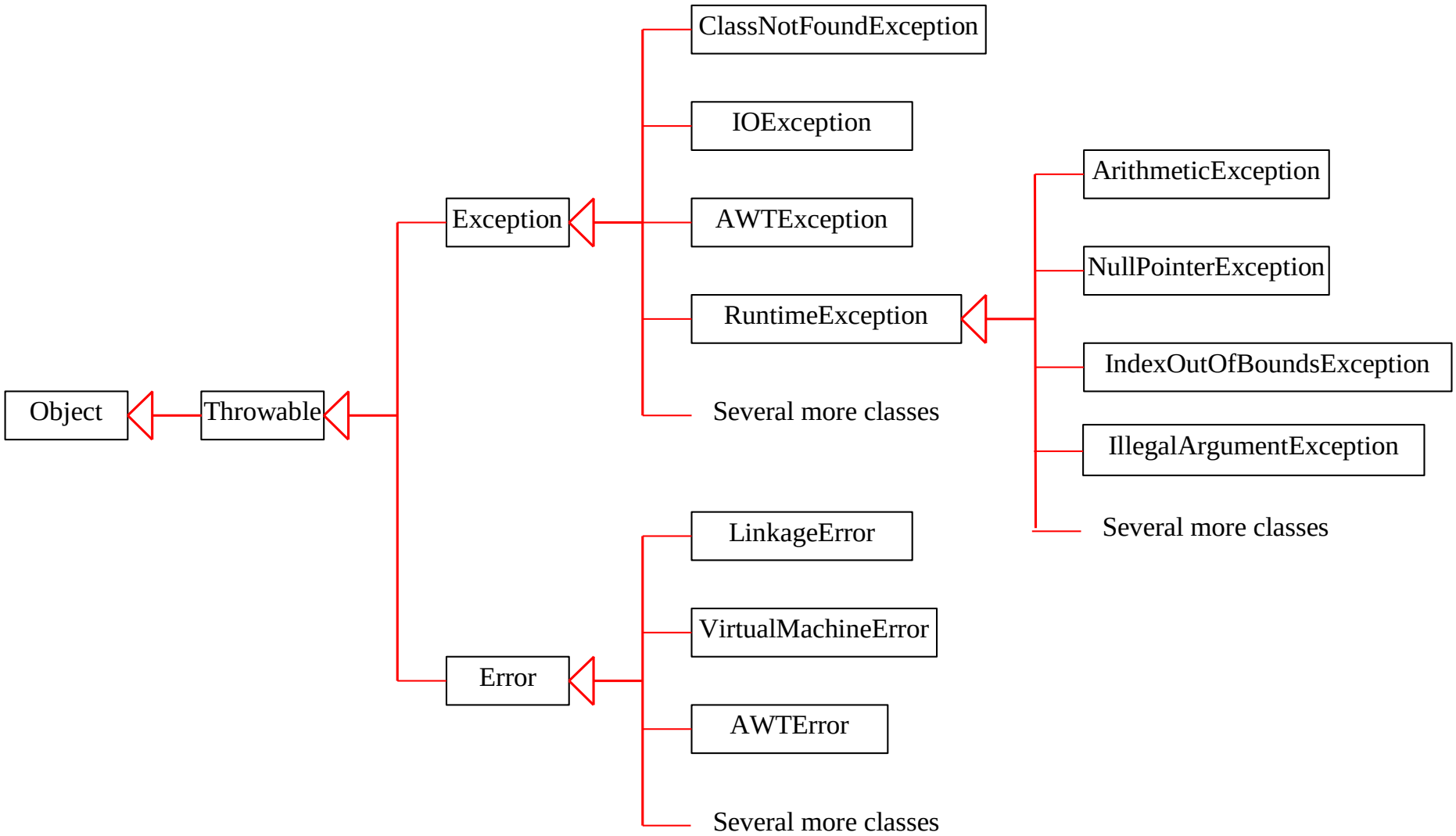
Exceptions

A Method in Java throws exceptions to tell the calling code:

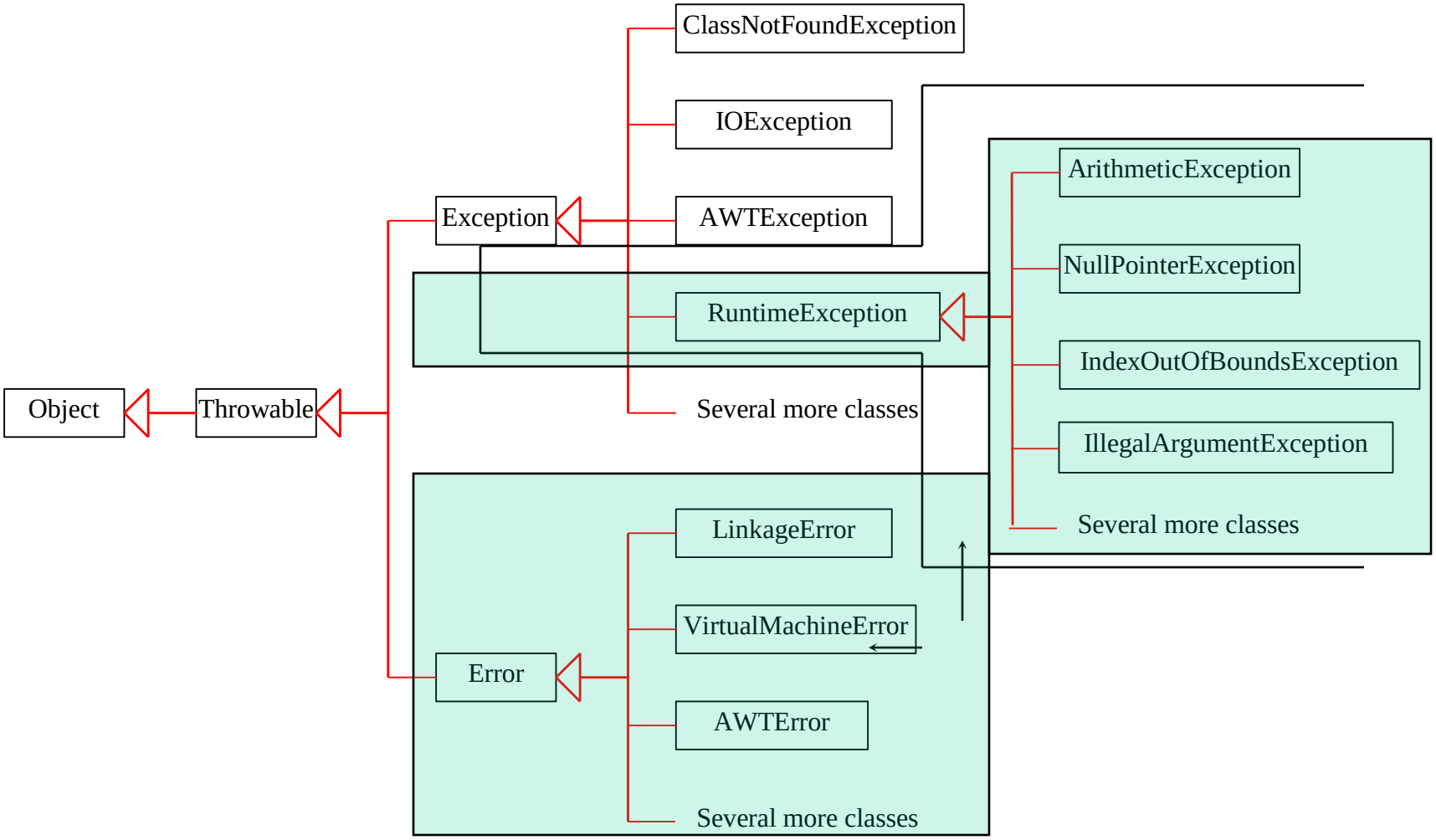
"Something bad happened. I failed."

Exceptions are objects of Exception or Error class or their subclasses.

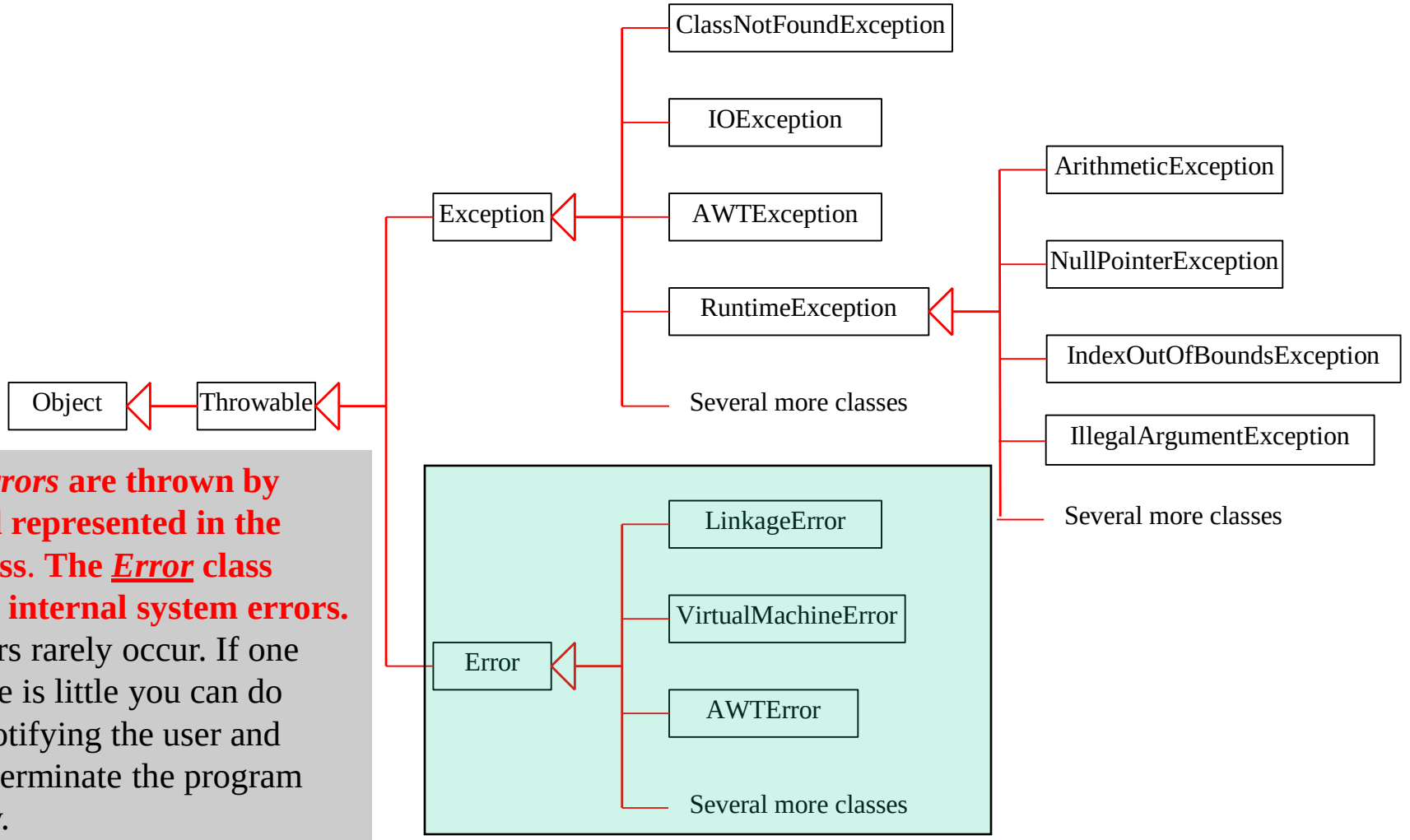
Exception Classes



Unchecked Exceptions

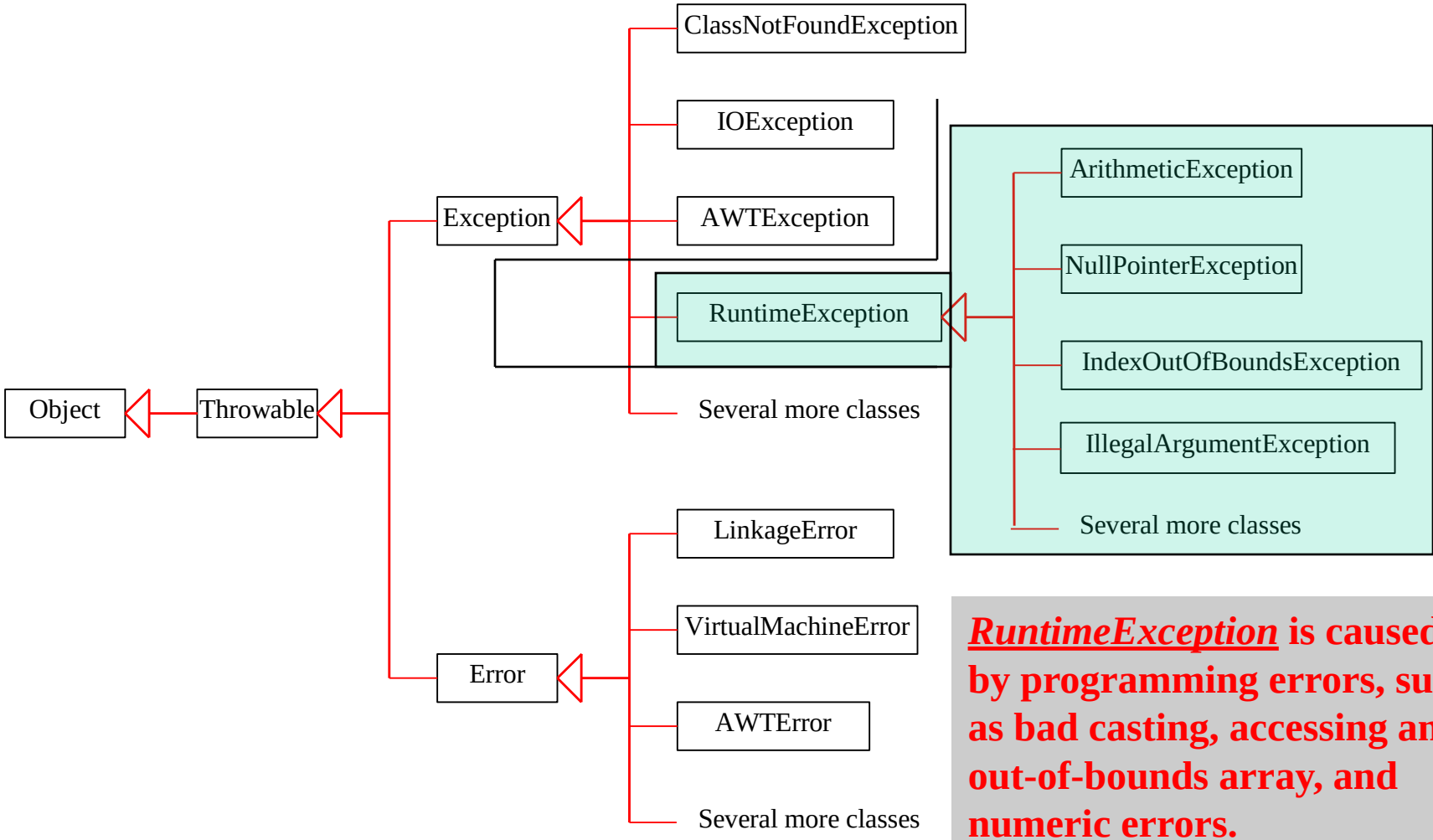


System Errors



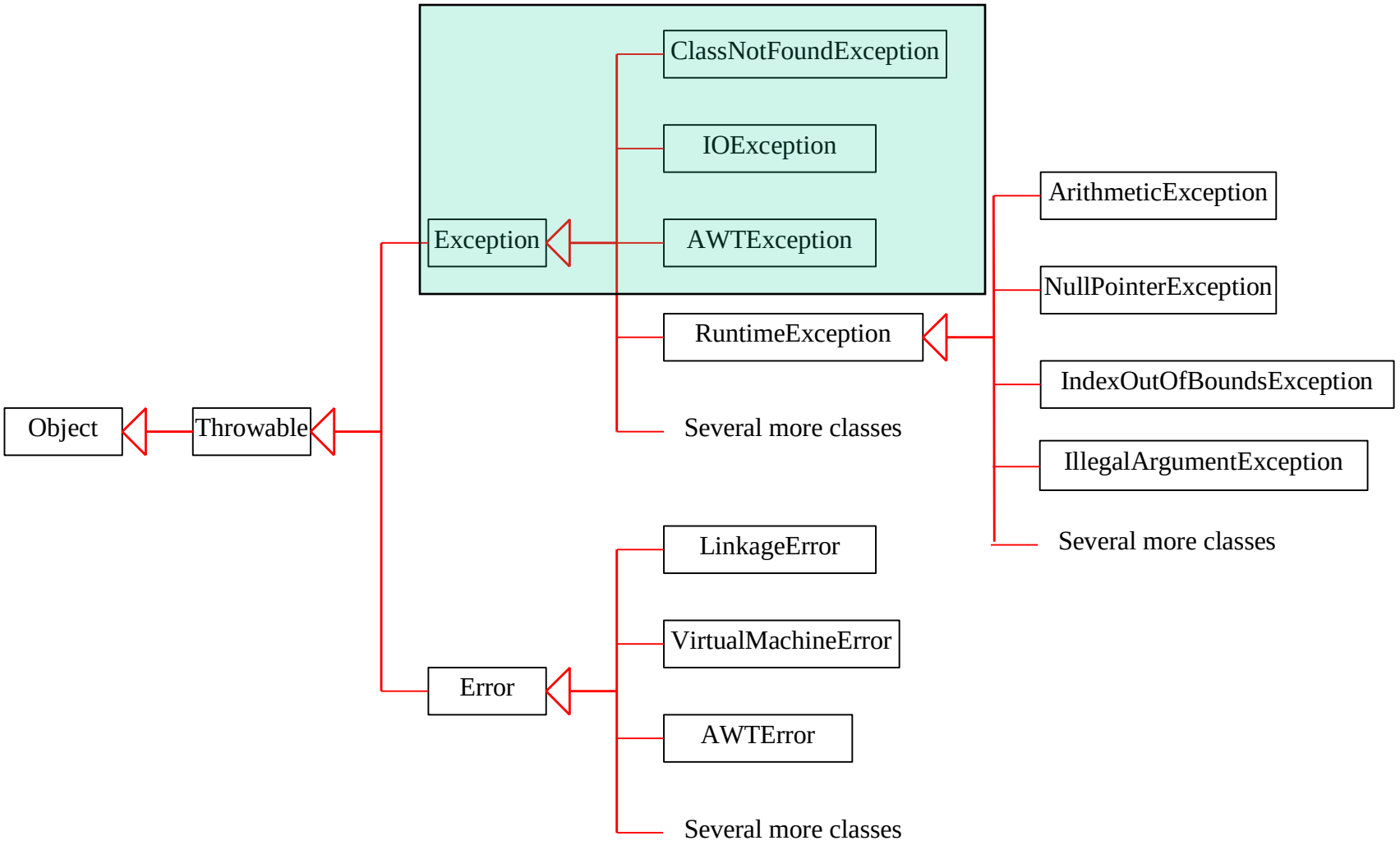
System errors **are thrown by JVM and represented in the** ***Error*** **class. The** ***Error*** **class describes internal system errors.** Such errors rarely occur. If one does, there is little you can do beyond notifying the user and trying to terminate the program gracefully.

Runtime Exceptions



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

Checked Exceptions



Exception Handling

Keywords:

Java Library Exceptions

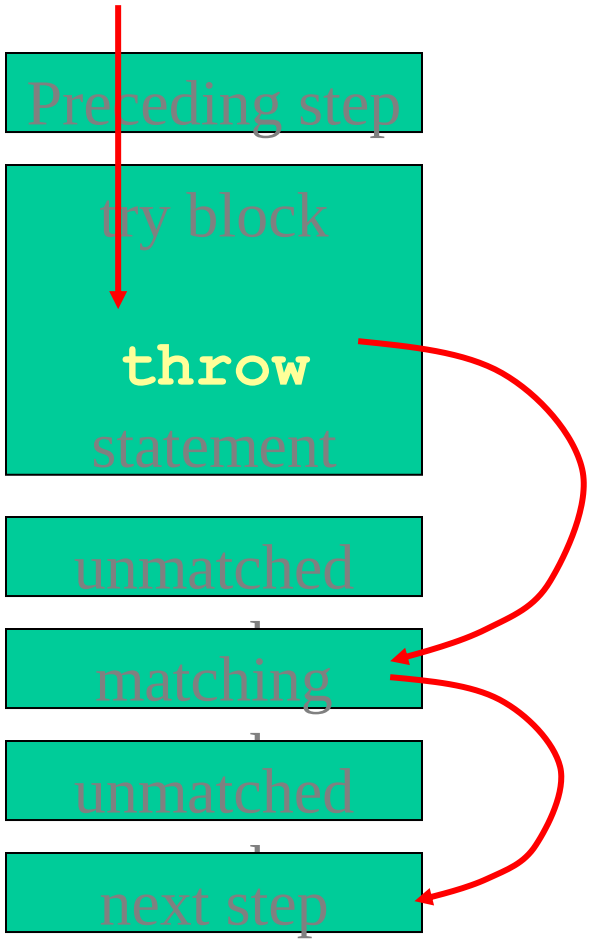
- Most Java routines throw exceptions.
- How do you know that the method you are going to call may throw an exception?

  You can look up the class documentation to see if a method throws exception
- Example:

  See the Scanner class methods at:

  http://java.sun.com/j2se/1.5.0/docs/api/java/util/Scanner.html

Sequence of Events for `throw`



Handling Exceptions

Java forces you to deal with checked exceptions.

Two possible ways to deal:

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

(a)

```
void p1() throws IOException {

  riskyMethod();

}
```

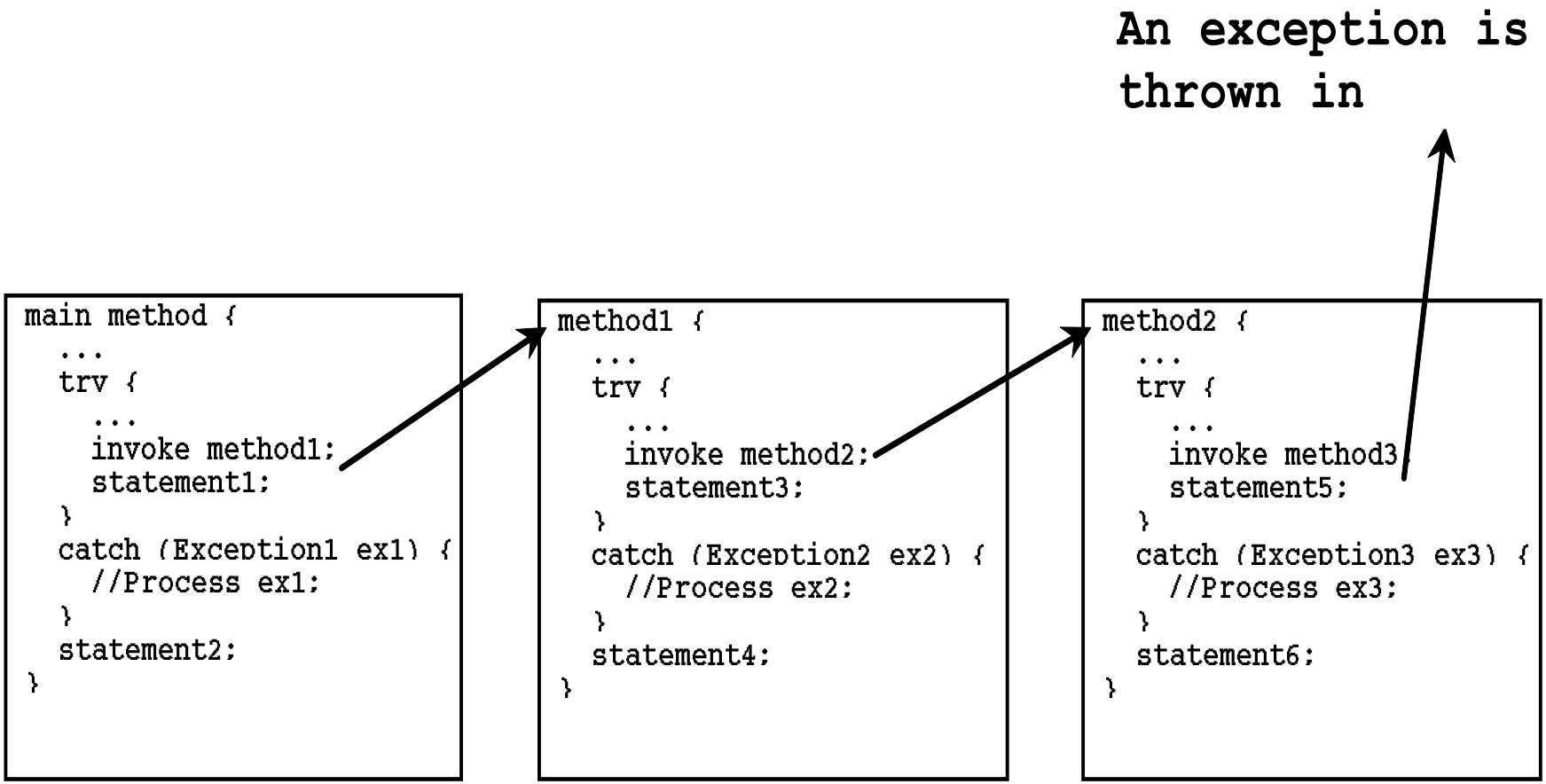
(b)

Catching Exceptions

- Install an exception handler with **try/ catch** statement

```
try {
   //Statements that may throw exceptions
}

catch (Exception1 exVar1) {
  //code to handle exceptions of type Exception1;
}

catch (Exception2 exVar2) {
  // code to handle exceptions of type Exception2;
}

...
catch (ExceptionN exVarN) {
  // code to handle exceptions of type exceptionN;
}

// statement after try-catch block
```

Catching Exceptions



Getting Information from Exceptions

Use instance methods of the java.lang.Throwable class

Some useful methods:

String **toString**()	Returns a short description of the exception
String **getMessage**()	Returns the detail description of the exception
void **printStackTrace**()	Prints the stacktrace information on the console

Example of printStackTrace() output

```
java.lang.NullPointerException at MyClass.mash(MyClass.java:9)
at MyClass.crunch(MyClass.java:6) at
MyClass.main(MyClass.java:3)
```

Example

```
public class Main {
   public static void main(String[] args) {
       java.io.PrintWriter output = null;
       try {
              output = new java.io.PrintWriter("text.txt");
              output.println("Welcome to Java");
              output.close();
       }
       catch(java.io.IOException ex){
               System.out.println(ex.toString());
              ex.printStackTrace() ;
       }
    }
}
```

Issues

```
public class Main {
   public static void main(String[] args) {
       java.io.PrintWriter output = null;
       try {
              output = new java.io.PrintWriter("text.txt");
              output.println("Welcome to Java");
              output.close();
       }
       catch(java.io.IOException ex){
               ex.printStackTrace() ;
       }
    }
}
```

Must execute output.close() even if exception happens

Solution

- Use *finally* clause for code that must be executed "no matter what"

```
try {
   //Statements that may throw exceptions
}

catch (Exception1 exVar1) {
  //code to handle exceptions of type Exception1;
}

catch (Exception2 exVar2) {
  // code to handle exceptions of type Exception2;
}
...
catch (ExceptionN exVar3) {
  // code to handle exceptions of type exceptionN;
}

finally { // optional
    // code executed whether there is an exception or not
}
```

Use finally block

```
public class Main {
   public static void main(String[] args) {
       java.io.PrintWriter output = null;
       try {
              output = new java.io. PrintWriter("text.txt");
              output.println("Welcome to Java");
       }
       catch(java.io.IOExcetion ex){
               ex.printStackTrace() ;
       }
       finally {
              if (output != null) output.close();
       }
    }
}
```

finally block

Executed when try block is exited in any of three ways:

- *After last statement of try block (success).*
- *After last statement of catch clause, if this catch block caught an exception.*
- *When an exception was thrown in try block and not caught*

Executed even if there is a return statement prior to reaching the finally block

Throwing Exceptions

When somebody writes a code that could encounter a runtime error,

- it creates an object of appropriate Exception class and throws it
- and must also declare it in case of checked exception

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

```
public class Circle {
        private double radius;
        private static int numberOfObjects = 0;

        public Circle() {   this(1.0);  }

        public Circle(double newRadius) throws IllegalArgumentException
        {
            setRadius(newRadius);    numberOfObjects++;
        }

        public double getRadius() {    return 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 class TestCircle {
        public static void main(String[] args) {
                try {
                        Circle c1 = new Circle(5);
                        Circle c2 = new Circle(-5);
                        Circle c3 = new Circle(0);
                }
                catch (IllegalArgumentException ex) {
                        System.out.println(ex);
                }
                System.out.println("Number of objects created: "
                                        + Circle.getNumberOfObjects());
        }
}
```

Output:

java.lang.IllegalArgumentException: Radius cannot be negative
Number of objects created: 1

Creating Custom Exception Classes

- Create custom exception classes if the predefined classes are not sufficient.

- To declare custom exception class:
  - Create a class that *extends Exception* or a subclass of Exception.
  - It is good practice to add:
    - An argument-less constructor
    - Another constructor with one string type parameter

```
public class InvalidRadiusException extends Exception {
        private double radius;
        public InvalidRadiusException() { super("invalid radius!"); }
        public InvalidRadiusException(double radius) {
            super("Invalid radius "); this.radius = radius;
        }
        public double getRadius() { return radius; }
}
```

```
public class Circle {
        private double radius;
        private static int numberOfObjects = 0;

        public Circle() {    this(1.0);   }
        public Circle(double newRadius) throws InvalidRadiusException{
            setRadius(newRadius); numberOfObjects++;
        }

        public void setRadius(double newRadius)
                        throws InvalidRadiusException {
            if (newRadius >= 0)       radius =  newRadius;
            else throw new InvalidRadiusException(newRadius);
        }
        public static int getNumberOfObjects() {
                return numberOfObjects;
        }
}
```

```
public class Main {
  public static void main(String[] args) {
    try {
      Circle c1 = new Circle(5);   c1.setRadius(-5);
      Circle c2 = new Circle(0);
    }
    catch (InvalidRadiusException ex) {
        System.out.println("Invalid Radius: " + ex.getRadius());
    }

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

Output:

Invalid radius: -5.0
Number of objects created: 1

When to create Custom Exception classes

- Use the exception classes in the API whenever possible.
- You should write your own exception classes if you answer 'yes' to one of the following:
  - ✓ **Do you need an exception type that isn't represented by those in the Java platform?**
  - ✓ **Would it help users if they could differentiate your exceptions from those thrown by classes written by other vendors?**
  - ✓ **Do you want to pass more than just a string to the exception handler?**

When to Use Exceptions

Use it if the event is truly exceptional and is an error

Do not use it to deal with simple, expected situations.

Example:

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

Can be replaced by:

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

Get more info!

- Java docs: Exception

  http://java.sun.com/j2se/1.5.0/docs/api/java/lang/Exception.html

- Sun Tutorial on Exception Handling

  http://java.sun.com/docs/books/tutorial/essential/exceptions/definition.html

- Exception Handling @mindprod.com

  http://mindprod.com/jgloss/exception.html