JAC444 / BTP400 Course Object-Oriented Software Development in Java

Exception

Objectives

Upon completion of this lecture, you should be able to:

- Separate Error-Handling Code from Regular Code
- Use Exceptions to Handle Exceptional Events
- Create Your Exceptions

Exceptions

In this lesson you will be learning about:

- What is and how to treat an exception in Java
- How to separate error handling from regular code
- How to write exception handler
- Exception class hierarchy
- How to create your own exception classes

What is an exception?

- **Definition**: An exception is an event that occurs during the execution of a program that disrupts the normal flow of instruction.
- **Examples**: Serious hardware errors, such as a hard disk crash, to simple programming errors, such as trying to access an out-of-bounds array element.
- **Java solution**: The Java method creates an exception object and hands it off to the runtime system.

Definitions

- Throwing an exception

  It happens when an error occurs the method creates an exception object and hands it off to the runtime system.

- The exception object

  The exception object contains information about the exception, including its type and the state of the program when the error occurred.

- Catching an exception

  Searching the the call stack until an appropriate exception handler is found. The handler catches the exception.

Advantages of Exceptions

- Separating Error Handling Code from “Regular” Code
- Propagating Errors Up the Call Stack
- Grouping Error Types and Error Differentiation

Error Handling Code

Problem: Read a file and copy its content into memory

```
… readFile ( … ) {

        open the file;
        determine its size;
        allocate that much memory;
        read the file into memory;
        close the file;

…
}
```

Potential Errors

- What happens if the file can not be opened?
- What if the length of the file can not be determined?
- What happens if enough memory can not be allocated?
- What happens if the read fails?
- What happens if the file can not be closed?

Error Detection Code Solution

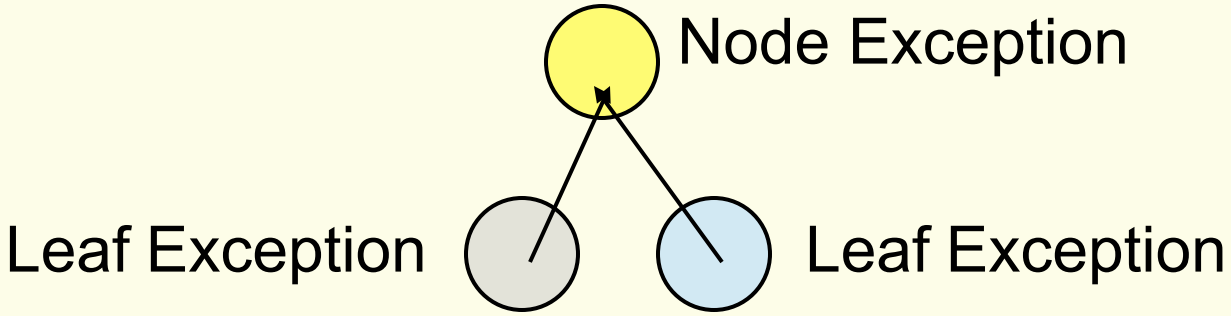
```
int readFile ( … )  {
   initialize errorCode = 0;
   //open the file;
   if (theFileIsOpen) {
           //determine the length of the file;
           if (gotTheFileLength) {
                   //allocate that much memory;
                   if (gotEnoughMemory) {
                           //read the file into memory;
                           if (readFailed) {
                               errorCode = -1;
                           }
                   } else {
                     errorCode = -2;
                   }
           } else {
             errorCode = -3;
     }
      ...
```

Java Solution: Exception Handler

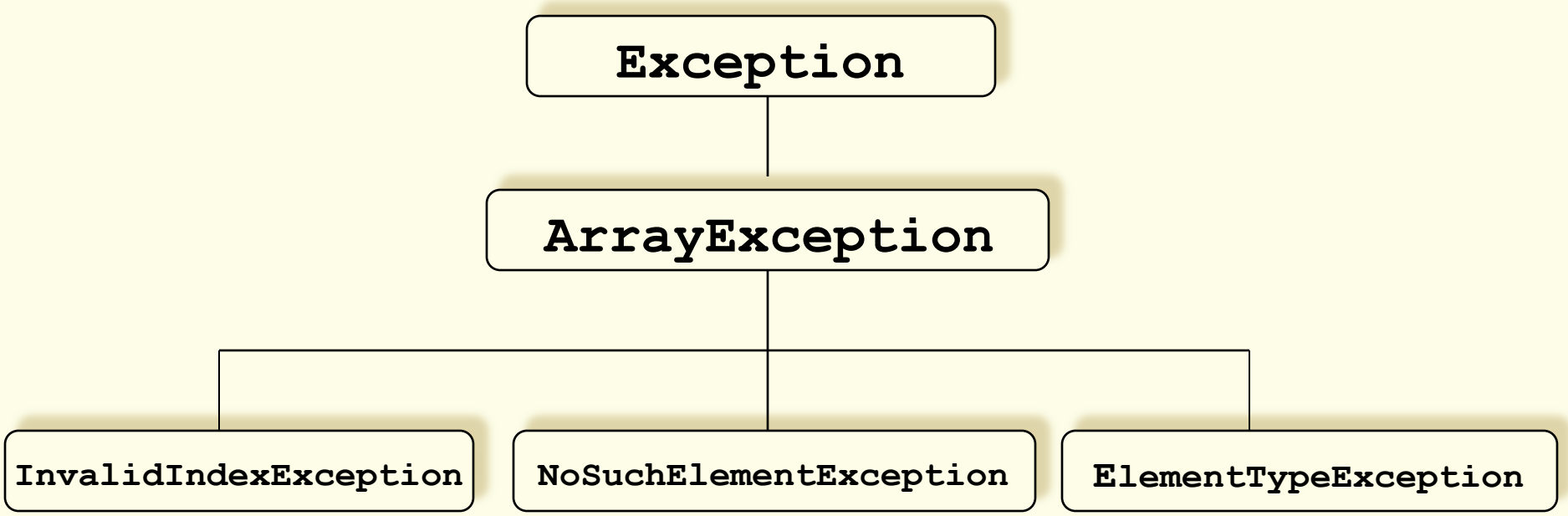
```
void readFile() {
     try {
                    open the file;
                    determine its size;
                    allocate that much memory;
                    read the file into memory;
                    close the file;
     } catch (fileOpenFailed) {
                    doSomething;
     } catch (sizeDeterminationFailed)  {
                    doSomething;
     } catch (memoryAllocationFailed) {
                    doSomething;
     } catch (readFailed) {
                    doSomething;
     } catch (fileCloseFailed) {
                    doSomething;     …
```

Exception Hierarchy

- All exceptions that are thrown within a Java program are first-class objects.
- *Leaf* class (a class with no subclasses) represents a specific type of exception.
- *Node* class (a class with one or more subclasses) represents a group of related exceptions.



ArrayException Example



Java Exception: Catch / Specify

Java language requires that methods either:

Catch

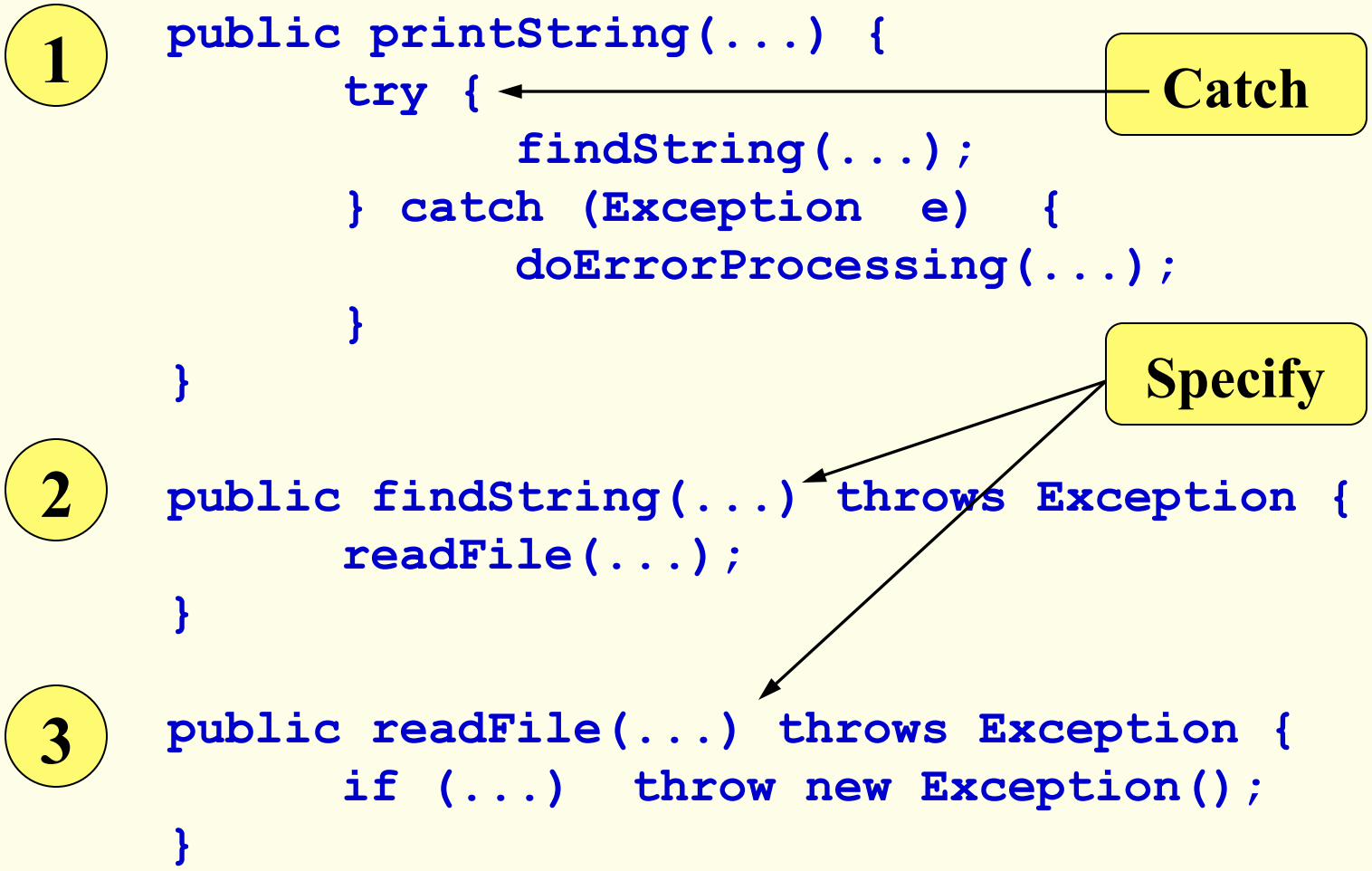
or

Specify

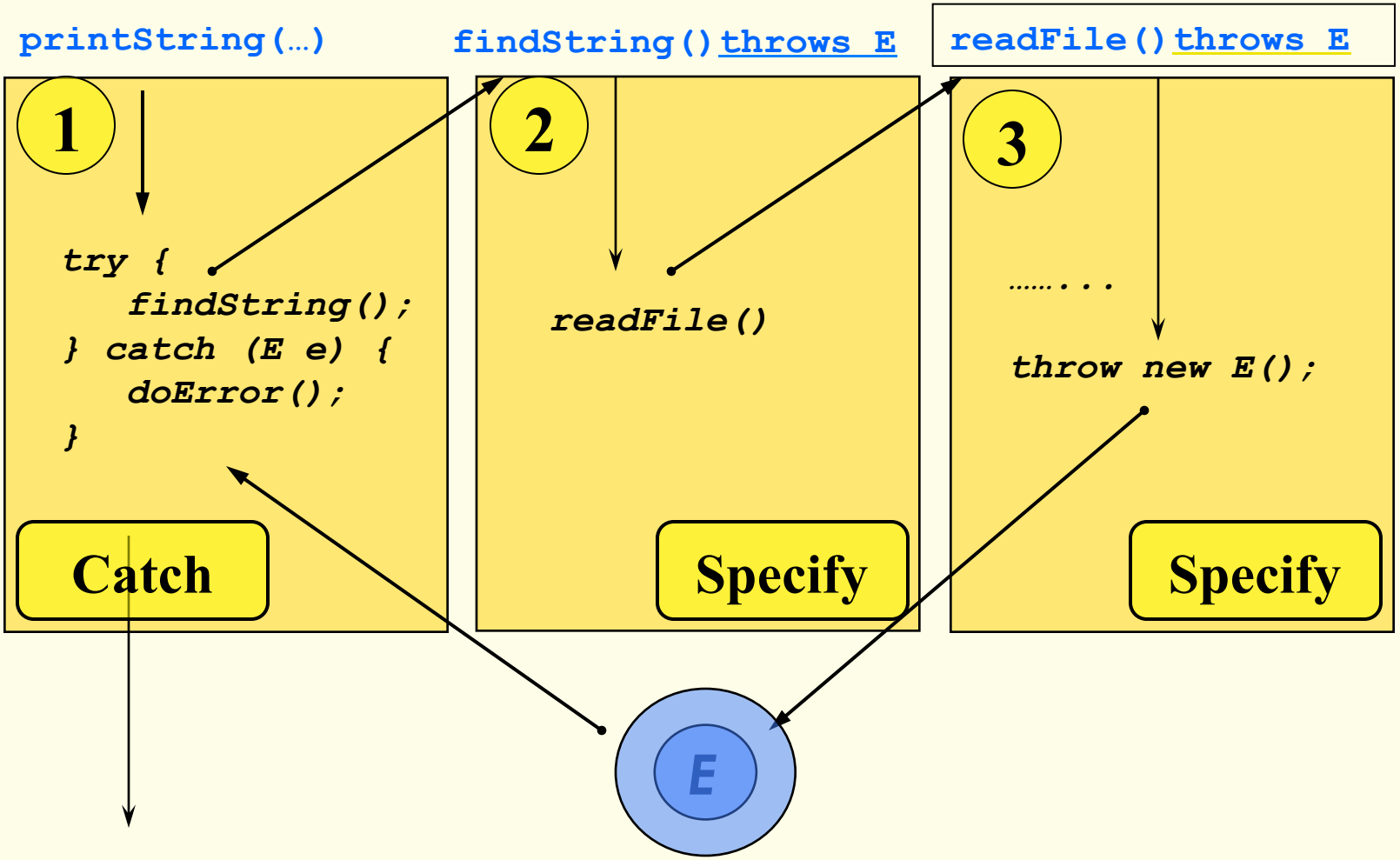
an exception (checked exceptions)

If an exception is not caught or specified by a method the program does NOT compile

Java Solution: Catch or Specify



Exceptions: Flow of Control



Catch / Specify

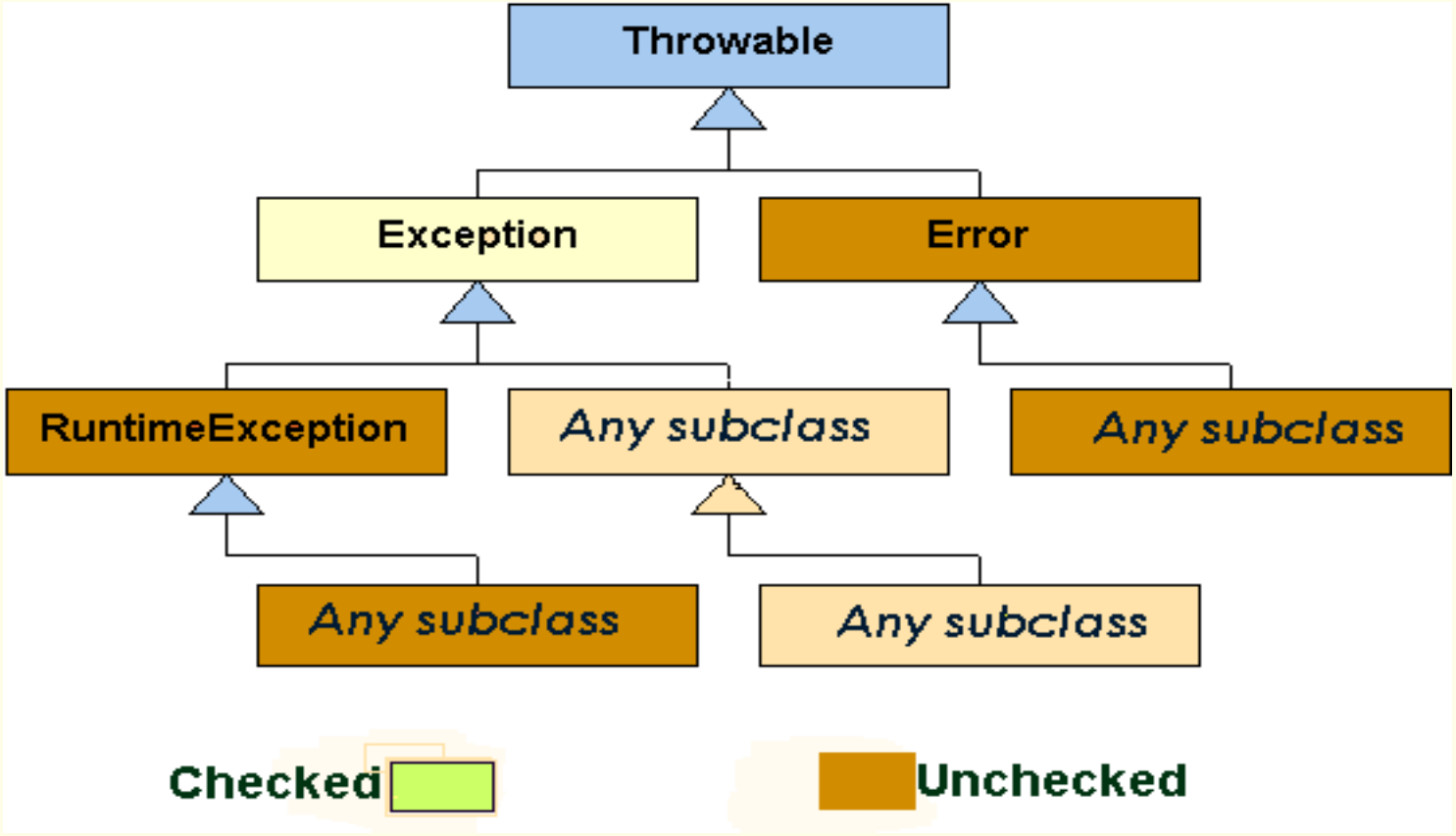
- **Catch**
  A method can catch an exception by providing an exception handler for that type of exception

- **Specify**
  The method could specify that it can throw that exception

What are checked exceptions?

Checked exceptions are exceptions that are not runtime exceptions and are checked by the compiler

Exception Class Hierarchy



How to write an exception handler

1. Write the `try` block
   It is a block that encloses the statements that might throw an exception

2. Write the `catch` block(s)
   It defines the associate with a `try` block by providing one or more blocks of statements directly after the `try` block.

3. Write the `finally` block
   `finally` block provides a mechanism that allows your method to clean up after itself

The `try` Block

```
try {
   Java statements
}
```

Example:

```
PrintWriter out = null;
try {
   out = new PrintWriter ( new FileWriter("X"));
   for (int i = 0;  i < size;  i ++)
      System.out.println(vector.elementAt(i));
}
```

Important note:

A `try` statement must be accompanied by at at least one `catch` block or one `finally` block.

The `catch` Block(s)

One associates exception handlers with a **`try`** statement by providing one or more **`catch`** blocks directly after the **`try`** block:

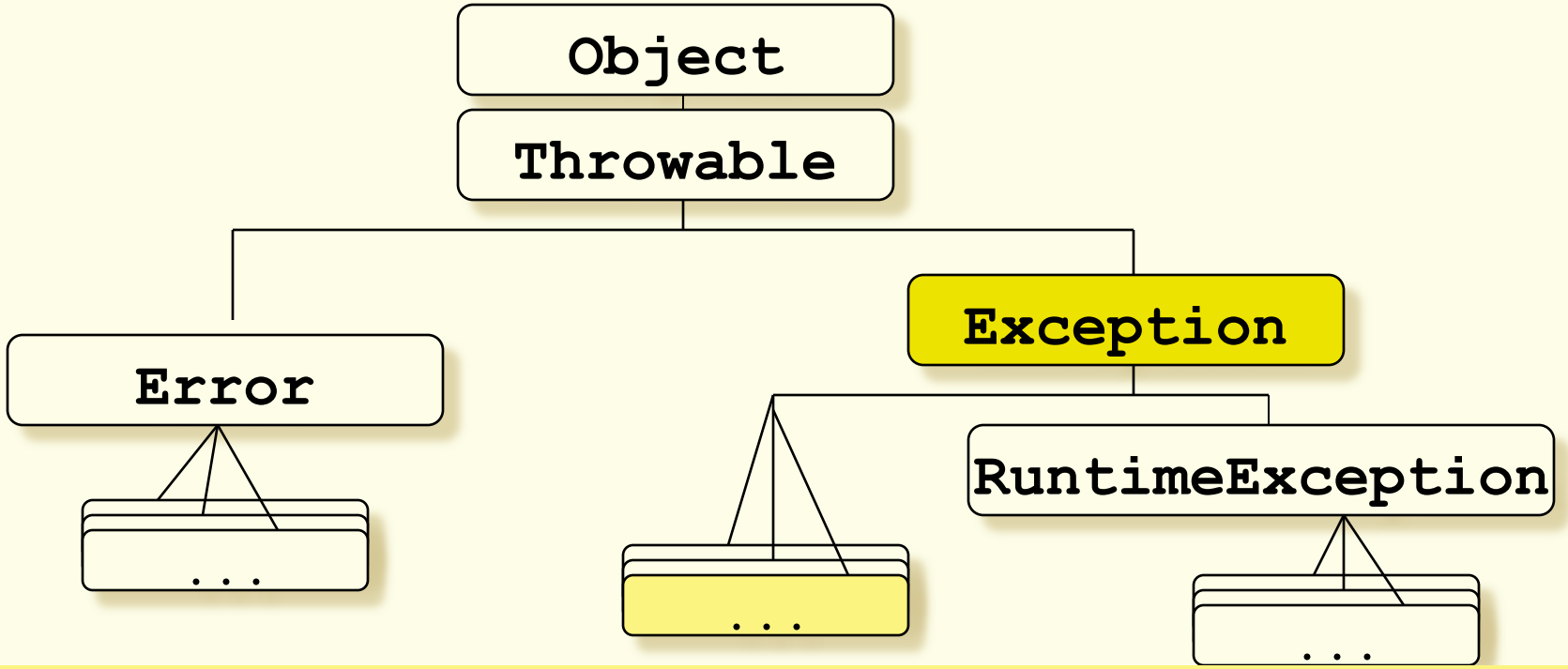
```
try {
        . . .
} catch ( . . . ) {
        . . .
} catch ( . . . ) {
        . . .
} . . .
```

The general form of **`catch`** statement:

```
catch(ThrowableClass variableName)   {
      Java statements
}
```

Catch statement requires **a single formal argument**.

Catching Exception Types




```
try {
        . . .
} catch (Exception e) {
    System.err.println("Exception caught: " + e.getMessage( ) );
}
```

The `finally` Block

For cleanup code use a **`finally`** block.

```
try {
     . PrintWriter out ...
} catch (. . .) {
     . . .
} finally {
     if (out != null) {
        System.out.println("Closing PrintWriter");
        out.close( );
     } else {
        System.out.println("PrintWriter not open");
     }
}
```

Try, Catch, Finally Blocks

```
public void writeList ( ) {
    PrintWriter out = null;
    try {
       System.out.println("Entering try statement");
       out = new PrintWriter(new FileWriter("OutFile.txt"));
       for (int i = 0; i < size; i++)
          out.println ("At:" + i + " = " + vector.elementAt(i));

    } catch (ArrayIndexOutOfBoundsException e) {
       System.err.println("Caught Exception: " e.getMessage( ));
    } catch (IOException e) {
       System.err.println("Caught IOException: " + e.getMessage( ));

    } finally {
       if (out ! = null) {
          System.out.println("Closing PrintWriter");
          out.close ( );
       } else {
          System.out.println("PrintWriter not open:);
       }
    }
}
```

Specifying Exceptions

One can specify exceptions in the method definition with the keyword:

`throws`

The `throws` clause is composed of the `throws` keyword followed by a comma-separated list of all the exceptions thrown by method.

Example:

```
public void writeList(...)throws IOException,
                                 ArrayIndexOutOfBoundsException{
        ...
}
```

The `Throw` Statement

The **`throw`** statement is used to create an exception object. It requires a single argument as a constructor of an exception object:

```
throw new Exception()
```

Example: The method is taken from a class that implements common stack object.

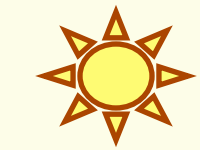
```
public Object pop( ) throws EmptyStackException {
        Object obj;
        if (size == 0)
                throw new EmptyStackException( );
        obj = objectAt(size - 1);
        setObjectAt(size - 1, null);
        size -- ;
        return obj;
}
```

The `Throwable` Class

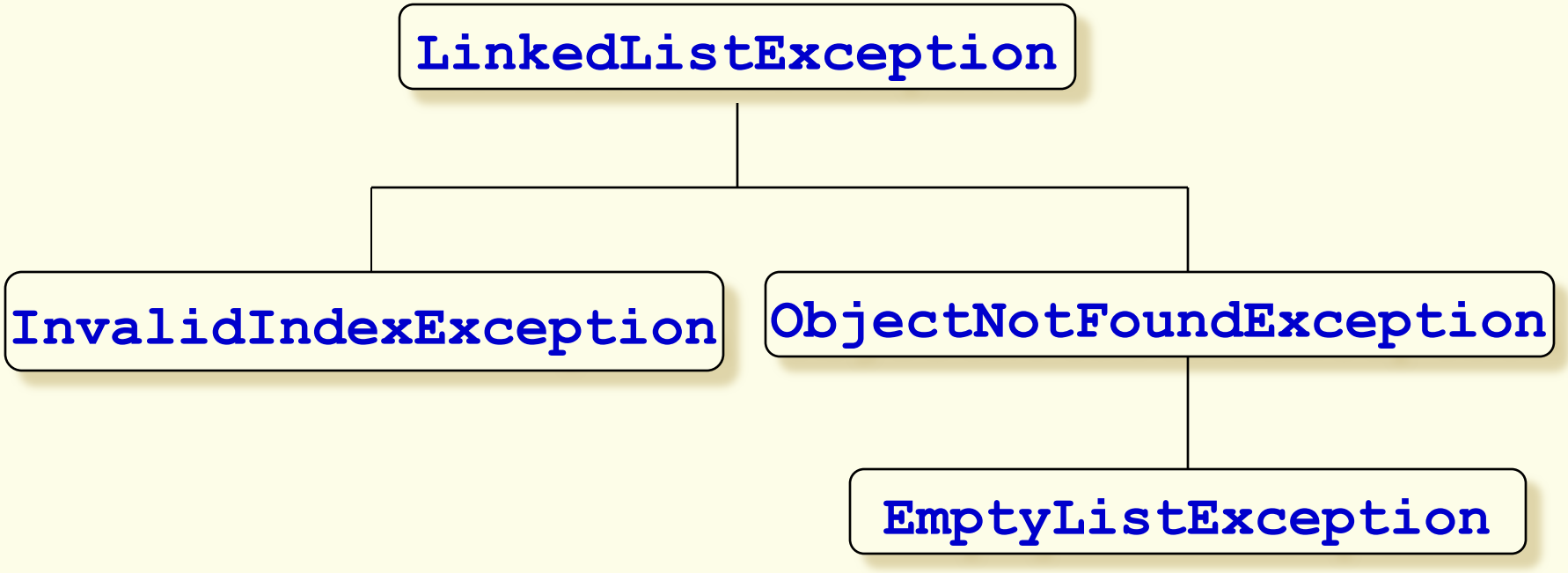
- **`Errors`**
  Java programs should not catch *Errors.*

- **`Exceptions`**
  Most programs **`throw`** and **`catch`** objects that derive from the **`Exception`** class.

- **`Runtime Exceptions`**
  The compiler allows runtime exceptions to go uncaught and unspecified.



Exception Class Hierarchy



Conclusion

After completion of this lesson you should:

1. Write programs using `java.lang.Exception` package and your defined exceptions

2. Apply the principal:

   If anything can go wrong, it will.