Exceptions

CSC207 Fall 2015

What are exceptions?

Exceptions report exceptional conditions: unusual, strange.

These conditions deserve exceptional treatment: not the usual go-to-the-next-step, plod-onwards approach.

Instead, an exception immediately halts the method that is executing, and continues halting methods down the call stack until either

- one of those methods agrees to deal with the problem, after which the program continues running normally, or
- the entire call stack is empty, at which point the user sees a message about the exception. (Ouch.)

Exceptions in Java

To **"throw an exception"**:

```
throw Throwable;
```

To **"catch an exception"** and deal with it:

```
try {
    statements
// The catch belongs to the try.
} catch (Throwable parameter) {
    statements
}
```

To say you aren't going to deal with exceptions (or may throw your own):

```
...methodName (parameters) throws Throwable {
      ...
}
```

An analogy

`throw`:

I'm in trouble, so I throw a rock through a window, with a message tied to it.

`try`:

Someone in the following block of code might throw rocks of various kinds. All you catchers line up ready for them.

`catch`:

If a rock of my kind comes by, I'll catch it and deal with it.

`throws`:

I’m warning you: if there’s trouble, I may throw a rock.

Why use exceptions?

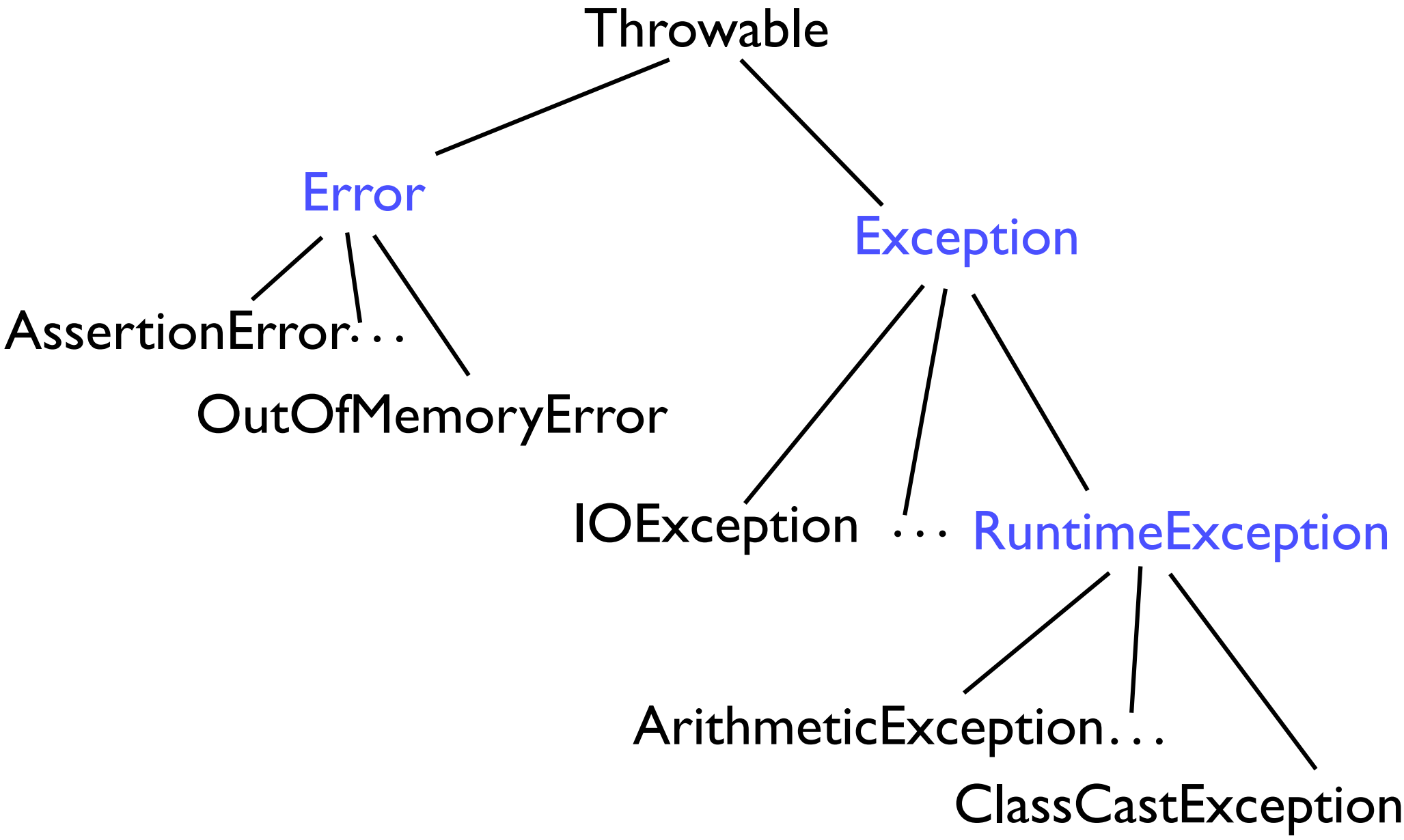
Why not just use special return values? These can be checked and handled, similar to exceptions.

But this approach would require sending and checking special values all the way down the call stack.

With exceptions, we don't have to. As a result, less programmer time is spent on handling errors, and code has cleaner structure:

- Error-handling code can be in one location, not sprinkled everywhere.
- In the code that may throw an exception, can focus on the algorithm and know the exception will be handled elsewhere.
- (Throw and catch should not be in the same method.)

The Hierarchy



`Throwable`

Constructors:

`Throwable(), Throwable(String message)`

Other useful methods:

`getMessage()`

`printStackTrace()`

`getStackTrace()`

You can also record (and look up) within a `Throwable` its "cause": another `Throwable` that caused it to be thrown.

Through this you can record (and look up) a chain of exceptions.

What should you `throw`?

You can throw an instance of `Throwable` or any subclass of it (whether an already defined subclass, or a subclass you define).

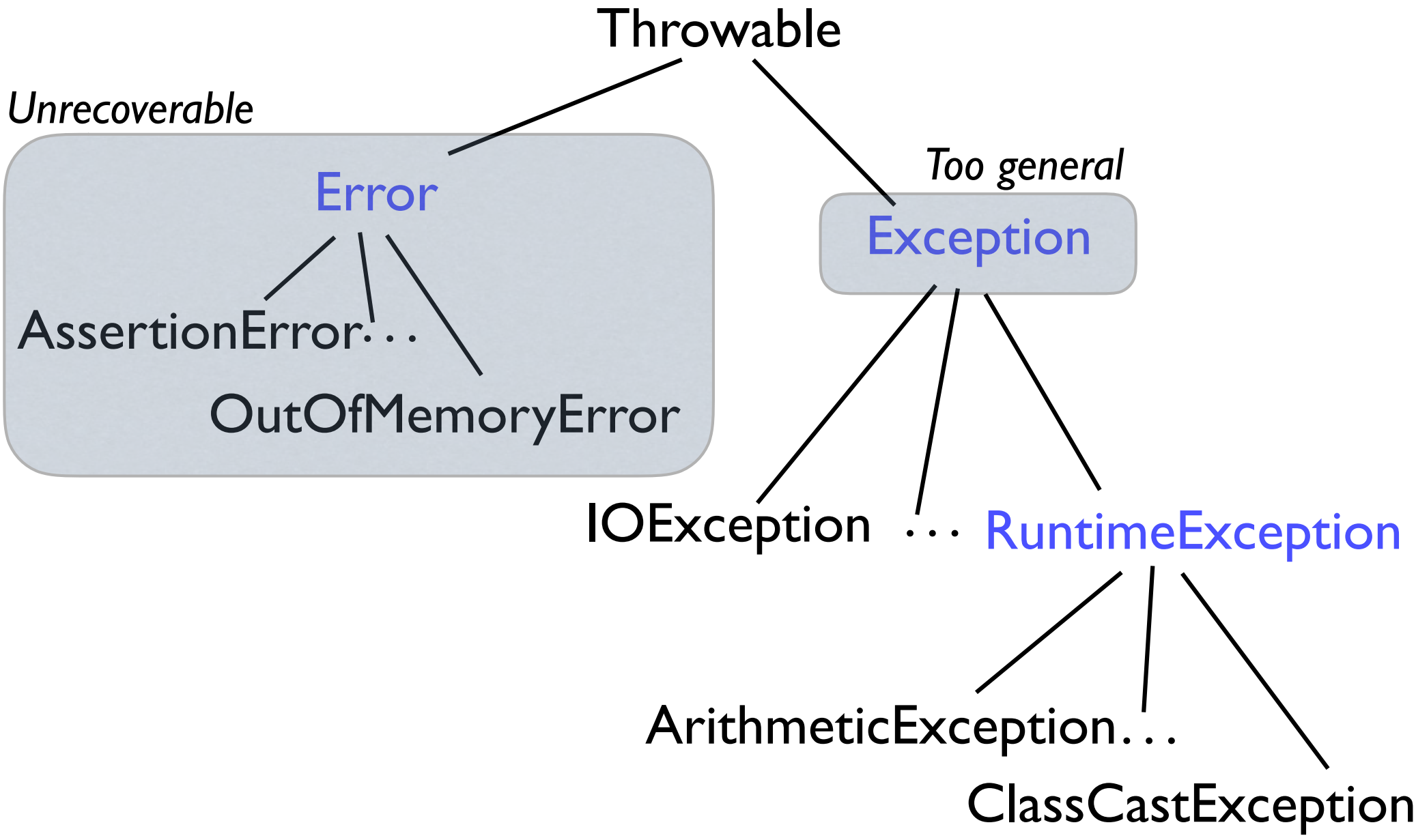
Don't throw an instance of `Error` or any subclass of it:
these are for unrecoverable circumstances (e.g., `OutOfMemoryError`).

Don't throw an instance of `Exception`:
throw something more specific.

It's okay to throw instances of:

- specific subclasses of `Exception` that are already defined, e.g., `UnsupportedOperationException`
- specific subclasses of `Exception` that you define.

Don’t throw these:



These do not need to be handled

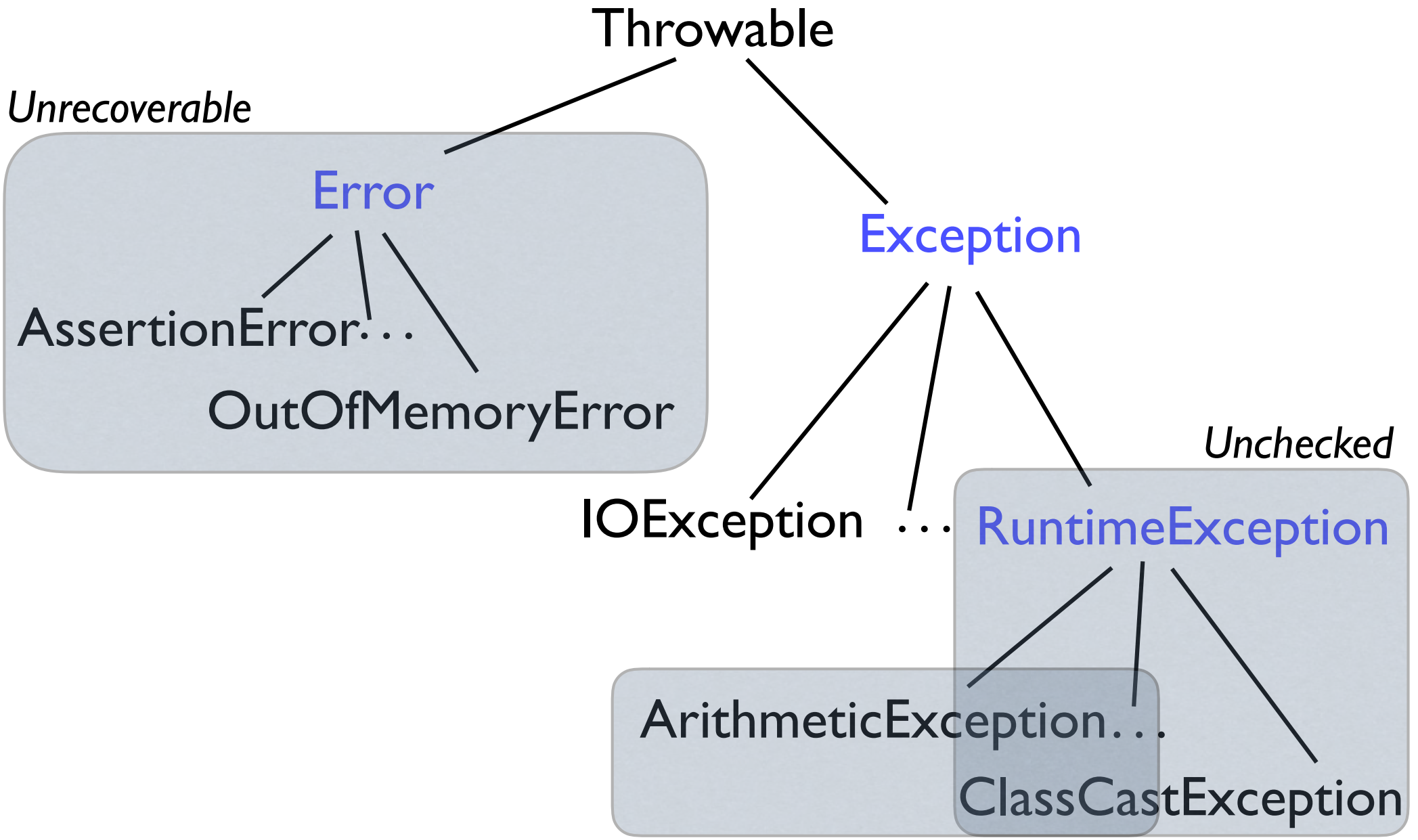
`Error`:

- "Indicates serious problems that a reasonable application should not try to catch."
- Do not have to handle these errors because they "are abnormal conditions that should never occur."

`RuntimeException`:

- These are called **unchecked** because Java does not require you to handle them.
- I.e., for a `RuntimeException`, it's okay if you don't catch it and you don't declare that you might throw it either.

These do not need to be handled



Checked vs. Unchecked Exceptions

When defining an `Exception` subclass, we need to decide whether to extend `RunTimeException` (unchecked) or `Exception` (checked).

```
public class MyException extends RuntimeException {...}
class MyClass {
    public void m()  /* No "throws", but it compiles! */  {...
        if (...) throw new MyException("oops!") {...}
  }
}

public class MyException extends Exception {...}
class MyClass {
    public void m() throws MyException { ...
    if (...) throw new MyException("oops!") {...}
  }
}
```

What does the Java API say?

`Exception`:

> "The class `Exception` and its subclasses are a form of `Throwable` that indicates conditions that a reasonable application might want to catch."

`RunTimeException` (unchecked):

> "`RuntimeException` is the superclass of those exceptions that can be thrown during the normal operation of the Java Virtual Machine."
>
> Examples: `ArithmeticException`, `IndexOutOfBoundsException`, `NoSuchElementException`, `NullPointerException`

non-`RuntimeException` (checked):

> Examples: `IOException`, `NoSuchMethodException`

Guideline for which to use

"Use **checked exceptions** for conditions from which the caller can reasonably be expected to recover."

"Avoid unnecessary use of **checked exceptions**."

- If the user didn’t use the API properly or if there is nothing to be done, then make it a RunTimeException.

"Use **run-time exceptions** to indicate programming errors. The great majority of run-time exceptions indicate precondition violations."

- Example: Suppose method getItem(int i) returns an item at a particular index in a collection and requires that i be in some valid range.
- The programmer can check that before they call o.getItem(x).
- So sending an invalid index should not cause a checked exception to be thrown.

We can have cascading catches

Much like an if with a series of else if clauses, a try can have a series of catch clauses.

After the last catch clause, you can have a clause:

```
finally { ... }
```

But finally is not like a last else on an if statement:
The finally clause is always executed, whether an exception was thrown or not, and whether or not the thrown exception was caught.

Example of a good use for this: close open files as a clean-up step.

An example of multiple catches

Suppose `ExSup` is the parent of `ExSubA` and `ExSubB`.

```
try {
    ...
} catch (ExSubA e) {
    // We do this if an ExSubA is thrown.
} catch (ExSup e) {
    // We do this if any ExSup that's not an ExSubA is thrown.
} catch (ExSubB e) {
    // We never do this, even if an ExSubB is thrown.
} finally {
    // We always do this, even if no exception is thrown.
}
```

`finally` vs. code after `try/catch`

```
try {
  // do something
} catch(MyException e) {
  // handle exception
} finally {
  cleanUp();
}
```

```
try {
  // do something
} catch(MyException e) {
  // handle exception
}
cleanUp();
```

Even if there are `return` statements or exceptions in the `try` or `catch` blocks, the code in `finally` be executed. That isn't the case with the code on the right-hand side.

Documenting Exceptions

```
/**
 * Return the mness of this object up to mlimit.
 * @param mlimit The max mity to be checked.
 * @return int The mness up to mlimit.
 * @throws MyException If the local alphabet has no m.
 */
public void m(int mlimit) throws MyException { ...
    if (...) throw new MyException ("oops!") { ...
    }
}
```

You need both:

- the Javadoc comment is for human readers, and
- the `throws` is for the compiler.

Both the reader and the compiler are checking that caller and callee have consistent interfaces.