From Yesterday

- private = accessible only to the class that declares it
- public = accessible to any class at all
- protected = accessible to the class and its sub-classes
- default = accessible to classes in same "package"

Specifier	class	subclass	package	world
private	X			
protected	X	X*	X	
public	X	X	X	X
package	X		X	

* Java Spec (sec. 6.6.2) A protected member or constructor of an object may be accessed from outside the package in which it is declared only by code that is responsible for the implementation of that object.

LockPick Take Two

```
class XBox implements LockBox {
    protected boolean open;
    …
}
class LockPick extends LockBox {
    public static void openXBox(XBox x) {
        x.open = true; // only if LockPick in same package
    }
}

XBox x = new XBox(…)
LockPick.openXBox(x);
```

Exceptions

Weiss sec. 2.5

Errors

- What to do when errors are encountered?

```
import java.io.PrintStream;

class DangerMouse {
  public static void main(String args[]) {
    printOneInteger(args, System.out);
  }
  public static void printOneInteger(String args[], PrintStream out) {
    System.out.println("got: " + getOneInteger(args););
  }

  public static int getOneInteger(String args[]) {
    return Integer.parseInt(args[0]);
  }
}
```

Avoiding Errors

- What to do when errors are encountered?
- Idea #1: Avoidance
  - Add checks before “dangerous” operations
  - Don’t do anything that will (might) fail
  - Too many checks!
  - What to do when a check fails?
- Idea #2: Avoidance + Error Codes
  - Add checks after “fallible” operations too
  - If errors encountered, return some kind of error code
  - Too many checks!
  - Clumsy, error-prone, confusing

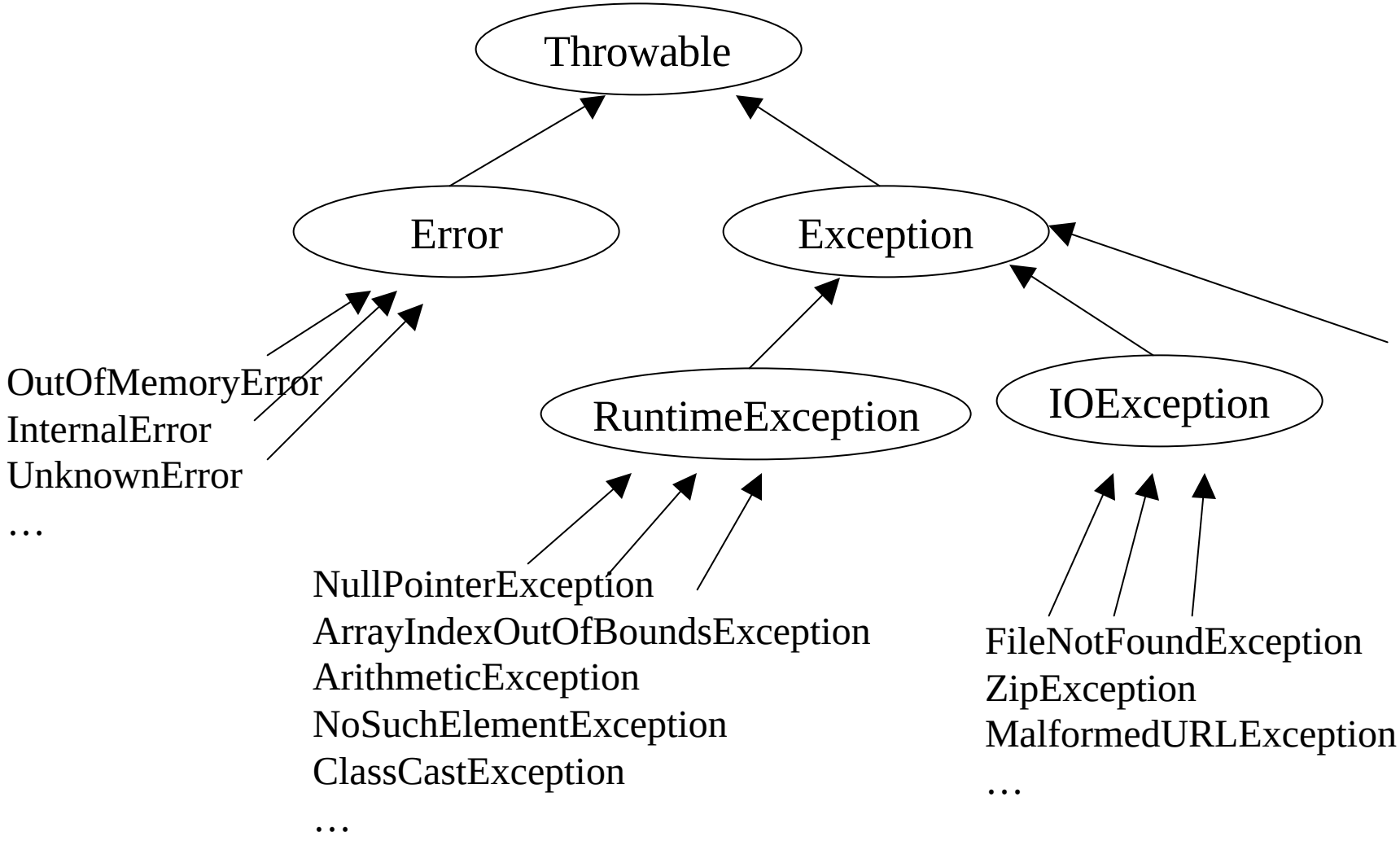
Ugly Code

```
public static void printOneInteger(String args[], PrintStream out) {
  int i = getOneInteger(args);
  if (i % 2 == 0) i = i / 2;
  else return -1; // some kind of error in args
  if (!checkForEnoughMemory(5 + 10)) return -2; // hope 10 is enough!
 String s = "got: " + i;
  if (s == null) return -4; // something went wrong with allocation
  if (out == null) return -3; // bad output stream
 if (out.println(s) < 0) return -5; // something went wrong with output
  return 0;
}

// return an 2*integer, or -1 if arg is missing, or -3 if not in right format
public static int getOneInteger(String args[]) {
  if (args == null || args.length == 0) return -1;
  if (!checkIntegerFormat(args[0]) return -3;
  return 2*Integer.parseInt(args[0]);
}
```

Structured Exception Handling

- Errors cause programs, even machines, to crash.
- Can't avoid all dangerous operations.
- Goal:
  - Want "normal case" code should flow nicely
  - Want to catch exceptional cases, and deal with them separately
  - Keep information about what went wrong:
    - what kind of exceptional case
    - details about what specifically went wrong
    - where it happened in the code
    - other info particular to this kind of exceptional case
  - Be able to return this info up the call-chain to whatever method can deal with the problem
    - But don't interfere with normal return statements!
    - Instead, we say that we "throw" the exceptional case up the call chain

Throwable Hierarchy



Throwable

- Contains a “stack trace” / “call chain”
  - which method called which method called … called the method that had a problem
- Has a String message (some detail about what happened)
- Can have a Throwable cause (some other error that caused this one)
- “An **Error** is a subclass of Throwable that indicates serious problems that a reasonable application should not try to catch. Most such errors are abnormal conditions.” (Java Documentation)
- “The class **Exception** and its subclasses are a form of Throwable that indicates conditions that a reasonable application might want to catch.”

Throwing an Exception

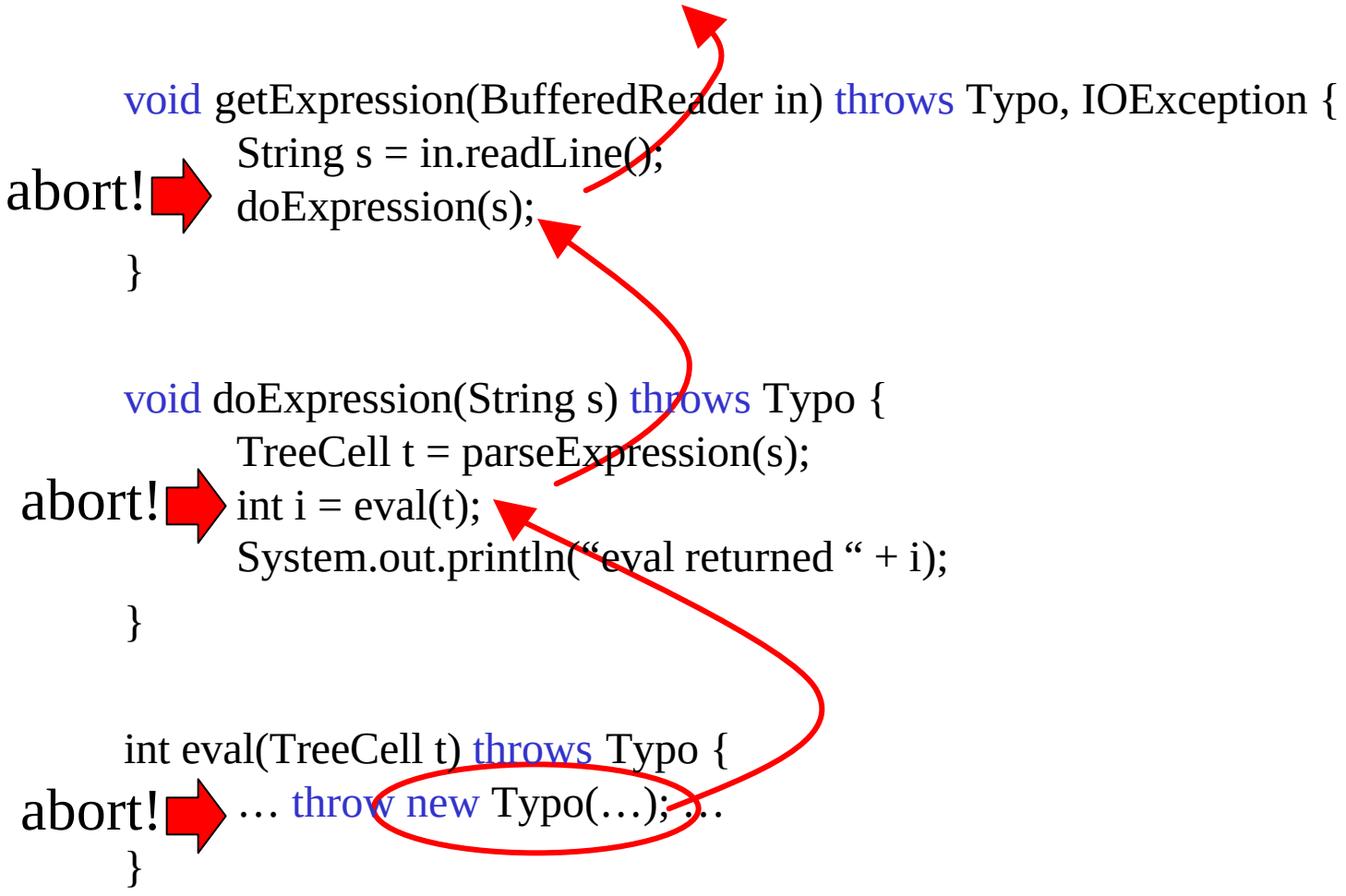
```
class Typo extends Exception {…}


static int eval(TreeCell t) throws Typo {
    String s = t.getElt();
    if (s.length() == 0) throw new Typo(“empty token”);
    if (s.equals(“+”)) return …
    else if (Character.isLetter(s.charAt(0))) return …
    else if (Character.isDigit(s.charAt(0))) return …
    else throw new Typo(“unrecognized operand: “ + s);
}
```

If s is empty, abort!
We create a new Typo object to hold details

- Keyword throws tells compiler (and programmer) what exceptions might get thrown by this method
- Keyword throw takes a Throwable object, aborts the current method (with NO return value!), and passes the Throwable object up the call-chain

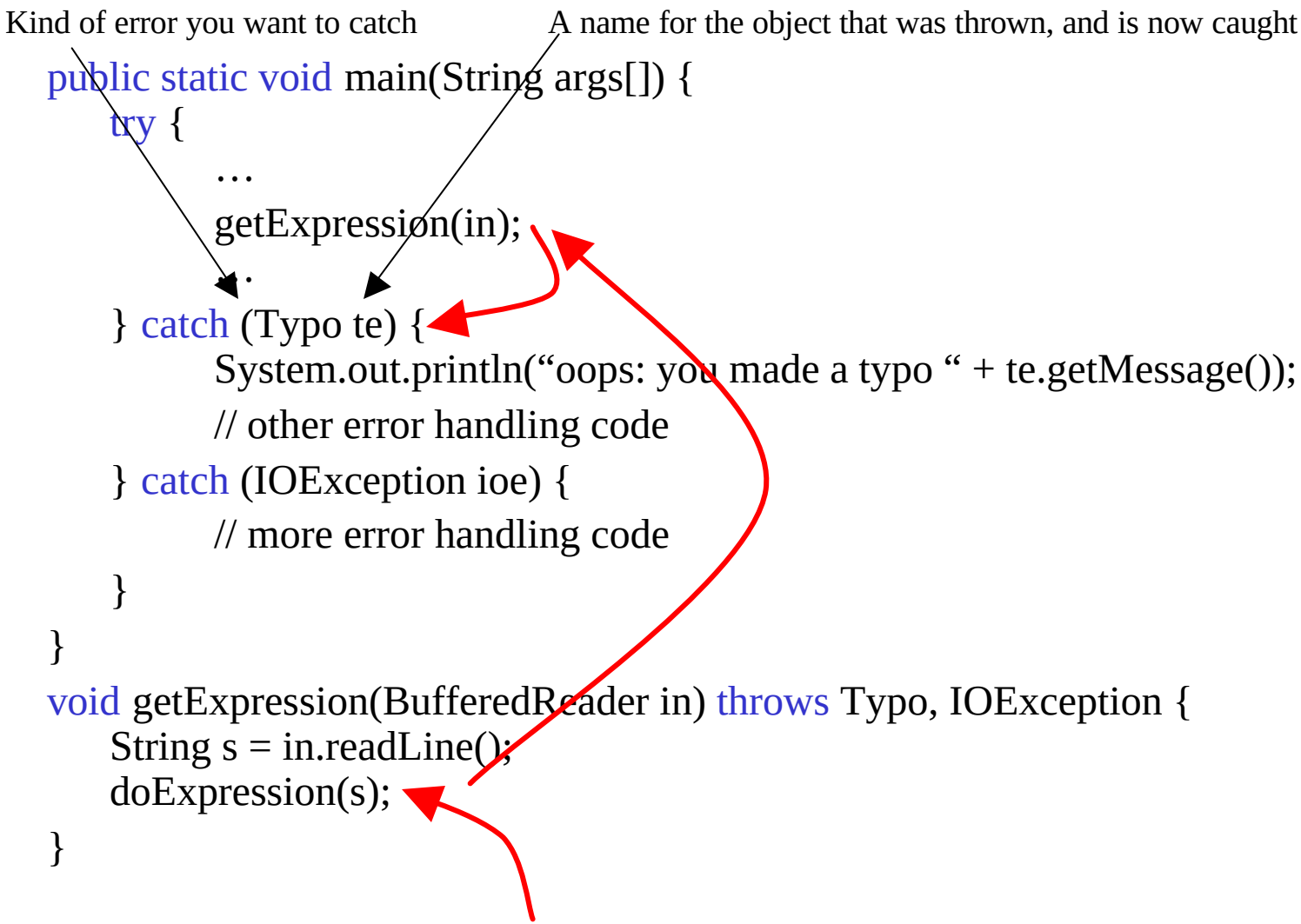
Propagating an Exception

- The exception (e.g., Throwable object) passes up the call chain, aborting every method it encounters…



Catching an Exception

- Until it lands inside a try-catch block that specifies the correct type of exception



Control Flow

```
…start…
try { … body … }
catch (Typo e) {  … catch-clause… }
…end…
```

- Normal execution (no exceptions thrown):
  start → body → ----- → end // no errors
- Exception Typo thrown
  start → part of body → catch-clause → end
- Exception other than Typo thrown
  start → part of body → ---- → ---- →abort!

Finally Clause

- Often want to execute certain code *no matter what*
  - e.g., close a file, with or without an exception happening

```
…start…
try { … body … }
catch (Typo e) {  … catch-clause… }
finally { … final-clause…}
…end…
```

- Rule: if body begins, then finally-clause will run
  - if no exceptions, runs after body
  - if exception is thrown and caught, right after catch-clause
  - if exception thrown and not caught, runs before propagating the exception up the call chain

Checked vs Unchecked

- Most exception types are checked. If a method body might generate a checked exception, it must either:
  - Have a try-catch block for that exception type
  - Declare the exception type in a throws declaration
- Some exception types are unchecked. These you do not need to catch (unless you want to) or declare.
- Why the distinction?
  - Could happen at any time: e.g. OutOfMemoryError
  - Nearly any line of code could generate one: e.g., NullPointerException
  - Nothing you could do about it anyway: e.g. InternalError