Exceptions
Ch 6

Topics

1) How can we handle exceptions?
2) How are exceptions organized?
3) Some convenient ways to work with exceptions.

Exceptions

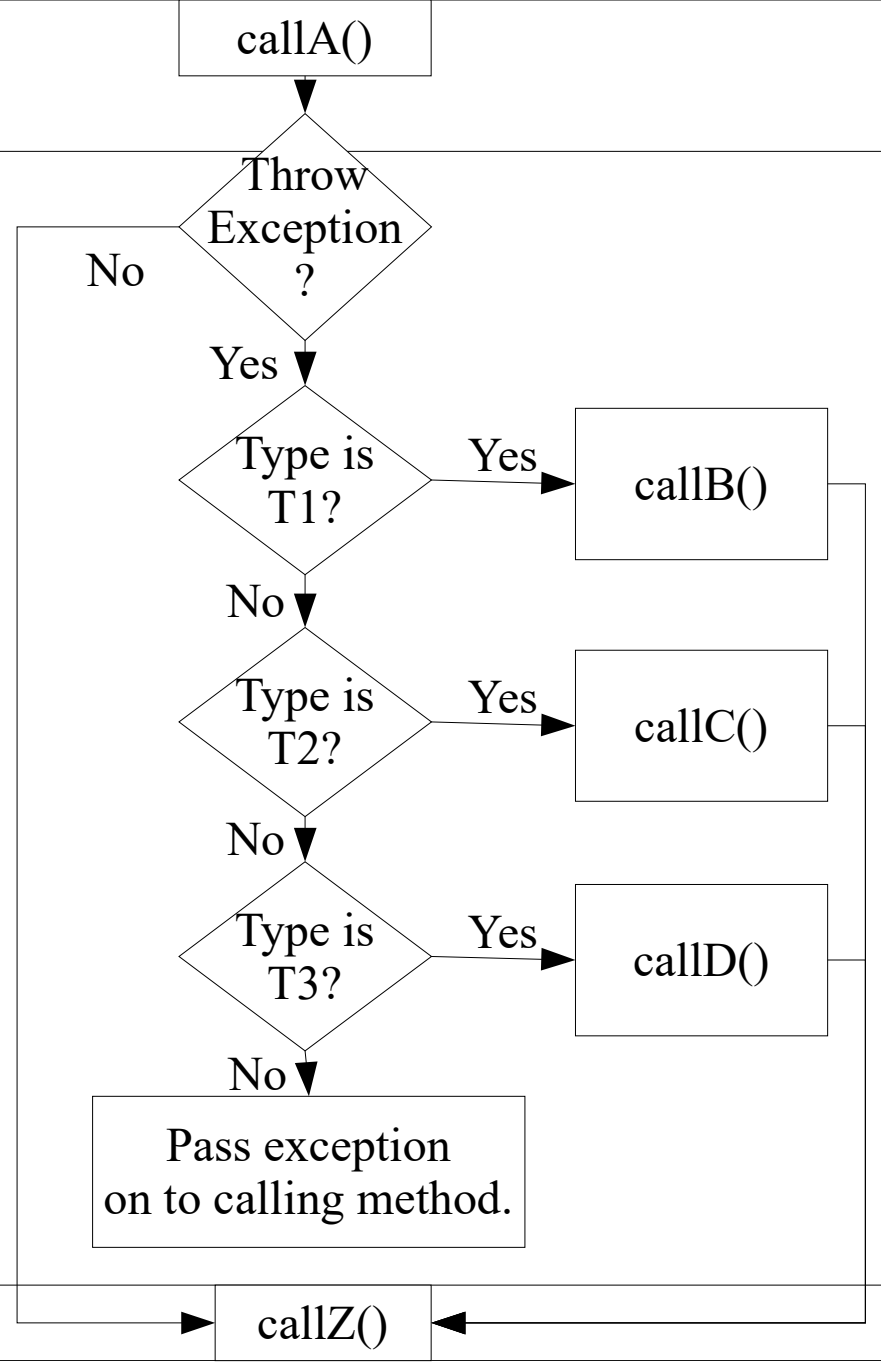
- Try-block: Code to check for an exception.
- Catch-block: Handle possible exceptions.
  - Check if thrown exception matches or is..

```
public static void main(String[] args) {
	String input = "123xxx";
	try {
		int num = Integer.parseInt(input);
		System.out.println("That's the number "+num);
	} catch (NumberFormatException e) {
		System.out.println("Bad input.");
	}
}
```

Try-Catch Flow

```
private void foo() {
    try {
        // May throw exceptions
        callA();
    } catch (T1 exception) {
        callB();
    } catch (T2 exception) {
        callC();
    } catch (T3 exception) {
        callD();
    }

    // Some more code
    callZ();
}
```

these try catch blocks are mutually exclusive
-> only call 1 of them



Try-Catch Example

```
void tryCatch() {
    double[] data = new double[]{};

    try {
        double avg = average(data);
        System.out.println("Average value: " + avg);
  2 } catch (IllegalArgumentException ex) {
        System.out.println("Unable to compute: " + ex.getMessage());
    }
}


double average(double[] data) {
    if (data.length == 0) {
     1  throw new IllegalArgumentException("Array must not be empty.");
    }
    double sum = 0;
    for (double val : data) {
        sum += val;
    }
    return sum / data.length;
}
```

this tryCatch is called call block

if there wasn't average -> throw another exception

if remove this guard block if here,
average of an empty array would be infinity

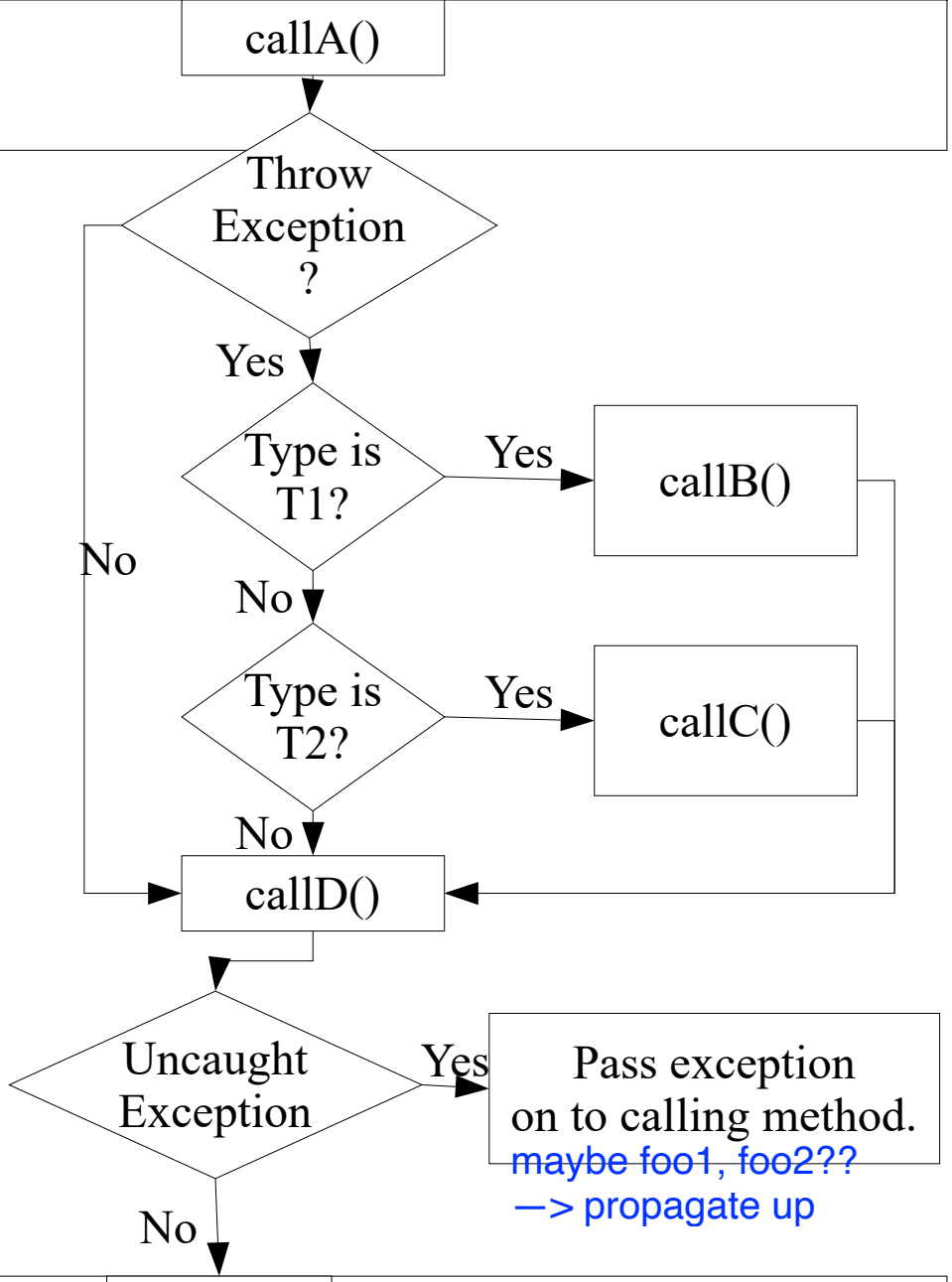
The finally Clause

- Finally clause..executed no matter what
  - Optional clause after all the catch clauses.
- Execution Possibilities
  - No exception:
    finally block executed..after all statements in try block
  - Exception in try is un-caught:
    finally block executed..immediately after
    the statement which threw the exception.
  - Exception in try is caught:
    finally block executed..after the catch block
    which catches that exception type.
- Often used for clean-up code (close file).

acts as a destructor like in c++ (bcuz java doesn't have destructor)
ex: inside finally block, close the file after reading it, close a socket, unlock a mutex, etc

Try-Catch Flow

```
private void foo() {
    try {
        // May throw exceptions
        callA();
    } catch (T1 exception) {
        callB();
    } catch (T2 exception) {
        callC();
    } finally {
        callD();
    }
    // Other code to do after:
    callZ();
}
```



in the previous chart: uncaught exception bails out immediately
in this chart: uncaught exception will execute the code anyway, guarantee the clean up
???????????

note: all roads lead to callD()

Try-Finally Example

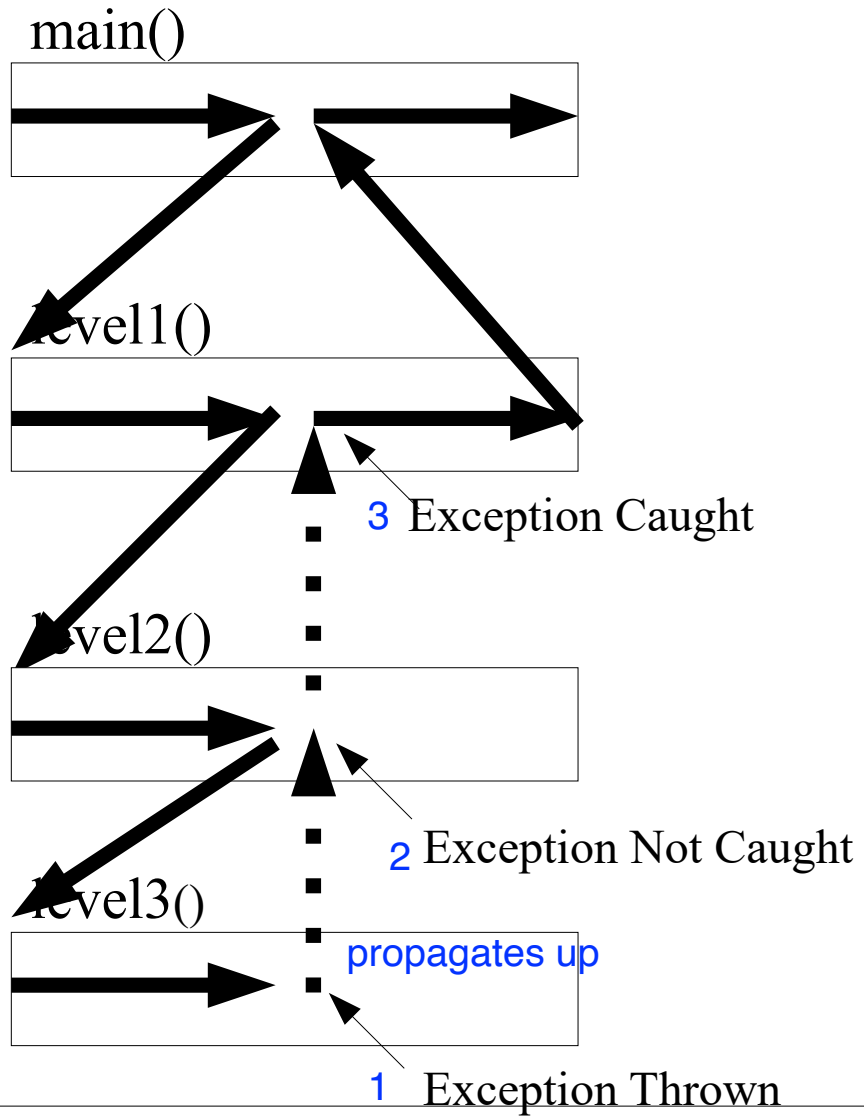
```
void tryFinally() throws IOException {
    double[] data = new double[]{};

    FileWriter fw = null;
    try {
        fw = new FileWriter("someData.txt");

        double avg = average(data);
        fw.write("Average value: " + avg);
    } finally {
        // Close the file, no matter what.
        fw.write("Encountered error... closing output file!");
        fw.close();
    }
}
double average(double[] data) {
    if (data.length == 0) {
        throw new IllegalArgumentException("List must not be empty.");
    }

    // .... return ....
}
```

Exception Propagation

- Uncaught exception:
  execution immediately.. returns to the calling method
  (after finally).
  - Propagates up until a method catches exception.
  - If main() does not handle it, the program is terminated.
- Exception handling is a design decision.
  - Could.. handle exception when it happens
  - Could have one of the calling methods handle it.
  - Could even let it terminate the program.
- Example:
  - Allow exception in database code.. to propagate up to UI
    to catch and display meaningful error.

Execution Flow

```
public class HappyCode {
    public static void main(String[] args) {
        level1();
    }
    static void level1() {
        try {
            level2();
        } catch (ArithmeticException e) {
            e.printStackTrace();
        }
    }
    static void level2() {
        level3();
    }
    static void level3() {
        int a = 1 / 0;
    }
}
```



Re-throwing Example

```
void tryRethrow() {
    double[] grades = new double[]{};
    double avg = getAverageGrade(grades);
    System.out.println("Average grade: " + avg);
}

private double getAverageGrade(double[] grades) {
    try {
        return average(grades);
    } catch (IllegalArgumentException ex) {
        // Wrap the exception is another exception
        throw new IllegalStateException("No grades entered", ex);
    }
}


double average(double[] data) {
    if (data.length == 0) {
        throw new IllegalArgumentException("List must not be empty.");
    }

    // .... return ....
}
```

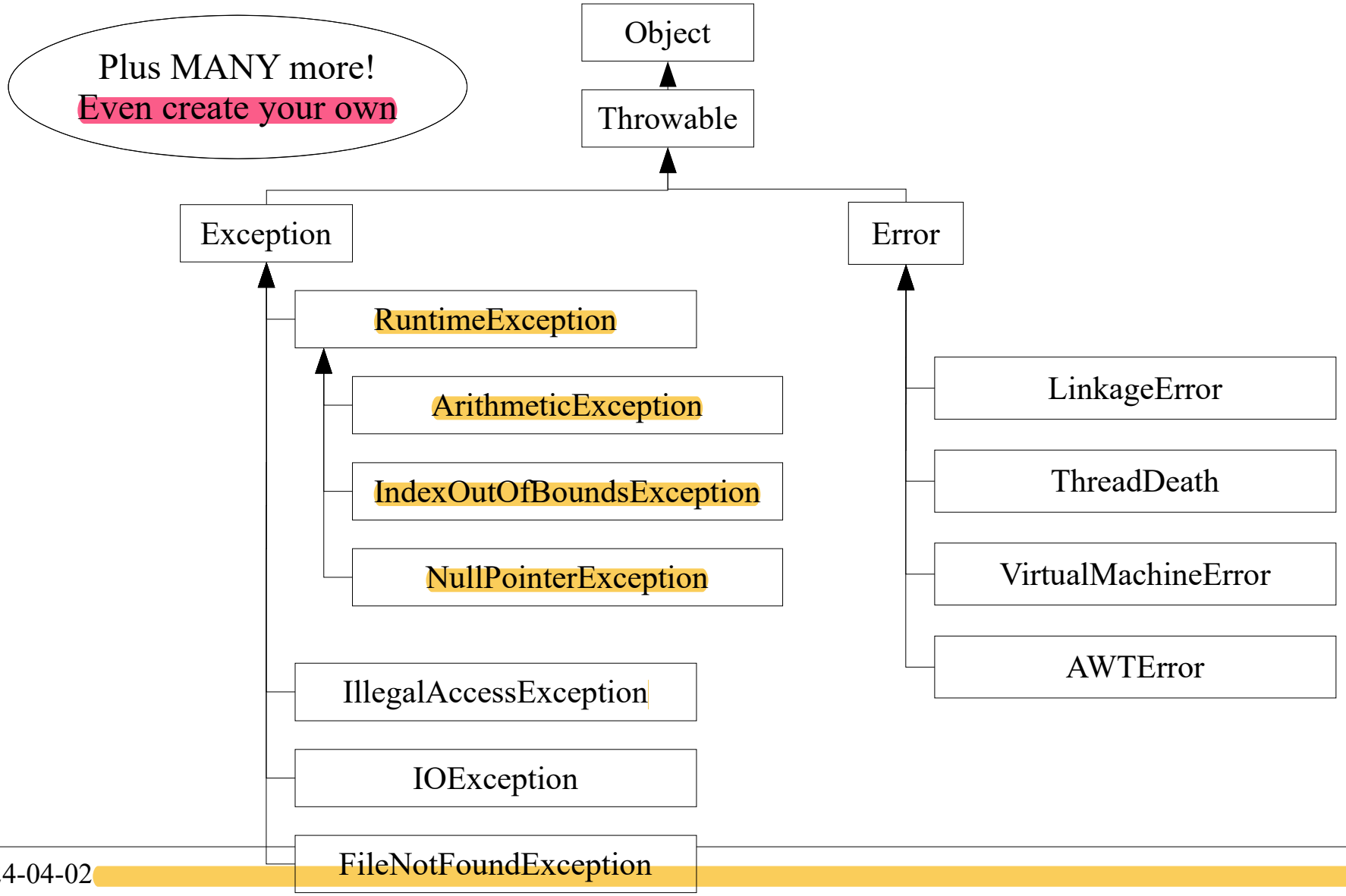
Exception Class Hierarchy

Exception Class Hierarchy

- All exceptions inherit from..Exception class
  - Many high-level exceptions in java.lang package.
  - Custom exceptions inherit from these high-level classes.
- Some methods in Exception
  - String getMessage()
    Returns a string which describes the exception.
  - void printStackTrace()
    Prints the stack trace to System.err (error).
  - void printStackTrace(PrintStream s)
    Prints the stack trace to the given PrintStream s.

never do a silent catch (a catch block that does nothing) —> dangerous!!

Error & Exception Hierarchy (part)



runtime exceptions (yellow colored): all are unchecked exceptions

checked exceptions: have to announce to be thrown
unchecked exceptions: can be quietly thrown

Checked vs Unchecked Exceptions

- Checked Exceptions
  - Must be either... caught by method
    or must be... listed in method's throws clause
  - This acknowledges that an exception can be thrown.

```
int foo() throws FileNotFoundException {
      ...
}
```

- Unchecked Exceptions
  - need not be caught or listed in throws clause.
  - RuntimeException or its derived classes are *unchecked*
    All other exceptions are *checked.*

Checked vs Unchecked

- Check vs unchecked exceptions
  - Unchecked make for cleaner..

```
public class DemoCheckedExceptions {
    void top() throws FileNotFoundException {
        foo1();
    }
    void foo1() throws FileNotFoundException {
        foo2();
    }
    void foo2() throws FileNotFoundException {
        throw new FileNotFoundException();
    }
}
```

the left here: explicit

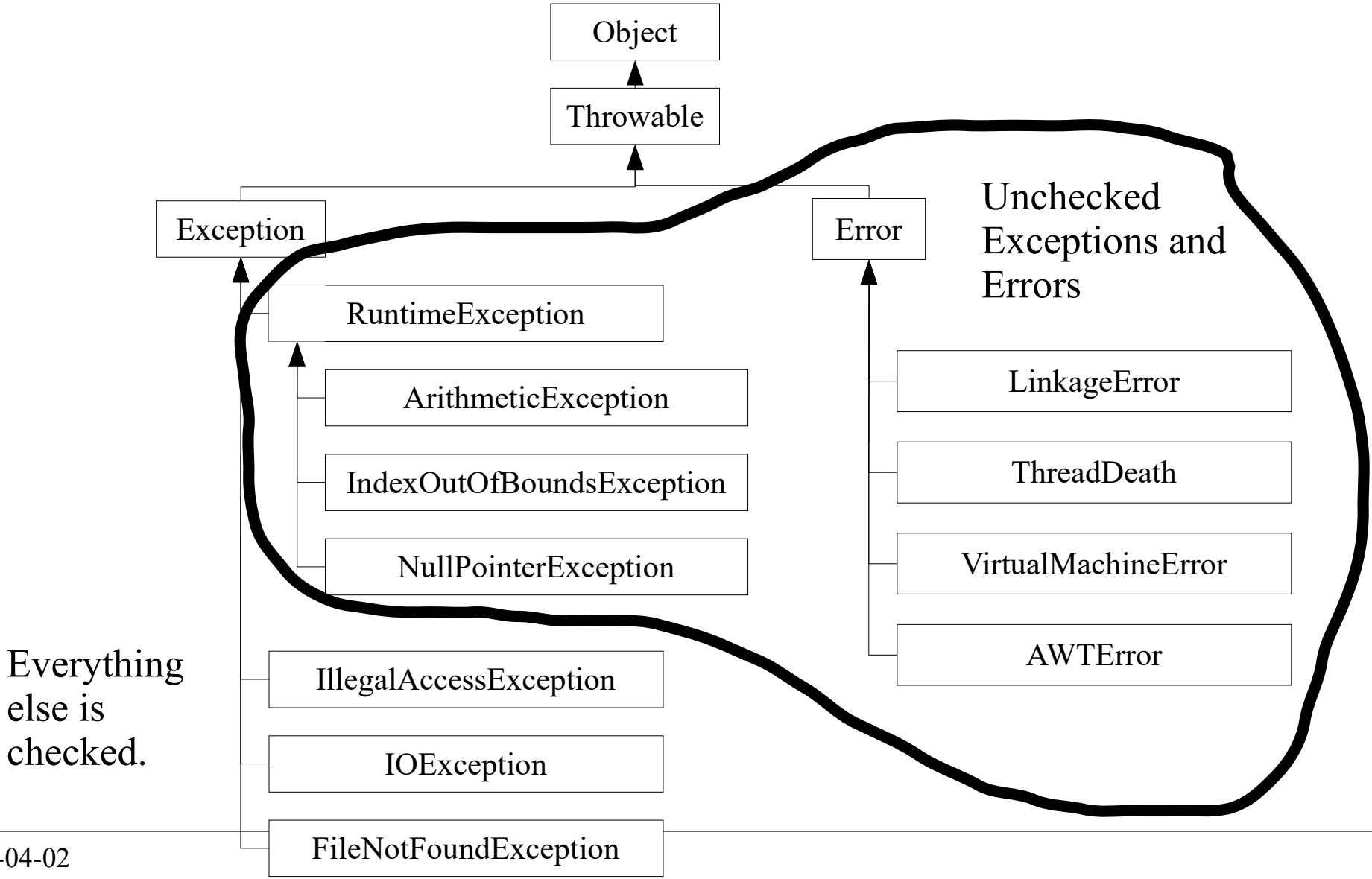
decoupled code

```
public class DemoUncheckedException
    void top(String[] args) {
        foo1();
    }
    void foo1() {
        foo2();
    }
    void foo2() {
        throw new
            NullPointerException();
    }
}
```

the right here: decoupled

- Prefer unchecked exceptions
  Can change which exceptions are thrown without
  changing all methods between throw and catch

Error & Exception Hierarchy (part)



Custom Exceptions

- Create your own exceptions by..inheriting from any existing exception

- A new exception class allows code to specifically catch the errors your code sends.

```
/**
 *    Indicates that no file was selected.
 */
public class NoFileSelected extends RuntimeException {
      public NoFileSelected() {
            super ();
      }
      public NoFileSelected(String message) {
            super (message);
      }
}
```

..Message explains cause or meaning of error (Optional)

throw

- You can explicitly throw an exception object:

```
String getFile() {
    if (fileName == null) {
        throw new NoFileSelected("File not selected.");
    }
    return fileName;
}
```

- As a designer, you choose.. how to handle failure:
  - throw an exception?
  - return a "failure" status (such as false or -1)?
  - try to correct the data (error recovery)

Clean Exceptions

- Exception handling can really complicate code.
- Suggestion:.. split method foo() into:
  - fooThrows(): does the work, but no exception handling.
  - foo(): call's fooThrows() then does exception handling.

Original Code

```
void foo() {
	try {
		// do something complicated
		// which throws exception
		for(...) {
			if (...)
				throw new DaUhOh();
		}
	} catch (SomeException e) {
		showUser("Oops...");
	}
}
```

Refactored Code

```
void foo() {
	try {
		fooThrows();
	} catch (DaUhOh e) {
		showUser("Oops...");
	}
}
void forThrows() throws DaUhOh {
	for(...) {
		if (...)
			throw new DaUhOh();
	}
}
```

Java 7's *Exceptional* Enhancements

Resources

- Some resources must be freed:
  - Ex: Scanner's close() must be called to avoid a resource leak.
  - Can use. try-finally

    to always close resource.

```
/**
 * Read a number form a file with
 * standard try-finally
 */
public static void readNum(String fileName)
    throws FileNotFoundException
{
    Scanner scanner = null;
    File file = new File(fileName);

    try {
        scanner = new Scanner(file);
        if (scanner.hasNextInt()) {
            int num = scanner.nextInt();
            System.out.println("# " + num);
        }
    } finally {
        if (scanner != null) {
            scanner.close();
        }
    }
}
```

Try-With-Resources

- Try-with-resources
  - automatically closes resource after try block
  - Can declare scanner *inside* the try ( )
  - Significantly cleans up code!

```
/**
 * Read a number from a file using
 * try-with-resources.
 */
public static void readNum(String fileName)
        throws FileNotFoundException
{
    File file = new File(fileName);

    try (Scanner scanner = new Scanner(file)){

        if (scanner.hasNextInt()) {
            int num = scanner.nextInt();
            System.out.println("# " + num);
        }
    }
}
```

- Works for objects implementing AutoClosable or Closable Interfaces.

Summary

- try-catch-finally & exception propagation.
- Checked vs unchecked exceptions
- exception inheritance hierarchy & own exceptions.
- clean exception code: unchecked & tryThrows()
- try-with-resources to close files/scanners