Exceptions and file I/O

```
Exception in thread "main" java.lang.NumberFormatException: For input string: "3.5"
        at java.lang.NumberFormatException.forInputString(NumberFormatException.java:48)
        at java.lang.Integer.parseInt(Integer.java:458)
        at java.lang.Integer.parseInt(Integer.java:499)
        at AddNums.main(AddNums.java:8)
```

Overview

- Exceptions
  - Handling unexpected events
    - e.g. File is missing
    - e.g. Trying to parse "$56.89" as a double
- File input/output
  - Output to a text file
  - Input from a text file
    - Parsing the input using a Scanner
  - Frees us from the limits of standard input
    - Read from multiple files, read data twice, etc.

Adding two numbers

- Goal: Defend against all types of bad input
  - Crashes if less than 2 arguments

```
public class AddNums
{
   public static void main(String [] args)
   {
      int num1 = Integer.parseInt(args[0]);
      int num2 = Integer.parseInt(args[1]);
      int sum  = num1 + num2;
      System.out.println(num1 + " + " + num2 + " = " + sum);
   }
}
```

```
% java AddNums
Exception in thread "main"
java.lang.ArrayIndexOutOfBoundsException: 0
          at AddNums.main(AddNums.java:5)
```

Adding two numbers

- Goal: Defend against all types of bad input
  - Take care and stay in bounds in array
  - Crashes if passed a non-integer argument

```
public class AddNums
{
   public static void main(String [] args)
   {
      if (args.length < 2)
      {
          System.out.println("AddNums <integer 1> <integer 2>");
          return;
      }
      int num1 = Integer.parseInt(args[0]);
      int num2 = Integer.parseInt(args[1]);
      int sum  = num1 + num2;
      System.out.println(num1 + " + " + num2 + " = " + sum);
   }
```

```
% java AddNums 2 3.5
Exception in thread "main" java.lang.NumberFormatException: For input string: "3.5"
        at java.lang.NumberFormatException.forInputString(NumberFormatException.java:48)
        at java.lang.Integer.parseInt(Integer.java:458)
        at java.lang.Integer.parseInt(Integer.java:499)
        at AddNums.main(AddNums.java:8)
```

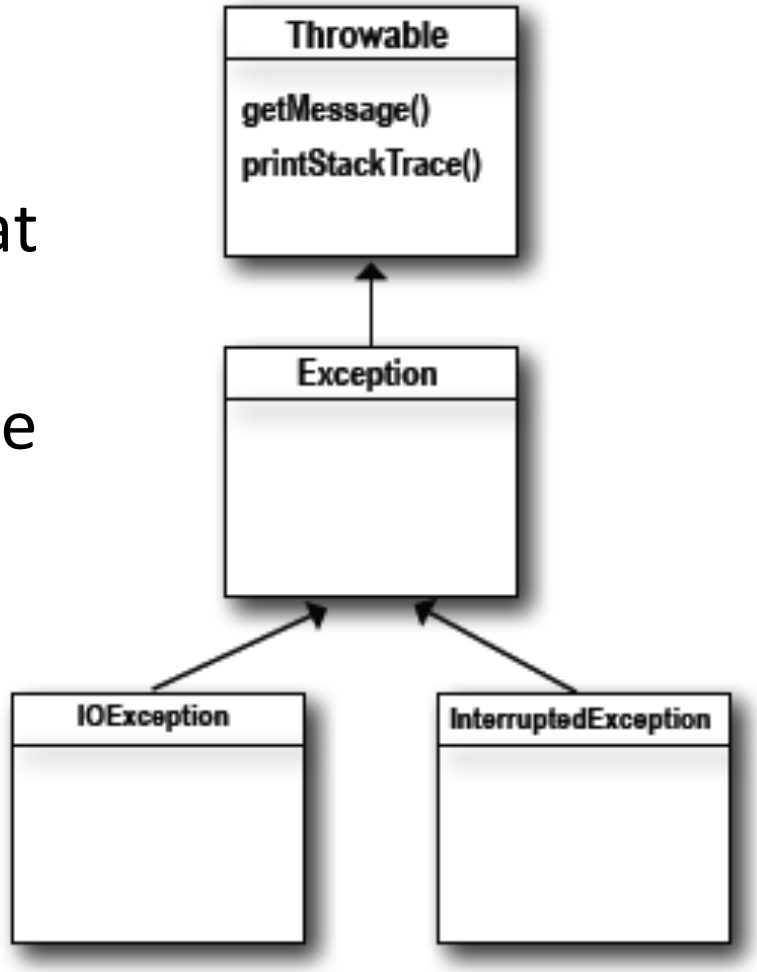
Adding two numbers

- How to check for invalid inputs to parseInt()?
  - e.g. 1.0, 192.168.1.4, $1, 123., one

```
public class AddNums
{
   public static void main(String [] args)
   {
      if (args.length < 2)
      {
          System.out.println("AddNums <integer 1> <integer 2>");
          return;
      }
      int num1 = Integer.parseInt(args[0]);
      int num2 = Integer.parseInt(args[1]);
      int sum  = num1 + num2;
      System.out.println(num1 + " + " + num2 + " = " + sum);
   }
}
```

Java exceptions

- When things go wrong:
  - Java "throws" an exception
  - An exception is an object that can be caught
  - Programmer can decide if the program can recover or not
    - Rather than crashing with a runtime error



try-catch block

```
try
{
    // Do some risky things

    // Do some more risk things
}
catch (Exception ex)
{
    // Try and recover from the problem
}
```

If something goes horribly wrong on a line in the `try` block, flow of control immediately jumps to the `catch` block.

Details about the exception are passed as an object into the catch block.

Like a parameter list of a method, `ex` is just a name for the `Exception` object in the `catch` block.

The mother of all exception types.

All other types of exceptions inherit from this parent class.

Add code to catch all exceptions

```
public class AddNums
{
   public static void main(String [] args)
   {
      try
      {
         int num1 = Integer.parseInt(args[0]);
         int num2 = Integer.parseInt(args[1]);
         int sum  = num1 + num2;
         System.out.println(num1 + " + " + num2 + " = " + sum);
      }
      catch (Exception ex)
      {
         System.out.println("Something went wrong!");
      }
      System.out.println("End of program");
   }
}
```

```
% java AddNums
Something went wrong!
End of program
```

```
% java AddNums 2 3.5
Something went wrong!
End of program
```

Not an ideal solution:

How is the user suppose to know what to do differently?

A better solution

```
public static void main(String [] args)
{
    if (args.length < 2)
    {
        System.out.println("AddNums <integer 1> <integer 2>");
        return;
    }
    int num1, num2;
    try
    {
        num1 = Integer.parseInt(args[0]);
    }
    catch (NumberFormatException ex)
    {
        System.out.println("1st argument invalid: " + args[0]);
        return;
    }
    try
    {
        num2 = Integer.parseInt(args[1]);
    }
    catch (NumberFormatException ex)
    {
        System.out.println("2nd argument invalid: " + args[1]);
        return;
    }
    int sum  = num1 + num2;
    System.out.println(num1 + " + " + num2 + " = " + sum);
}
```

Principle 1:
Don't catch stuff you can handle with appropriate program logic (such as staying in bounds in an array).

Normal {} scoping rules apply inside a try-block, so often you'll need to declare variables outside if you need them after the try-block.

Principle 2:
Don't use generic Exception class. Catch the specific type of exception you had in mind.

Writing to a text file

- Java has many built in file I/O classes
  - PrintWriter, class that allows writing text to a file

Constructor Summary

PrintWriter(File file) Creates a new PrintWriter, without automatic line flushing, with the specified file.
PrintWriter(File file, String csn) Creates a new PrintWriter, without automatic line flushing, with the specified file and char
PrintWriter(OutputStream out) Creates a new PrintWriter, without automatic line flushing, from an existing OutputStream
PrintWriter(OutputStream out, boolean autoFlush) Creates a new PrintWriter from an existing OutputStream.
PrintWriter(String fileName) Creates a new PrintWriter, without automatic line flushing, with the specified file name.
PrintWriter(String fileName, String csn) Creates a new PrintWriter, without automatic line flushing, with the specified file name an
PrintWriter(Writer out) Creates a new PrintWriter, without automatic line flushing.
PrintWriter(Writer out, boolean autoFlush) Creates a new PrintWriter.

Method Summary

PrintWriter	append(char c) Appends the specified character to this writer.
PrintWriter	append(CharSequence csq) Appends the specified character sequence to this writer.
PrintWriter	append(CharSequence csq, int start, int end) Appends a subsequence of the specified character sequence to this writer
void	print(double d) Prints a double-precision floating-point number.
void	print(float f) Prints a floating-point number.
void	print(int i) Prints an integer.
void	print(long l) Prints a long integer.
void	print(Object obj) Prints an object.
void	print(String s) Prints a string.
PrintWriter	printf(Locale l, String format, Object... args) A convenience method to write a formatted string to this writer using the specified for
PrintWriter	printf(String format, Object... args) A convenience method to write a formatted string to this writer using the specified for
void	println() Terminates the current line by writing the line separator string.
void	println(boolean x) Prints a boolean value and then terminates the line.
void	println(char x) Prints a character and then terminates the line.
void	println(char[] x) Prints an array of characters and then terminates the line.
void	println(double x) Prints a double-precision floating-point number and then terminates the line.

Perfect square writer

- Goal: Write perfect squares 0^2 – 999^2 to a file

```
import java.io.*;

public class PerfectSquareWriter
{
   public static void main(String [] args)
   {
       PrintWriter writer = new PrintWriter("squares.txt");
       for (int i = 0; i < 1000; i++)
          writer.println(i * i);
       writer.close();
   }
}
```

So Java can find the `PrintWriter` class.

`PrintWriter` constructor takes a string specifying the filename to write to.

```
% javac PerfectSquareWriter.java
PerfectSquareWriter.java:8: unreported exception
java.io.FileNotFoundException;
must be caught or declared to be thrown
       PrintWriter writer = new PrintWriter("squares.txt");
                            ^
1 error
```

Perfect square writer

- Lesson: Some risky behaviors require try-catch

```
import java.io.*;

public class PerfectSquareWriter
{
   public static void main(String [] args)
   {
      try
      {
         PrintWriter writer = new PrintWriter("squares.txt");
         for (int i = 0; i < 1000; i++)
            writer.println(i * i);
         writer.close();
      }
      catch (FileNotFoundException ex)
      {
          System.out.println("Failed to open file!");
      }
   }
}
```

This line had to be in a try-catch block catching a `FileNotFoundException` (or a parent thereof).

Not required, but good style to cleanup after you are done with a file.

```
% more squares.txt
0
1
4
9
16
...
```

Reading a text file

- Need two Java classes:
  - File class, represents a filename
    - System independent abstraction of a file's path
    - Not actually used for reading or writing
  - Scanner class, parses out values
    - Very similar to StdIn.read* methods

Handy methods: File class

Method	Description
`boolean canRead()`	Test if the program can read from the file.
`boolean canWrite()`	Test if the program can write to the file.
`boolean delete()`	Attempt to delete the file.
`boolean exists()`	See if the given file exists.
`long length()`	Get length of the file in bytes
`String getName()`	Returns the filename portion of the path
`String getPath()`	Returns the path without the filename
`boolean mkdir()`	Creates a directory specified by the path

```
File file = new File("c:\\workspace\\nums.txt");
System.out.println(file.getName());
System.out.println(file.getPath());
```

Windows paths need escaping of the backslash character by using two of them.

```
nums.txt
c:\workspace\nums.txt
```

Handy methods: Scanner class

Method	Description
`String next()`	Returns the next string, separated via whitespace
`String nextLine()`	Returns the entire line up to the next line break
`int nextInt()`	Returns the next integer
`double nextDouble()`	Returns the next double
`boolean hasNext()`	Are there any more tokens available?
`boolean hasNextLine()`	Is there another line available?
`boolean hasNextInt()`	Can the next token be interpreted as an int?
`boolean hasNextDouble()`	Can the next token be interpreted as a double?
`void close()`	Free up resources

Averaging numbers

```
public class AvgNums
{
   public static void main(String [
   {
      double sum = 0.0;
      long count = 0;
      while (!StdIn.isEmpty())
      {
         sum += StdIn.readDouble();
         count++;
      }
      System.out.println(sum / count
   }
}
```

Original program, reads numbers from standard input.

```
% java AvgNums < nums.txt
8.614076923076924
```

```
public class AvgNumsFile
{
   public static void main(String [] args)
   {
      double sum = 0.0;
      long count = 0;
      if (args.length < 1)
      {
         System.out.println("AvgNumsFile <filename>");
         return;
      }
      try
      {
         Scanner scanner = new Scanner(new File(args[0]));
         while (scanner.hasNext())
         {
            sum += scanner.nextDouble();
            count++;
         }
         scanner.close();
         System.out.println(sum / count);
      }
      catch (FileNotFoundException ex)
      {
            System.out.println("Failed to open file!");
      }
   }
}
```

```
% java AvgNumsFile nums.txt
8.614076923076924
```

New program, read from filename given by args[0].

Trying to break it

```
public class AvgNumsFile
{
   public static void main(String [] args)
   {
      double sum = 0.0;
      long count = 0;
      if (args.length < 1)
      {
          System.out.println("Av
          return;
      }
      try
      {
         Scanner scanner = new Scanner(new File(args[0]));
         while (scanner.hasNext())
         {
            sum += scanner.nextDouble();
            count++;
         }
         scanner.close();
         System.out.println(sum / count);
      }
      catch (FileNotFoundException ex)
      {
            System.out.println("Failed to open file!");
      }
   }
}
```

```
% java AvgNumsFile noexist.txt
Failed to open file!
```

```
% java AvgNumsFile mobydick.txt
Exception in thread "main"
java.util.InputMismatchException
        at java.util.Scanner.throwFor(Scanner.java:840)
        at java.util.Scanner.next(Scanner.java:1461)
        at java.util.Scanner.nextDouble(Scanner.java:2387)
        at AvgNumsFile.main(AvgNumsFile.java:21)
```

Multiple catch blocks

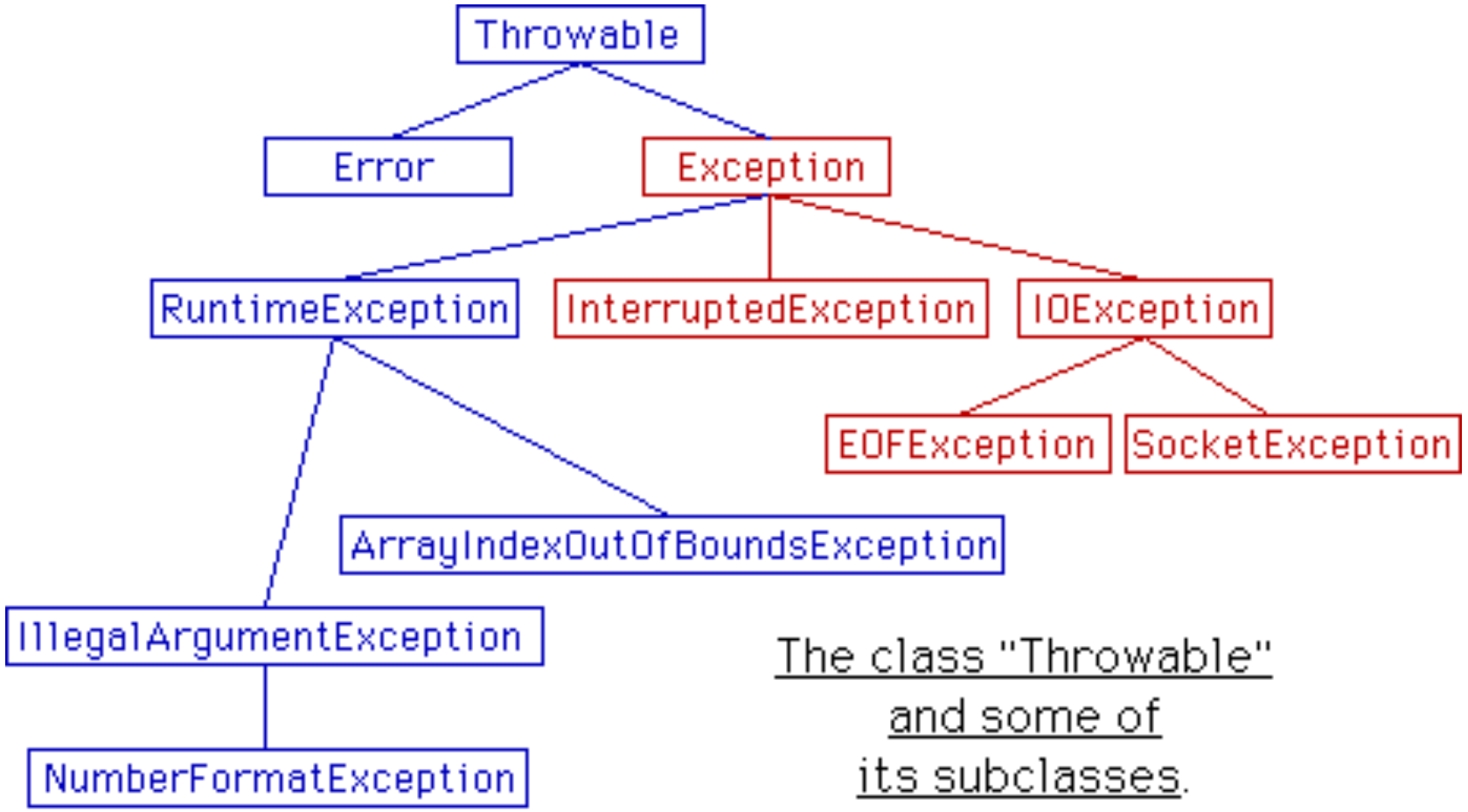
```
...
double sum = 0.0;
long count = 0;
if (args.length < 1)
{
    System.out.println("AvgNumsFile <filename>");
    return;
}
try
{
   Scanner scanner = new Scanner(new File(args[0]));
   while (scanner.hasNext())
   {
      sum += scanner.nextDouble();
      count++;
   }
   scanner.close();
   System.out.println(sum / count);
}
catch (FileNotFoundException ex)
{
   System.out.println("Failed to open file!");
}
catch (InputMismatchException ex)
{
   System.out.println("Invalid data in file!");
}
...
```

```
% java AvgNumsFile mobydick.txt
Invalid data in file!
```

Throwing exceptions

- How do exceptions start their life?
  - Some method "throws" them
  - Whoever is using the method has to catch
  - Or else that method can throw it
  - What if nobody catches it?
    - Checked exceptions
      - Causes compile error, exceptions that must be caught
      - Methods marked with a "throw" clause
    - Unchecked exceptions
      - Causes runtime error, exceptions where catching is optional
      - Usually a programming error
      - e.g. ArrayIndexOutOfBoundsException, NullPointerException

Java exception class hierarchy



http://www.faqs.org/docs/javap/c9/s3.html

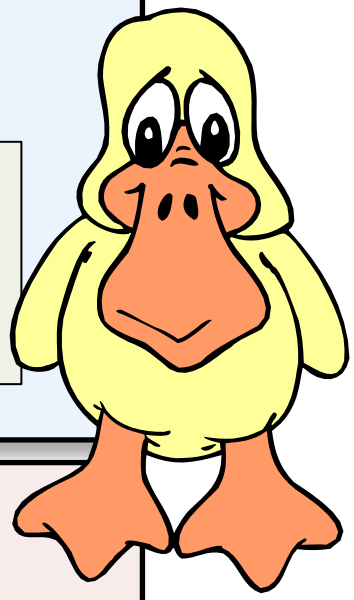
Ducking an exception

```
public static double getFileAvg(String filename) throws FileNotFoundException
{
    double sum = 0.0;
    long count = 0;

    Scanner scanner = new Scanner(new File(filename));
    while (scanner.hasNext())
    {
       sum += scanner.nextDouble();
       count++;
    }
    scanner.close();
    return (sum / count);
}
```

Not our problem anymore, whoever calls getFileAvg() has to catch now.

Methods can throw 0 or more exception types.



```
public static void main(String [] args)
{
   if (args.length < 1)
   {
      System.out.println("AvgNumsFile <filename>");
      return;
   }
   System.out.println(getFileAvg(args[0]));
}
```

```
% javac AvgNumsFile.java
AvgNumsFile.java:26: unreported exception java.io.FileNotFoundException; must be
 caught or declared to be thrown
      double avg = getFileAvg(args[0]);
                               ^
1 error
```

Finally, the finally block

- Finally block executes no matter what
  - If no exception, runs after try-block
  - If exception occurs, runs after catch-block
  - Useful for doing cleanup that is always needed

```
try
{
    turnOverOn();
    x.bake();
}
catch (BakingException ex)
{
    ex.printStackTrace();
}
finally
{
    turnOverOff();
}
```

Prints out the stack trace (like what you see when you get a runtime error). Handy for debugging what line in the try-block is causing the trouble.

Summary

- Exceptions
  - An important part of writing defensive code
  - Many of Java classes require handling exceptions
    - e.g. File I/O, network communication, playing sounds, using threads
  - Checked versus unchecked exceptions
- File I/O
  - Text file input/output
  - PrintWriter class, writing text to file
  - Scanner and File classes, reading and parsing text