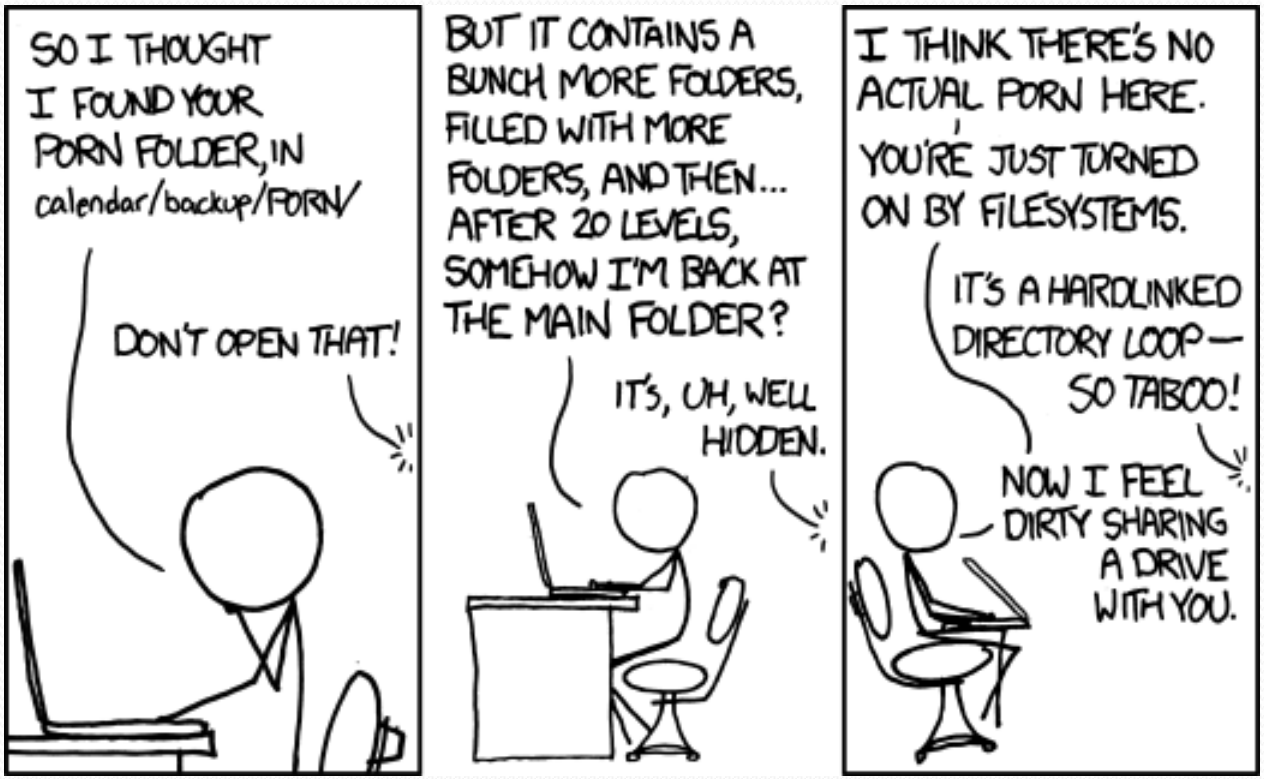
Building Java Programs

Chapter 6

Lecture 14: File Input with `Scanner`

reading: 6.1 – 6.2, 5.4

(Slides adapted from Stuart Reges, Hélène Martin, and Marty Stepp)



Input/output (I/O)

```
import java.io.*;
```

- Create a `File` object to get info about a file on your drive.
  - (This doesn't actually create a new file on the hard disk.)

```
File f = new File("example.txt");
if (f.exists() && f.length() > 9000) {
    f.delete();
}
```

Method name	Description
`canRead()`	returns whether file is able to be read
`delete()`	removes file from disk
`exists()`	whether this file exists on disk
`getName()`	returns file's name
`length()`	returns number of bytes in file
`renameTo(`*file*`)`	changes name of file

Reading files

- To read a file, pass a `File` when constructing a `Scanner`.

```
Scanner name = new Scanner(new File("file name"));
```

  - Example:

```
File file = new File("mydata.txt");
Scanner input = new Scanner(file);
```

  - or (shorter):

```
Scanner input = new Scanner(new File("mydata.txt"));
```

Compiler error w/ files

```
import java.io.*;      // for File
import java.util.*;    // for Scanner

public class ReadFile {
    public static void main(String[] args) {
        Scanner input = new Scanner(new File("data.txt"));
        String text = input.next();
        System.out.println(text);
    }
}
```

- The program fails to compile with the following error:

```
ReadFile.java:6: unreported exception java.io.FileNotFoundException;
must be caught or declared to be thrown
        Scanner input = new Scanner(new File("data.txt"));
                        ^
```

Exceptions

- **exception**: An object representing a runtime error.
  - dividing an integer by 0
  - calling `substring` on a `String` and passing too large an index
  - trying to read the wrong type of value from a `Scanner`
  - trying to read a file that does not exist
  - We say that a program with an error "*throws*" an exception.
  - It is also possible to "*catch*" (handle or fix) an exception.

- **checked exception**: An error that must be handled by our program (otherwise it will not compile).
  - We must specify how our program will handle file I/O failures.

The `throws` clause

- **`throws` clause**: Keywords on a method's header that state that it may generate an exception (and will not handle it).

- Syntax:

```
public static type name(params) throws type {
```

  - Example:

```
public class ReadFile {
    public static void main(String[] args)
            throws FileNotFoundException {
```

  - Like saying, *"I hereby announce that this method might throw an exception, and I accept the consequences if this happens."*

File paths

- **absolute path**: specifies a drive or a top `"/"` folder

  `C:/Documents/smith/hw6/input/data.csv`

  - Windows can also use backslashes to separate folders.

- **relative path**: does not specify any top-level folder

  `names.dat`
  `input/kinglear.txt`

  - Assumed to be relative to the *current directory*:

    ```
    Scanner input = new Scanner(new File("data/readme.txt"));
    ```

    If our program is in `H:/hw6`,
    `Scanner` will look for `H:/hw6/data/readme.txt`

Input tokens

- **token**: A unit of user input, separated by whitespace.
  - A `Scanner` splits a file's contents into tokens.

- If an input file contains the following:

```
23   3.14
  "John Smith"
```

The `Scanner` can interpret the tokens as the following types:

Token	Type(s)
`23`	`int`, `double`, `String`
`3.14`	`double`, `String`
`"John`	`String`
`Smith"`	`String`

Files and input cursor

- Consider a file `weather.txt` that contains this text:

```
16.2   23.5
   19.1 7.4  22.8

18.5  -1.8 14.9

```

- A `Scanner` views all input as a stream of characters:

```
16.2   23.5\n   19.1 7.4  22.8\n\n18.5  -1.8 14.9\n
^
```

- **input cursor**: The current position of the `Scanner`.

Consuming tokens

- **consuming input**: Reading input and advancing the cursor.
  - Calling `nextInt` etc. moves the cursor past the current token.

```
16.2   23.5\n   19.1 7.4   22.8\n\n18.5   -1.8 14.9\n
^
```

```
double d = input.nextDouble();     // 16.2
16.2   23.5\n   19.1 7.4   22.8\n\n18.5   -1.8 14.9\n
    ^
```

```
String s = input.next();           // "23.5"
16.2   23.5\n   19.1 7.4   22.8\n\n18.5   -1.8 14.9\n
           ^
```

File input question

- Recall the input file `weather.txt`:

```
16.2   23.5
   19.1 7.4  22.8

18.5  -1.8 14.9
```

- Write a program that prints the change in temperature between each pair of neighboring days.

```
16.2 to 23.5, change = 7.3
23.5 to 19.1, change = -4.4
19.1 to 7.4, change = -11.7
7.4 to 22.8, change = 15.4
22.8 to 18.5, change = -4.3
18.5 to -1.8, change = -20.3
-1.8 to 14.9, change = 16.7
```

File input answer

```
// Displays changes in temperature from data in an input file.
import java.io.*;    // for File
import java.util.*;  // for Scanner

public class Temperatures {
    public static void main(String[] args)
            throws FileNotFoundException {
        Scanner input = new Scanner(new File("weather.txt"));
        double prev = input.nextDouble();   // fencepost
        for (int i = 1; i <= 7; i++) {
            double next = input.nextDouble();
            System.out.println(prev + " to " + next +
                    ", change = " + (next - prev));
            prev = next;
        }
    }
}
```

Reading an entire file

- Suppose we want our program to work no matter how many numbers are in the file.
  - Currently, if the file has more numbers, they will not be read.
  - If the file has fewer numbers, what will happen?

A crash! Example output from a file with just 3 numbers:

```
16.2 to 23.5, change = 7.3
23.5 to 19.1, change = -4.4
Exception in thread "main" java.util.NoSuchElementException
    at java.util.Scanner.throwFor(Scanner.java:838)
    at java.util.Scanner.next(Scanner.java:1347)
    at Temperatures.main(Temperatures.java:12)
```

`Scanner` exceptions

- `NoSuchElementException`
  - You read past the end of the input.

- `InputMismatchException`
  - You read the wrong type of token (e.g. read `"hi"` as an `int`).

- Finding and fixing these exceptions:
  - Read the exception text for line numbers in your code (the first line that mentions your file; often near the bottom):

```
Exception in thread "main" java.util.NoSuchElementException
    at java.util.Scanner.throwFor(Scanner.java:838)
    at java.util.Scanner.next(Scanner.java:1347)
    at MyProgram.myMethodName(MyProgram.java:19)
    at MyProgram.main(MyProgram.java:6)
```

`Scanner` tests for valid input

Method	Description
`hasNext()`	returns `true` if there is a next token
`hasNextInt()`	returns `true` if there is a next token and it can be read as an `int`
`hasNextDouble()`	returns `true` if there is a next token and it can be read as a `double`

- These methods of the `Scanner` do not consume input; they just give information about what the next token will be.
  - Useful to see what input is coming, and to avoid crashes.
  - These methods can be used with a console `Scanner`, as well.
    - When called on the console, they sometimes pause waiting for input.

Using `hasNext` methods

- Avoiding type mismatches:

```
Scanner console = new Scanner(System.in);
System.out.print("How old are you? ");
if (console.hasNextInt()) {
    int age = console.nextInt();   // will not crash!
    System.out.println("Wow, " + age + " is old!");
} else {
    System.out.println("You didn't type an integer.");
}
```

- Avoiding reading past the end of a file:

```
Scanner input = new Scanner(new File("example.txt"));
if (input.hasNext()) {
    String token = input.next();   // will not crash!
    System.out.println("next token is " + token);
}
```

File input question 2

- Modify the temperature program to process the entire file, regardless of how many numbers it contains.
  - Example: If a ninth day's data is added, output might be:

```
16.2 to 23.5, change = 7.3
23.5 to 19.1, change = -4.4
19.1 to 7.4, change = -11.7
7.4 to 22.8, change = 15.4
22.8 to 18.5, change = -4.3
18.5 to -1.8, change = -20.3
-1.8 to 14.9, change = 16.7
14.9 to 16.1, change = 1.2
```

File input answer 2

```
// Displays changes in temperature from data in an input file.
import java.io.*;    // for File
import java.util.*;  // for Scanner

public class Temperatures {
    public static void main(String[] args)
            throws FileNotFoundException {
        Scanner input = new Scanner(new File("weather.txt"));
        double prev = input.nextDouble();   // fencepost
        while (input.hasNextDouble()) {
            double next = input.nextDouble();
            System.out.println(prev + " to " + next +
                    ", change = " + (next - prev));
            prev = next;
        }
    }
}
```

File input question 3

- Modify the temperature program to handle files that contain non-numeric tokens (by skipping them).

- For example, it should produce the same output as before when given this input file, `weather2.txt`:

```
16.2   23.5
Tuesday   19.1   Wed 7.4   THURS. TEMP: 22.8

18.5  -1.8  <-- What happened there?!
   14.9 :-)
```

  - You may assume that the file begins with a real number.

File input answer 3

```
// Displays changes in temperature from data in an input file.
import java.io.*;    // for File
import java.util.*;  // for Scanner

public class Temperatures2 {
    public static void main(String[] args)
            throws FileNotFoundException {
        Scanner input = new Scanner(new File("weather.txt"));
        double prev = input.nextDouble();   // fencepost
        while (input.hasNext()) {
            if (input.hasNextDouble()) {
                double next = input.nextDouble();
                System.out.println(prev + " to " + next +
                        ", change = " + (next - prev));
                prev = next;
            } else {
                input.next();  // throw away unwanted token
            }
        }
    }
}
```

Gas prices question

- Write a program that reads a file `gasprices.txt`
  - Format: *Belgium $/gal US $/gal date*

```
8.20      3.81  3/21/11
8.08      3.84  3/28/11
8.38      3.92  4/4/11
8.62      4.03  4/11/11
```

- The program should print the average gas price over all data in the file for both countries:

```
Belgium average: $8.32/gal
USA average: $3.90/gal
```

Gas prices solution

```
public class GasPrices {
  public static void main(String[] args)
              throws FileNotFoundException {
    Scanner s = new Scanner(new File("gasprices.txt"));
    double belgium = 0;
    double usa = 0;
    int count = 0;

    while (s.hasNext()) {
      belgium += s.nextDouble();
      usa += s.nextDouble();
      count++;
      s.next(); // skip date
    }

    System.out.printf("Belgium average: $%.2f/gal\n", belgium /
count);
    System.out.printf("USA average: $%.2f/gal\n", usa / count);
  }
}
```

Hours question

- Given a file `hours.txt` with the following contents:

```
123 Riley 12.5 8.1 7.6 3.2
456 Molly 4.0 11.6 6.5 2.7 12
789 Andrew 8.0 8.0 8.0 8.0 7.5
```

  - Consider the task of computing hours worked by each person:

```
Riley (ID#123) worked 31.4 hours (7.85 hours/day)
Molly (ID#456) worked 36.8 hours (7.36 hours/day)
Andrew (ID#789) worked 39.5 hours (7.90 hours/day)
```

Hours answer (flawed)

```
// This solution does not work!
import java.io.*;                   // for File
import java.util.*;                 // for Scanner

public class HoursWorked {
    public static void main(String[] args)
            throws FileNotFoundException {
        Scanner input = new Scanner(new File("hours.txt"));
        while (input.hasNext()) {
            // process one person
            int id = input.nextInt();
            String name = input.next();
            double totalHours = 0.0;
            int days = 0;
            while (input.hasNextDouble()) {
                totalHours += input.nextDouble();
                days++;
            }
            System.out.printf(
                "%s (ID#%d) worked %.1f hours (%.2f hours/day)\n",
                name, id, totalHours, totalHours / days);
        }
    }
}
```

Flawed output

```
Ben (ID#123) worked 487.4 hours (97.48 hours/day)
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.nextInt(Scanner.java:2091)
        at HoursWorked.main(HoursBad.java:9)
```

- The inner `while` loop is grabbing the next person's ID.
- We want to process the tokens, but we also care about the line breaks (they mark the end of a person's data).

- A better solution is a hybrid approach:
  - First, break the overall input into lines.
  - Then break each line into tokens.

Line-based `Scanner` methods

Method	Description
`nextLine()`	returns next entire line of input (from cursor to `\n`)
`hasNextLine()`	returns `true` if there are any more lines of input to read (always true for console input)

```
Scanner input = new Scanner(new File("<filename>"));
while (input.hasNextLine()) {
    String line = input.nextLine();
    <process this line>;
}
```

Consuming lines of input

```
23   3.14 John Smith   "Hello" world
                45.2      19
```

- The `Scanner` reads the lines as follows:

  ```
  23\t3.14 John Smith\t"Hello" world\n\t\t45.2  19\n
  ^
  ```

  - `String line = input.nextLine();`

    ```
    23\t3.14 John Smith\t"Hello" world\n\t\t45.2  19\n
                                       ^
    ```

  - `String line2 = input.nextLine();`

    ```
    23\t3.14 John Smith\t"Hello" world\n\t\t45.2  19\n
                                                  ^
    ```

  - Each `\n` character is consumed but not returned.

Scanners on Strings

- A `Scanner` can tokenize the contents of a `String`:

```
Scanner <name> = new Scanner(<String>);
```

  - Example:

```
String text = "15  3.2 hello   9  27.5";
Scanner scan = new Scanner(text);

int num = scan.nextInt();
System.out.println(num);              // 15

double num2 = scan.nextDouble();
System.out.println(num2);             // 3.2

String word = scan.next();
System.out.println(word);             // "hello"
```

Mixing lines and tokens

Input file `input.txt`:	Output to console:
`The quick brown fox jumps over` `the lazy dog.`	`Line has 6 words` `Line has 3 words`

```
// Counts the words on each line of a file
Scanner input = new Scanner(new File("input.txt"));
while (input.hasNextLine()) {
    String line = input.nextLine();
    Scanner lineScan = new Scanner(line);

    // process the contents of this line
    int count = 0;
    while (lineScan.hasNext()) {
        String word = lineScan.next();
        count++;
    }
    System.out.println("Line has " + count + " words");
}
```

Hours question

- Fix the `Hours` program to read the input file properly:

```
123 Riley 12.5 8.1 7.6 3.2
456 Molly 4.0 11.6 6.5 2.7 12
789 Andrew 8.0 8.0 8.0 8.0 7.5
```

  - Recall, it should produce the following output:

```
Riley (ID#123) worked 31.4 hours (7.85 hours/day)
Molly (ID#456) worked 36.8 hours (7.36 hours/day)
Andrew (ID#789) worked 39.5 hours (7.90 hours/day)
```

Hours answer, corrected

```
// Processes an employee input file and outputs each employee's hours.
import java.io.*;    // for File
import java.util.*;  // for Scanner

public class Hours {
    public static void main(String[] args) throws FileNotFoundException {
        Scanner input = new Scanner(new File("hours.txt"));
        while (input.hasNextLine()) {
            String line = input.nextLine();
            processEmployee(line);
        }
    }

    public static void processEmployee(String line) {
        Scanner lineScan = new Scanner(line);
        int id = lineScan.nextInt();           // e.g. 456
        String name = lineScan.next();         // e.g. "Greg"
        double sum = 0.0;
        int count = 0;
        while (lineScan.hasNextDouble()) {
            sum = sum + lineScan.nextDouble();
            count++;
        }

        double average = sum / count;
        System.out.printf("%s (ID#%d) worked %.1f hours (%.2f hours/day)\n",
                name, id, sum, sum / count);    }
}
```