

Input Validation

When humans interact with technology, a great diversity in experience is brought to bear on the task, and things often go amiss. If the technology is well-designed, mistakes or unusual or unexpected interactions are anticipated and accommodated in a safe and non-destructive manner. Computer software is no exception. When a user enters a syntactically incorrect value or selects a disabled feature, for example, the software must recognize, accommodate, and recover from the anomalous condition with minimal disruption. In other words, our software must expect the unexpected. In this section, we will illustrate how to write simple programs that recognize and recover from invalid user input. We call this *input validation*.

Many of our programs were designed to receive input from the keyboard using the `readLine()` method of the `BufferedReader` class. The `readLine()` method returns a string holding a full line of input. If the user entered an integer or floating point number, the string was converted to an `int` using the `Integer.parseInt()` method or to a `double` using the `Double.parseDouble()` method. For example

```
String s = readLine();
int value = Integer.parseInt(s);
```

But, what if the user entered something like "thirteen", instead of "13"? Here's the reaction from the `DemoMethod` program presented earlier:

```
PROMPT>java DemoMethod
Enter an integer: thirteen
Exception in thread "main" java.lang.NumberFormatException: thirteen
    at java.lang.Integer.parseInt(Compiled Code)
    at java.lang.Integer.parseInt(Integer.java:458)
    at DemoMethod.main(DemoMethod.java:21)
PROMPT>
```

Obviously, thirteen is not our lucky number. The output is hardly what we'd call a user-friendly error message. The program has crashed, and we're left high and dry. The critical term above is "NumberFormatException". There was an attempt to parse the string "thirteen" into an `int` and the `parseInt()` method didn't like what it found. The string "thirteen" has no correspondence to an integer — at least, not in the eyes of the `parseInt()` method. It reacted by throwing a "number format exception".

In this section, we'll examine a simple way to implement input validation. If the user input is not correctly format, we want to gracefully recover, if possible. And we definitely don't want our program to crash. Input validation is well-suited to implementation in methods; so, this a good place to introduce the topic. We'll re-visit the topic in more detail later when we examine exceptions.

The trick to input validation, as presented in this section, is to inspect the input string *before* passing it to a parsing method. If an invalid string is parsed, then it's too late for graceful recovery. We want to identify the problem before parsing, and recover in a manner that seems appropriate for the given program. The demo program `InputInteger` illustrates one approach to the problem (see Figure 1).

```

1  import java.io.*;
2
3  public class InputInteger
4  {
5      public static void main(String[] args) throws IOException
6      {
7          // setup 'stdin' as handle for keyboard input
8          BufferedReader stdin =
9              new BufferedReader(new InputStreamReader(System.in), 1);
10
11         // send prompt, get input and check if valid
12         String s;
13         do
14         {
15             System.out.print("Enter an integer: ");
16             s = stdin.readLine();
17         }
18         while (!isValidInteger(s));
19
20         // convert string to integer (safely!)
21         int i = Integer.parseInt(s);
22
23         // done!
24         System.out.println("You entered " + i + " (Thanks!)");
25     }
26
27     // check if string contains a valid integer
28     public static boolean isValidInteger(String str)
29     {
30         // return 'false' if empty string
31         if (str.length() == 0)
32             return false;
33
34         // skip over minus sign, if present
35         int i;
36         if (str.indexOf('-') == 0)
37             i = 1;
38         else
39             i = 0;
40
41         // ensure all characters are digits
42         while (i < str.length())
43         {
44             if (!Character.isDigit(str.charAt(i)))
45                 break;
46             i++;
47         }
48
49         // if reached the end of the line, all characters are OK!
50         if (i == str.length())
51             return true;
52         else
53             return false;
54     }
55 }

```

Figure 1. InputInteger.java

A sample dialogue with this program follows:

```
PROMPT>java InputInteger
Enter an integer:                               (blank line)
Enter an integer: -                             (only a minus sign entered)
Enter an integer: ninety nine                  (alpha characters not allowed)
Enter an integer: -ninety nine                 (sorry! try again)
Enter an integer:   99                         (leading spaces not allowed)
Enter an integer: 99 98 97                     (no spaces allowed)
Enter an integer: 99                           (finally!)
You entered 99 (Thanks!)
```

A variety of incorrect responses are shown above. In all cases, the program reacted by re-issuing the prompt and inputting another line. As evident in the 55 lines of source code, even this simple implementation of input validation is tricky. The good news is that the input routine is packaged in a method. At the level of "using" the method, the code is very clean (see lines 11-18).

Let's look inside the definition of the `isValidInteger()` method. For the purpose of this program, an integer string has the following characteristics: (a) it must contain no leading or trailing spaces, (b) it may contain an optional minus sign at the beginning, and (c) it must contain only digit characters until the end of the string.

The first "processing" task is to ensure that the string is not an empty string. If the line length is zero, the method returns `false` — the string does not contain a valid integer! (See lines 30-32). The next order of business is to check if the first character is a minus sign. An index variable `i` is initialized with 0 if the first character is not a minus sign, or 1 otherwise to skip over the minus sign. The string is scanned from this point to the end checking that each character is a digit. The check is performed in line 44 as follows:

```
if (!Character.isDigit(str.charAt(i)))
```

The character at position `i` in the string is extracted using the `charAt()` method of the `String` class and presented to the `isDigit()` method of the `Character` wrapper class. The return value is `true` if the character is a digit, `false` otherwise. If `false` is returned the relational test is `true` — because of the NOT operator (`!`) — and the following statement executes. The following statement is a `break`, which causes an immediate exit from the `while` loop. The final value of the index variable `i` is either `str.length()` if all the characters checked out as digits or something less than `str.length()` if the loop terminated early. This condition is checked in line 50 and the appropriate boolean result is returned: `true` if the string is a valid integer, `false` otherwise.

Despite the best intentions, the approach to input validation just shown is not as robust as we'd like. If the user enters 12345678999, for example, the program still crashes with a number format exception. (The largest integer represented by an `int` is $2^{31} - 1 = 2,147,483,647$.) As well, it is not entirely clear that we should reject input with leading or trailing spaces. A far better approach to input validation is to "deal with" the built-in exceptions generated by Java's API classes. We'll learn how to do this later. For the moment, the approach shown in `InputInteger` will serve us well.

Since `isValidInteger()` is a static method, it is available to other programs, provided the `InputInteger.class` file is reachable by the compiler. We could, for example, include the following lines in another Java program:

```
String s;  
s = stdin.readLine();  
if (InputInteger.isValidInteger(s))  
{  
    /** process input **/  
}
```

The prefix `InputInteger` simply identifies the the class where the static method `isValidInteger()` is found, much the same as “`Math`” in `Math.sqrt(25)` identifies the class where the `sqrt()` method is found.