

Supplement V.D: Text I/O Using Reader and Writer

For Introduction to Java Programming, 6E
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0 Introduction

§8.8, "Text I/O," in the text introduced text I/O using the Scanner class and PrintWriter class, which greatly simplified Text I/O. Prior to JDK 1.5, you have to use several classes to perform text I/O. If you are interested to know how to perform Text I/O in the old way, this supplement is for you.

1 The Reader and Writer Classes

Figure 1 lists the classes for performing text I/O.

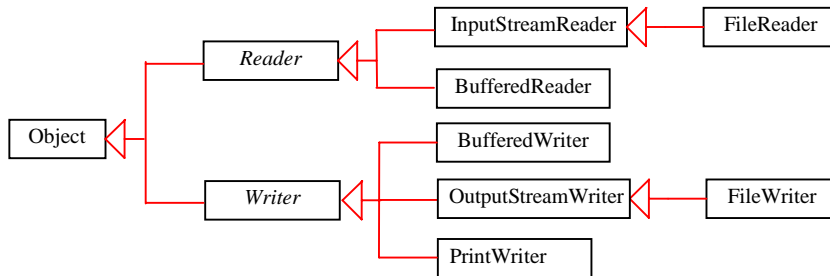


Figure 1

Reader, Writer, and their subclasses are for text I/O.

Reader is the root for text input classes, and Writer is the root for text output classes. Figures 16.6 and 16.7 list all the methods in Reader and Writer.

<i>java.io.Reader</i>	
<code>+read(): int</code>	Reads the next character from the input stream. The value returned is an int in the range from 0 to 65535, which represents a Unicode character. Returns -1 at the end of the stream.
<code>+read(cbuf: char[]): int</code>	Reads characters from the input stream into an array. Returns the actual number of characters read. Returns -1 at the end of the stream.
<code>+read(cbuf: char[], off: int, len: int): int</code>	Reads characters from the input stream and stores them in <code>cbuf[off]</code> , <code>cbuf[off+1]</code> , ..., <code>cbuf[off+len-1]</code> . The actual number of bytes read is returned. Returns -1 at the end of the stream.
<code>+close(): void</code>	Closes this input stream and releases any system resources associated with it.
<code>+skip(n: long): long</code>	Skips over and discards <code>n</code> characters of data from this input stream. The actual number of characters skipped is returned.
<code>+markSupported(): boolean</code>	Tests whether this input stream supports the mark and reset methods.
<code>+mark(readAheadLimit: int): void</code>	Marks the current position in this input stream.
<code>+ready(): boolean</code>	Returns true if this input stream is ready to be read.
<code>+reset(): void</code>	Repositions this stream to the position at the time the mark method was last called on this input stream.

Figure 2

The abstract Reader class defines the methods for reading a stream of characters.

NOTE

The read() method reads a character. If no data are available, it blocks the thread from executing the next statement. The thread that invokes the read() method is suspended until the data become available.

<i>java.io.Writer</i>	
+write(int c): void	Writes the specified character to this output stream. The parameter c is the Unicode for a character.
+write(cbuf: byte[]): void	Writes all the characters in array cbuf to the output stream.
+write(cbuf: char[], off: int, len: int): void	Writes cbuf[off], cbuf[off+1], ..., cbuf[off+len-1] into the output stream.
+write(str: String): void	Writes the characters from the string into the output stream.
+write(str: String, off: int, len: int): void	Writes a portion of the string characters into the output stream.
+close(): void	Closes this input stream and releases any system resources associated with it.
+flush(): void	Flushes this output stream and forces any buffered output characters to be written out.

Figure 3

The abstract Writer class defines the methods for writing a stream of characters.

NOTE

All the methods in the text I/O classes except PrintWriter are declared to throw java.io.IOException.

2 FileReader/FileWriter

FileReader/FileWriter are convenience classes for reading/writing characters from/to files using the default character encoding on the host computer. FileReader/FileWriter associates an input/output stream with an external file.

All the methods in FileReader/FileWriter are inherited from their superclasses. To construct a FileReader, use the following constructors:

```
public FileReader(String filename)
public FileReader(File file)
```

<Side Remark: [FileNotFoundException](#)>

A `java.io.FileNotFoundException` would occur if you attempt to create a `FileReader` with a nonexistent file. For example, Listing 1 reads and displays all the characters from the file `temp.txt`.

Listing 1 `TestFileReader.java` (Input Using `FileReader`)

*****PD: Please add line numbers in the following code*****

<Side Remark Line 1: `import`>

<Side Remark Line 8: `input` object>

<Side Remark Line 12: `read` character>

<Side Remark Line 23: `close` file>

```
import java.io.*;

public class TestFileReader {
    public static void main(String[] args) {
        FileReader input = null;
        try {
            // Create an input stream
            input = new FileReader("temp.txt");

            int code;
            // Repeatedly read a character and display it on the console
            while ((code = input.read()) != -1)
                System.out.print((char)code);
        }
        catch (FileNotFoundException ex) {
            System.out.println("File temp.txt does not exist");
        }
        catch (IOException ex) {
            ex.printStackTrace();
        }
        finally {
            try {
                input.close(); // Close the stream
            }
            catch (IOException ex) {
                ex.printStackTrace();
            }
        }
    }
}
```

The constructors and methods in `FileReader` may throw `IOException`, so they are invoked from a try-catch block. Since `java.io.FileNotFoundException` is a subclass of `IOException`, the catch clause for `FileNotFoundException` (Line 15) is put before the catch clause for `IOException` (Line 18). Closing files in the `finally` class ensures that the file are always closed in any case (Line 23).

<Side Remark: `test` end of a file>

Recall that Java allows the assignment operator in an expression (see page 37). The expression `((code = input.read()) != -1)` (Line 12) reads a byte from `input.read()`, assigns it to `code`, and checks whether it is -1. The input value of -1 signifies the end of a file.

NOTE

<Side Remark: EOFException>

Attempting to read data after the end of a file is reached would cause java.io.EOFException.

To construct a FileWriter, use the following constructors:

```
public FileWriter(String filename)
public FileWriter(File file)
public FileWriter(String filename, boolean append)
public FileWriter(File file, boolean append)
```

If the file does not exist, a new file will be created. If the file already exists, the first two constructors will delete the current contents of the file. To retain the current content and append new data into the file, use the last two constructors by passing true to the append parameter. For example, suppose the file temp.txt exists, Listing 2 appends a new string, "Introduction to Java," to the file.

Listing 2 TestFileWriterer.java (Output Using FileWriter)

*****PD: Please add line numbers in the following code*****

<Side Remark Line 6: Append to file>

```
import java.io.*;

public class TestFileWriter {
    public static void main(String[] args) throws IOException {
        // Create an output stream to the file
        FileWriter output = new FileWriter("temp.txt", true);

        // Output a string to the file
        output.write("Introduction to Java");

        // Close the stream
        output.close();
    }
}
```

If you replace Line 6 with the following statement,

```
FileWriter output = new FileWriter("temp.txt");
```

<Side Remark: file exists?>

the current contents of the file are lost. To avoid this, use the File class's exists() method to check whether a file exists before creating it, as follows:

```
File file = new File("temp.txt");
if (!file.exists()) {
    FileWriter output = new FileWriter(file);
}
```

3 InputStreamReader/OutputStreamWriter (Optional)

InputStreamReader/OutputStreamWriter are used to convert between bytes and characters. Characters written to an

OutputStreamWriter are encoded into bytes using a specified encoding scheme. Bytes read from an InputStreamReader are decoded into characters using a specified encoding scheme. You can specify an encoding scheme using a constructor of InputStreamReader/OutputStreamWriter. If no encoding scheme is specified, the system's default encoding scheme is used. All the methods in InputStreamReader/OutputStreamWriter are inherited from Reader/Writer except getEncoding(), which returns the name of the encoding being used by this stream. Since FileReader is a subclass of InputStreamReader, you can also invoke getEncoding() from a FileReader object. For example, the following code

```
public static void main(String[] args) throws IOException {  
    FileReader input = new FileReader("temp.txt");  
    System.out.println("Default encoding is " + input.getEncoding());  
}
```

displays the default encoding for the host machine. For a list of encoding schemes supported in Java, please see <http://java.sun.com/j2se/1.5.0/docs/guide/intl/encoding.doc.html> and <http://mindprod.com/jgloss/encoding.html>.

NOTE: Java programs use Unicode. When you read a character from a FileReader stream, the Unicode code of the character is returned. The encoding of the character in the file may be different from the Unicode encoding. Java automatically converts it to the Unicode. When you write a character to a FileWriter stream, Java automatically converts the Unicode of the character to the encoding specified for the file. This is pictured in Figure 4.

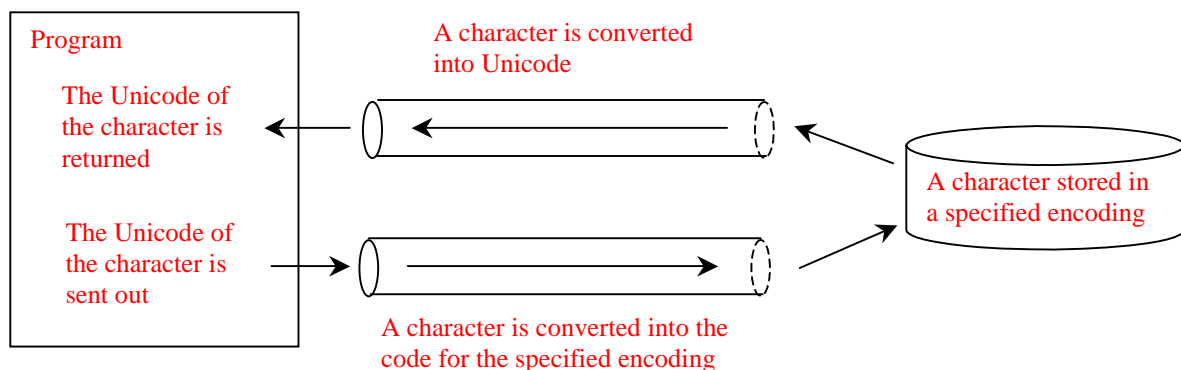


Figure 4

The encoding of the file may be different from the encoding used in the program.

*****End of NOTE**

4 BufferedReader/BufferedWriter

BufferedReader/BufferedWriter can be used to speed up input and output by reducing the number of reads and writes. Buffered streams employ a buffered array of characters that acts as a cache. In the case of input, the array reads a chunk of characters into the buffer before the individual characters are read. In the case of output, the array accumulates a block of characters before writing the entire block to the output stream.

The use of buffered streams enables you to read and write a chunk of characters at once instead of reading or writing the bytes one at a time. You can wrap a BufferedReader/BufferedWriter around any Reader/Writer streams. The following constructors are used to create a BufferedReader/BufferedWriter:

```
// Create a BufferedReader
public BufferedReader(Reader in)
public BufferedReader(Reader in, int bufferSize)

// Create a BufferedWriter
public BufferedWriter(Writer out)
public BufferedWriter(Writer out, int bufferSize)
```

If no buffer size is specified, the default size is 8192 characters. A buffered input stream reads as many data as possible into its buffer in a single read call. By contrast, a buffered output stream calls the write method only when its buffer fills up or when the flush() method is called.

The buffered stream classes inherit methods from their superclasses. In addition to using the methods from their superclasses, BufferedReader has a readLine() method to read a line, and BufferedWriter has a newLine() method to write a line separator. If the end of stream is reached, readLine() returns null.

NOTE

The readLine() method return a line without the line separator. The newLine() method writes a system-dependent line separator to a file. The line separator string is defined by the system and is not necessarily a single ('\n') character. To get the system line separator, use

```

static String lineSeparator = (String)java.security.
AccessController.doPrivileged(
new sun.security.action.GetPropertyAction("line.separator"));

```

*****End of NOTE**

Listing 3 uses BufferedReader to read text from the file "Welcome.java", displays the text on the console, and copies the text to a file named "Welcome.java~".

Listing 3 TestBufferedReaderWriter.java (Using Buffers)

*****PD: Please add line numbers in the following code*****

<Side Remark Line 6: input stream>

<Side Remark Line 8: output stream>

<Side Remark Line 15: read line>

<Side Remark Line 22: close stream>

```

import java.io.*;

public class TestBufferedReaderWriter {
    public static void main(String[] args) throws IOException {
        // Create an input stream
        BufferedReader input =
            new BufferedReader(new FileReader("Welcome.java"));

        // Create an output stream
        BufferedWriter output =
            new BufferedWriter(new FileWriter("Welcome.java~"));

        // Repeatedly read a line and display it on the console
        String line;
        while ((line = input.readLine()) != null) {
            System.out.println(line);
            output.write(line);
            output.newLine(); // Write a line separator
        }

        // Close the stream
        input.close();
        output.close();
    }
}

```

A BufferedReader is created on top of a FileReader (Lines 6-7), and a BufferedWriter on top of a FileWriter (Lines 10-11). Data from the file are read repeatedly, one line at a time (Line 15). Each line is displayed in Line 16, and output to a new file (Line 17) with a line separator (Line 18).

You are encouraged to rewrite the program without using buffers and then compare the performance of the two programs. This will show you the improvement in performance obtained by using buffers when reading from a large file.

TIP

Since physical input and output involving I/O devices are typically very slow compared with CPU processing

speeds, you should use buffered input/output streams to improve performance.

5 PrintWriter and PrintStream

BufferedWriter is used to output characters and strings. PrintWriter and PrintStream can be used to output objects, strings, and numeric values as text. PrintWriter was introduced in JDK 1.2 to replace PrintStream. Both classes are almost identical in the sense that they provide the same function and the same methods for outputting strings and numeric values as text. PrintWriter is more efficient than PrintStream and therefore is the class you ought to use.

PrintWriter and PrintStream contain the following overloaded print and println methods:

```
public void print(Object o)           public void println(Object o)
public void print(String s)          public void println(String s)
public void print(char c)            public void println(char c)
public void print(char[] cArray)     public void println(char[] cArray)
public void print(int i)              public void println(int i)
public void print(long l)            public void println(long l)
public void print(float f)           public void println(float f)
public void print(double d)          public void println(double d)
public void print(boolean b)         public void println(boolean b)
```

A numeric value, character, or boolean value is converted into a string and printed to the output stream. To print an object is to print the object's string representation returned from the toString() method. PrintWriter and PrintStream also contain the printf method for printing formatted output, which was introduced in Section 2.17, "Formatting Output."

You have already used these methods in System.out. out is declared as a static variable of the PrintStream type in the System class. By default, out refers to the standard output device, that is, the screen console. You can use the System.setOut(PrintStream) to set a new out. Since System was introduced before PrintWriter, out is declared PrintStream and not PrintWriter.

This section introduces PrintWriter, but PrintStream can be used in the same way. To construct a PrintWriter, use the following constructors:

```
public PrintWriter(Writer out)
```

```
public PrintWriter(Writer out, boolean autoFlush)
```

If `autoFlush` is `true`, the `println` methods will cause the buffer to be flushed.

NOTE

The constructors and methods in `PrintWriter` and `PrintStream` do not throw an `IOException`. So you don't need to invoke them from a `try-catch` block.

Listing 4 is an example of generating ten integers and storing them in a text file using `PrintWriter`. The example later writes the data back from the file and computes the total.

Listing 4 TestPrintWriter.java (Output Data and Strings)

*****PD: Please add line numbers in the following code*****

<Side Remark Line 8: check file>

<Side Remark Line 14: output stream>

<Side Remark Line 18: output to file>

<Side Remark Line 22: close stream>

<Side Remark Line 25: input stream>

<Side Remark Line 30: read line>

<Side Remark Line 40: close stream>

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

public class TestPrintWriter {
    public static void main(String[] args) throws IOException {
        // Check if file temp.txt already exists
        File file = new File("temp.txt");
        if (file.exists()) {
            System.out.println("File temp.txt already exists");
            System.exit(0);
        }

        // Create an output stream
        PrintWriter output = new PrintWriter(new FileWriter(file));

        // Generate ten integers and write them to a file
        for (int i = 0; i < 10; i++) {
            output.print((int)(Math.random() * 100) + " ");
        }

        // Close the output stream
        output.close();

        // Open an input stream
        BufferedReader input =
            new BufferedReader(new FileReader("temp.txt"));

        int total = 0; // Store total
        String line;
        while ((line = input.readLine()) != null) {
            // Extract numbers using string tokenizer
            StringTokenizer tokens = new StringTokenizer(line);
            while (tokens.hasMoreTokens())
                total += Integer.parseInt(tokens.nextToken());
        }
    }
}
```

```

        System.out.println("Total is " + total);

        // Close input stream
        input.close();
    }
}

```

Lines 7-11 check whether the file exists. If so, exit the program. Line 14 creates a PrintWriter stream for the file. Lines 17-19 generate ten random integers and output the integers separated by a space.

Line 25 opens the file for input. Lines 30-35 read all the lines from the file and use StringTokenizer to extract tokens from the line. Each token is converted to a number and added to the total (Line 34).

6 Case Study: Text Viewer

This case study writes a program that views a text file in a text area. The user enters a filename in a text field and clicks the View button; the file is then displayed in a text area, as shown in Figure 5.



Figure 5

The program displays the specified file in the text area.

Clearly, you need to use text input to read a text file. Normally, you should use BufferedReader wrapped on a FileReader to improve performance. When the View button is pressed, the program gets the input filename from the text field; it then creates a text input stream. The data are read one line at a time and appended to the text area for display. Listing 5 displays the source code for the program.

Listing 5 FileViewer.java (View Text Files)

```

***PD: Please add line numbers in the following code***
<Side Remark Line 17: create UI>
<Side Remark Line 38: display file>

```

<Side Remark Line 53: input stream>

<Side Remark Line 56: read line>

<Side Remark Line 57: display line>

```
import java.awt.*;
import java.awt.event.*;
import java.io.*;
import javax.swing.*;

public class FileViewer extends JFrame implements ActionListener {
    // Button to view a file
    private JButton jbtView = new JButton("View");

    // Text field to the receive file name
    private JTextField jtfFilename = new JTextField(12);

    // Text area to display the file
    private JTextArea jtaFile = new JTextArea();

    public FileViewer() {
        // Panel p to hold a label, a text field, and a button
        Panel p = new Panel();
        p.setLayout(new BorderLayout());
        p.add(new Label("Filename"), BorderLayout.WEST);
        p.add(jtfFilename, BorderLayout.CENTER);
        p.add(jbtView, BorderLayout.EAST);

        // Add jtaFile to a scroll pane
        JScrollPane jsp = new JScrollPane(jtaFile);

        // Add jsp and p to the frame
        getContentPane().add(jsp, BorderLayout.CENTER);
        getContentPane().add(p, BorderLayout.SOUTH);

        // Register listener
        jbtView.addActionListener(this);
    }

    /** Handle the View button */
    public void actionPerformed(ActionEvent e) {
        if (e.getSource() == jbtView)
            showFile();
    }

    /** Display the file in the text area */
    private void showFile() {
        // Use a BufferedReader to read text from the file
        BufferedReader input = null;

        // Get file name from the text field
        String filename = jtfFilename.getText().trim();

        String inLine;

        try {
            // Create a buffered stream
            input = new BufferedReader(new FileReader(filename));

            // Read a line and append the line to the text area
            while ((inLine = input.readLine()) != null) {
                jtaFile.append(inLine + '\n');
            }
        } catch (FileNotFoundException ex) {
            System.out.println("File not found: " + filename);
        } catch (IOException ex) {
            System.out.println(ex.getMessage());
        } finally {
            try {
```

```

        if (input != null) input.close();
    }
    catch (IOException ex) {
        System.out.println(ex.getMessage());
    }
}

public static void main(String[] args) {
    FileViewer frame = new FileViewer();
    frame.setTitle("FileViewer");
    frame.setSize(400, 300);
    frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    frame.setVisible(true);
}
}

```

A BufferedReader is created on top of a FileReader (Line 53). Data from the file are read repeatedly, one line at a time, and appended to the text area (Line 57). If the file does not exist, the catch clause in Lines 60-62 catches and processes it. All other I/O errors are caught and processed in Lines 63-65. Whether the program runs with or without errors, the input stream is closed in Lines 66-73.