



Programming and Software Development

COMP90041

Lecture 10

File I/O

NOTE: Some of the Material in these slides are adopted from

- * Lectures Notes prepared by Dr. Peter Schachte, Dr. Rose Williams, and
- * the Textbook resources

- Interfaces
- Handling Exceptions

Review: Week 8-9

- File I/O
- Buffered Reader
- Binary Files

Outline

- **File I/O**
- **Buffered Reader**
- **Binary Files**

Outline

- A *stream* is an object that enables the flow of data between a program and some I/O device or file
 - If the data flows into a program, then the stream is called an *input stream*
 - If the data flows out of a program, then the stream is called an *output stream*

Streams

- Input streams can flow from the keyboard or from a file
 - **System.in is an input stream that connects to the keyboard**
Scanner keyboard = new Scanner(System.in);
- Output streams can flow to a screen or to a file
 - **System.out is an output stream that connects to the screen**
System.out.println("Output stream");

Streams

- Files that are designed to be read by human beings, and that can be read or written with an editor are called ***text files***
 - An advantage of text files is that they are usually the same on all computers, so that they can move from one computer to another
- Files that are designed to be read by programs and that consist of a sequence of binary digits are called ***binary files***
 - An advantage of binary files is that they are ***more efficient to process*** than text files

Text Files and Binary Files

- The class **PrintWriter** is a stream class that can be used to write to a text file
 - An object of the class **PrintWriter** has the methods **print**, **println**, and **printf**
 - These are similar to the **System.out** methods of the same names, but are used for text file output, not screen output

Writing to a Text File: PrintWriter

- All the file I/O classes that follow are in the package **java.io**, so a program that uses **PrintWriter** will start with a set of **import** statements:
import java.io.PrintWriter;
import java.io.FileOutputStream;
import java.io.FileNotFoundException;

Writing to a Text File: imports

- A stream of the class **PrintWriter** is created and connected to a text file for writing as follows:

```
PrintWriter outputStreamName;  
outputStreamName = new PrintWriter(new  
FileOutputStream(fileName));
```

- The class **FileOutputStream** takes a string representing the file name as its argument
- The class **PrintWriter** takes the anonymous **FileOutputStream** object as its argument

Writing to a Text File: syntax

- This produces an object of the class **PrintWriter** that is connected to the file **FileName** (Eg. **TextFileOutputDemo**)
 - The process of connecting a stream to a file is called *opening the file*
 - If the file already exists, then doing this causes the old contents to be lost
 - If the file does not exist, then a new, empty file named **FileName** is created
- After doing this, the methods **print** and **println** can be used to write to the file

Writing to a Text File: open a file

- When a text file is opened in this way, a **FileNotFoundException** can be thrown
 - In this context it actually means that the file could not be created
 - This type of exception can also be thrown when a program attempts to open a file for reading and there is no such file
- It is therefore necessary to enclose this code in exception handling blocks
 - The file should be opened inside a **try** block
 - A **catch** block should catch and handle the possible exception
 - The variable that refers to the **PrintWriter** object should be declared outside the block (and initialized to **null**) so that it is not local to the block

Writing to a Text File: exceptions

- When a program is finished writing to a file, it should always close the stream connected to that file

outputStreamName.close();

- This allows the system to release any resources used to connect the stream to the file
- If the program does not close the file before the program ends, Java will close it automatically, but it is safest to close it explicitly

Writing to a Text File: close a file

- Output streams connected to files are usually *buffered*
 - Rather than physically writing to the file as soon as possible, the data is saved in a temporary location (*buffer*)
 - When enough data accumulates, or when the method **flush** is invoked, the buffered data is written to the file all at once
 - This is more **efficient**, since physical writes to a file can be slow

Writing to a Text File: buffer

- The method **close** invokes the method **flush**, thus insuring that all the data is written to the file
 - If a program relies on Java to close the file, and the program terminates abnormally, then any output that was buffered may not get written to the file
 - Also, if a program writes to a file and later reopens it to read from the same file, it will have to be closed first anyway
 - The sooner a file is closed after writing to it, the less likely it is that there will be a problem

Writing to a Text File: **close** & **flush**

- The rules for how file names should be formed depend on a given operating system, not Java
 - When a file name is given to a java constructor for a stream, it is just a string, not a Java identifier (e.g., `"fileName.txt"`)
 - Any suffix used, such as `.txt` has no special meaning to a Java program

File Names

- Every input file and every output file used by a Java program has two names:
 1. The real file name used by the operating system
 2. The name of the stream that is connected to the file
- The actual file name is used to connect to the stream
- The stream name serves as a temporary name for the file, and is the name that is primarily used within the program

A File Has Two Names

- When performing file I/O there are many situations in which an exception, such as **FileNotFoundException**, may be thrown
- Many of these exception classes are subclasses of the class **IOException**
 - The class **IOException** is the root class for a variety of exception classes having to do with input and/or output
- These exception classes are all checked exceptions
 - Therefore, they must be caught or declared in a throws clause

IOException

- In contrast, the exception classes **NoSuchElementException**, **InputMismatchException**, and **IllegalStateException** are all unchecked exceptions
 - Unchecked exceptions are not required to be caught or declared in a throws clause

Unchecked Exceptions

- Since opening a file can result in an exception, it should be placed inside a **try** block
- If the variable for a **PrintWriter** object needs to be used outside that block, then the variable must be declared outside the block
 - Otherwise it would be local to the block, and could not be used elsewhere
 - If it were declared in the block and referenced elsewhere, the compiler will generate a message indicating that it is an undefined identifier

Pitfall: a try Block is a Block

- To create a **PrintWriter** object and connect it to a text file for *appending*, a second argument, set to **true**, must be used in the constructor for the **FileOutputStream** object

```
outputStreamName = new PrintWriter(new  
FileOutputStream(FileName, true));
```

- After this statement, the methods **print**, **println** and/or **printf** can be used to write to the file
- The new text will be written *after the old text* in the file

Appending to a Text File

- If a class has a suitable `toString()` method, and `anObject` is an object of that class, then `anObject` can be used as an argument to `System.out.println`, and it will produce sensible output
- The same thing applies to the methods `print` and `println` of the class `PrintWriter`
`outputStreamName.println(anObject);`

toString Helps with Text File Output

Display 10.2 Some Methods of the Class PrintWriter

PrintWriter and FileOutputStream are in the `java.io` package.

```
public PrintWriter(OutputStream streamObject)
```

This is the only constructor you are likely to need. There is no constructor that accepts a file name as an argument. If you want to create a stream using a file name, you use

```
new PrintWriter(new FileOutputStream(File_Name))
```

When the constructor is used in this way, a blank file is created. If there already was a file named `File_Name`, then the old contents of the file are lost. If you want instead to append new text to the end of the old file contents, use

```
new PrintWriter(new FileOutputStream(File_Name, true))
```

(For an explanation of the argument `true`, read the subsection "Appending to a Text File.")

When used in either of these ways, the `FileOutputStream` constructor, and so the `PrintWriter` constructor invocation, can throw a `FileNotFoundException`, which is a kind of `IOException`.

If you want to create a stream using an object of the class `File`, you can use a `File` object in place of the `File_Name`. (The `File` class will be covered in Section 10.3. We discuss it here so that you will have a more complete reference in this display, but you can ignore the reference to the class `File` until after you've read that section.)

(continued)

Some Methods of the PrintWriter (Part 1 of 3)

Display 10.2 Some Methods of the Class PrintWriter

```
public void println(Argument)
```

The *Argument* can be a string, character, integer, floating-point number, boolean value, or any combination of these, connected with + signs. The *Argument* can also be any object, although it will not work as desired unless the object has a properly defined `toString()` method. The *Argument* is output to the file connected to the stream. After the *Argument* has been output, the line ends, and so the next output is sent to the next line.

```
public void print(Argument)
```

This is the same as `println`, except that this method does not end the line, so the next output will be on the same line.

(continued)

Some Methods of the PrintWriter (Part 2 of 3)

Display 10.2 Some Methods of the Class PrintWriter

```
public PrintWriter printf(Arguments)
```

This is the same as `System.out.printf`, except that this method sends output to a text file rather than to the screen. It returns the calling object. However, we have always used `printf` as a void method.

```
public void close()
```

Closes the stream's connection to a file. This method calls `flush` before closing the file.

```
public void flush()
```

Flushes the output stream. This forces an actual physical write to the file of any data that has been buffered and not yet physically written to the file. Normally, you should not need to invoke `flush`.

Some Methods of the PrintWriter (Part 3 of 3)

- The class **Scanner** can be used for reading from the keyboard as well as reading from a text file
 - Simply replace the argument **System.in** (to the **Scanner** constructor) with a suitable stream that is connected to the text file
- **Scanner StreamObject =
new Scanner(new FileInputStream(FileName));**
- Methods of the **Scanner** class for reading input behave the same whether reading from the keyboard or reading from a text file
 - For example, the **nextInt** and **nextLine** methods

Reading From a Text File Using Scanner

Display 10.3 Reading Input from a Text File Using Scanner

```
1 import java.util.Scanner;
2 import java.io.FileInputStream;
3 import java.io.FileNotFoundException;
4
5 public class TextFileScannerDemo
6 {
7     public static void main(String[] args)
8     {
9         System.out.println("I will read three numbers and a line");
10        System.out.println("of text from the file morestuff.txt.");
11
12        Scanner inputStream = null;
13
14        try
15        {
16            inputStream =
17                new Scanner(new FileInputStream("morestuff.txt"));
18        }
```

(continued)

Example (Part 1 of 4)

Display 10.3 Reading Input from a Text File Using Scanner

```
19      catch(FileNotFoundException e)
20      {
21          System.out.println("File morestuff.txt was not found");
22          System.out.println("or could not be opened.");
23          System.exit(0);
24      }
25      int n1 = inputStream.nextInt();
26      int n2 = inputStream.nextInt();
27      int n3 = inputStream.nextInt();
28
29      inputStream.nextLine(); //To go to the next line
30
31      String line = inputStream.nextLine();
32
```

(continued)

Example (Part 2 of 4)

Display 10.3 Reading Input from a Text File Using Scanner

```
33     System.out.println("The three numbers read from the file are:");
34     System.out.println(n1 + ", " + n2 + ", and " + n3);
35
36     System.out.println("The line read from the file is:");
37     System.out.println(line);
38
39     inputStream.close();
40 }
41 }
```

File morestuff.txt

```
1 2
3 4
Eat my shorts.
```

*This file could have been made with a
text editor or by another Java
program.*

(continued)

Example (Part 3 of 4)

Display 10.3 Reading Input from a Text File Using Scanner

SCREEN OUTPUT

I will read three numbers and a line
of text from the file morestuff.txt.
The three numbers read from the file are:
1, 2, and 3
The line read from the file is:
Eat my shorts.

Example (Part 4 of 4)

- A program that tries to read beyond the end of a file using methods of the **Scanner** class will cause an exception to be thrown
- However, instead of having to rely on an exception to signal the end of a file, the **Scanner** class provides methods such as **hasNextInt** and **hasNextLine**
 - These methods can also be used to check that the next token to be input is a suitable element of the appropriate type

Testing for the End of a Text File

Display 10.4 Checking for the End of a Text File with hasNextLine

```
1 import java.util.Scanner;
2 import java.io.FileInputStream;
3 import java.io.FileNotFoundException;
4 import java.io.PrintWriter;
5 import java.io.FileOutputStream;
6
7 public class HasNextLineDemo
8 {
9     public static void main(String[] args)
10    {
11        Scanner inputStream = null;
12        PrintWriter outputStream = null;
```

(continued)

Checking for the end of a Text File with hasNextLine method (Part 1 of 4)

Display 10.4 Checking for the End of a Text File with hasNextLine

```
13     try
14     {
15         inputStream =
16             new Scanner(new FileInputStream("original.txt"));
17         outputStream = new PrintWriter(
18                         new FileOutputStream("numbered.txt"));
19     }
20     catch(FileNotFoundException e)
21     {
22         System.out.println("Problem opening files.");
23         System.exit(0);
24     }

25     String line = null;
26     int count = 0;
```

(continued)

Checking for the end of a Text File with hasNextLine method (Part 2 of 4)

Display 10.4 Checking for the End of a Text File with hasNextLine

```
27     while (inputStream.hasNextLine( ))  
28     {  
29         line = inputStream.nextLine( );  
30         count++;  
31         outputStream.println(count + " " + line);  
32     }  
33     inputStream.close( );  
34     outputStream.close( );  
35 }  
36 }
```

(continued)

Checking for the end of a Text File with hasNextLine method (Part 3 of 4)

Display 10.4 Checking for the End of a Text File with hasNextLine

File original.txt

```
Little Miss Muffet
sat on a tuffet
eating her curves away.
Along came a spider
who sat down beside her
and said "Will you marry me?"
```

File numbered.txt (after the program is run)

```
1 Little Miss Muffet
2 sat on a tuffet
3 eating her curves away.
4 Along came a spider
5 who sat down beside her
6 and said "Will you marry me?"
```

Checking for the end of a Text File with hasNextLine method (Part 4 of 4)

Display 10.5 Checking for the End of a Text File with hasNextInt

```
1 import java.util.Scanner;
2 import java.io.FileInputStream;
3 import java.io.FileNotFoundException;
4
5 public class HasNextIntDemo
6 {
7     public static void main(String[] args)
8     {
9         Scanner inputStream = null;
10
11         try
12         {
13             inputStream =
14                 new Scanner(new FileInputStream("data.txt"));
15         }
16         catch(FileNotFoundException e)
17         {
18             System.out.println("File data.txt was not found");
19             System.out.println("or could not be opened.");
20             System.exit(0);
21         }
22     }
23 }
```

(continued)

Checking for the end of a Text File with hasNextInt method (Part 1 of 2)

Display 10.5 Checking for the End of a Text File with hasNextInt

```
20     int next, sum = 0;
21     while (inputStream.hasNextInt( ))
22     {
23         next = inputStream.nextInt( );
24         sum = sum + next;
25     }
26
27     inputStream.close( );
28
29 }  
System.out.println("The sum of the numbers is " + sum);
```

File data.txt

1 2
3 4 hi 5

Reading ends when either the end of the file is reached or a token that is not an int is reached. So, the 5 is never read.

SCREEN OUTPUT

The sum of the numbers is 10

Checking for the end of a Text File with hasNextInt method (Part 2 of 2)

- File I/O
- [Buffered Reader](#)
- Binary Files

Outline

- The class **BufferedReader** is a stream class that can be used to read from a text file
 - An object of the class **BufferedReader** has the methods **read** and **readLine**
- A program using **BufferedReader**, like one using **PrintWriter**, will start with a set of **import** statements:

```
import java.io.BufferedReader;  
import java.io.FileReader;  
import java.io.FileNotFoundException;  
import java.io.IOException;
```

Introduction to BufferedReader

- Like the classes **PrintWriter** and **Scanner**, **BufferedReader** has no constructor that takes a file name as its argument
 - It needs to use another class, **FileReader**, to convert the file name to an object that can be used as an argument to its (the **BufferedReader**) constructor
- A stream of the class **BufferedReader** is created and connected to a text file as follows:
BufferedReader readerObject;
readerObject = new BufferedReader(new
FileReader(fileName));
 - This opens the file for reading

Introduction to BufferedReader

- After these statements, the methods **read** and **readLine** can be used to read from the file
 - The **readLine** method is the same method used to read from the keyboard, but in this case it would read from a file
 - The **read** method reads a single character, and returns a value (of type **int**) that corresponds to the character read
 - Since the read method does not return the character itself, a type cast must be used:
char next = (char)(readerObject.read());

Reading From a Text File

Display 10.7 Reading Input from a Text File Using BufferedReader

```
1 import java.io.BufferedReader;
2 import java.io.FileReader;
3 import java.io.FileNotFoundException;
4 import java.io.IOException;

5 public class TextInputDemo
6 {
7     public static void main(String[] args)
8     {
9         try
10     {
11         BufferedReader inputStream =
12             new BufferedReader(new FileReader("morestuff2.txt"));

13         String line = inputStream.readLine();
14         System.out.println(
15             "The first line read from the file is:");
16         System.out.println(line);
```

(continued)

Example (Part 1 of 3)

Display 10.7 Reading Input from a Text File Using BufferedReader

```
17
18     line = inputStream.readLine();
19     System.out.println(
20             "The second line read from the file is:");
21     System.out.println(line);
22     inputStream.close();
23 }
24 catch(FileNotFoundException e)
25 {
26     System.out.println("File morestuff2.txt was not found");
27     System.out.println("or could not be opened.");
28 }
29 catch(IOException e)
30 {
31     System.out.println("Error reading from morestuff2.txt.");
32 }
33 }
34 }
```

(continued)

Example (Part 2 of 3)

Display 10.7 Reading Input from a Text File Using BufferedReader

File morestuff2.txt

```
1 2 3
Jack jump over
the candle stick.
```

This file could have been made with a text editor or by another Java program.

SCREEN OUTPUT

The first line read from the file is:

```
1 2 3
```

The second line read from the file is:

```
Jack jump over
```

Example (Part 3 of 3)

- A program using a **BufferedReader** object in this way may throw two kinds of exceptions
 - An attempt to open the file may throw a **FileNotFoundException** (which in this case has the expected meaning)
 - An invocation of **readLine** may throw an **IOException**
 - Both of these exceptions should be handled

Reading from a Text File

Display 10.8 Some Methods of the Class BufferedReader

BufferedReader and FileReader are in the `java.io` package.

```
public BufferedReader(Reader readerObject)
```

This is the only constructor you are likely to need. There is no constructor that accepts a file name as an argument. If you want to create a stream using a file name, you use

```
new BufferedReader(new FileReader(File_Name))
```

When used in this way, the `FileReader` constructor, and thus the `BufferedReader` constructor invocation, can throw a `FileNotFoundException`, which is a kind of `IOException`.

The `File` class will be covered in the section entitled “The `File` Class.” We discuss it here so that you will have a more complete reference in this display, but you can ignore the following reference to the class `File` until after you’ve read that section.

If you want to create a stream using an object of the class `File`, you use

```
new BufferedReader(new FileReader(File_Object))
```

When used in this way, the `FileReader` constructor, and thus the `BufferedReader` constructor invocation, can throw a `FileNotFoundException`, which is a kind of `IOException`.

(continued)

Some Methods of BufferedReader (Part 1 of 2)

Display 10.8 Some Methods of the Class BufferedReader

```
public String readLine() throws IOException
```

Reads a line of input from the input stream and returns that line. If the read goes beyond the end of the file, null is returned. (Note that an EOFException is not thrown at the end of a file. The end of a file is signaled by returning null.)

```
public int read() throws IOException
```

Reads a single character from the input stream and returns that character as an int value. If the read goes beyond the end of the file, then -1 is returned. Note that the value is returned as an int. To obtain a char, you must perform a type cast on the value returned. The end of a file is signaled by returning -1. (All of the "real" characters return a positive integer.)

```
public long skip(long n) throws IOException
```

Skips n characters.

```
public void close() throws IOException
```

Closes the stream's connection to a file.

Some Methods of BufferedReader (Part 1 of 2)

- Unlike the **Scanner** class, the class **BufferedReader** has no methods to read a number from a text file
 - Instead, a number must be read in as a string, and then converted to a value of the appropriate numeric type using one of the wrapper classes
 - To read in a single number on a line by itself, first use the method **readLine**, and then use **Integer.parseInt**, **Double.parseDouble**, etc. to convert the string into a number
 - If there are multiple numbers on a line, **StringTokenizer** can be used to decompose the string into tokens, and then the tokens can be converted as described above

Reading Numbers

- The method **readLine** of the class **BufferedReader** returns **null** when it tries to read beyond the end of a text file
 - A program can test for the end of the file by testing for the value **null** when using **readLine**
- The method **read** of the class **BufferedReader** returns **-1** when it tries to read beyond the end of a text file
 - A program can test for the end of the file by testing for the value **-1** when using **read**

Testing for the End of a Text File

- When a file name is used as an argument to a constructor for opening a file, it is assumed that the file is in the same directory or folder as the one in which the program is run
- If it is not in the same directory, the full or relative path name must be given

Path Names

- A *path name* not only gives the name of the file, but also the directory or folder in which the file exists
- A *full path name* gives a complete path name, starting from the root directory
- A *relative path name* gives the path to the file, starting with the directory in which the program is located

Path Names

- The way path names are specified depends on the operating system
 - A typical UNIX path name that could be used as a file name argument is
"/user/sallyz/data/data.txt"
 - A **BufferedReader** input stream connected to this file is created as follows:
**BufferedReader inputStream =
new BufferedReader(new
FileReader("/user/sallyz/data/data.txt"));**

Path Names

- The Windows operating system specifies path names in a different way
 - A typical Windows path name is the following:
C:\dataFiles\goodData\data.txt
 - A **BufferedReader** input stream connected to this file is created as follows:
**BufferedReader inputStream = new
BufferedReader(new FileReader
("C:\\dataFiles\\goodData\\\\data.txt"));**
 - Note that in Windows \\ must be used in place of \, since a single backslash denotes an the beginning of an escape sequence

Path Names

- A double backslash (\\\) must be used for a Windows path name enclosed in a quoted string
 - This problem does not occur with path names read in from the keyboard
- Problems with escape characters can be avoided altogether by always using UNIX conventions when writing a path name
 - A Java program will accept a path name written in either Windows or Unix format regardless of the operating system on which it is run

Path Names

- Each of the Java I/O library classes serves only one function, or a small number of functions
 - Normally two or more class constructors are combined to obtain full functionality
- Therefore, expressions with two constructors are common when dealing with Java I/O classes

Nested Constructor Invocations

new BufferedReader(new FileReader("stuff.txt"))

- Above, the anonymous **FileReader** object establishes a connection with the **stuff.txt** file
 - However, it provides only very primitive methods for input
- The constructor for **BufferedReader** takes this **FileReader** object and adds a richer collection of input methods
 - This transforms the inner object into an instance variable of the outer object

Nested Constructor Invocations

- The standard streams **System.in**, **System.out**, and **System.err** are automatically available to every Java program
 - **System.out** is used for normal screen output
 - **System.err** is used to output error messages to the screen
- The **System** class provides three methods (**setIn**, **setOut**, and **setErr**) for redirecting these standard streams:

```
public static void setIn(InputStream inStream)
public static void setOut(PrintStream outStream)
public static void setErr(PrintStream outStream)
```

System.in, System.out, and System.err

- Using these methods, any of the three standard streams can be redirected
 - For example, instead of appearing on the screen, error messages could be redirected to a file
- In order to redirect a standard stream, a new stream object is created
 - Like other streams created in a program, a stream object used for redirection must be closed after I/O is finished
 - Note, standard streams do not need to be closed

System.in, System.out, and System.err

- Redirecting **System.err**:

```
public void getInput()
{
    ...
    PrintStream errStream = null;
    try
    {
        errStream = new PrintStream(new
            FileOutputStream("errMessages.txt"));
        System.setErr(errStream);
        ... //Set up input stream and read
    }
```

System.in, System.out, and System.err

- Redirecting **System.err**:

```
public void getInput() {  
    ...  
    PrintStream errStream = null;  
    try {  
        errStream = new PrintStream(new  
            FileOutputStream("errMessages.txt"));  
        System.setErr(errStream);  
        ... //Set up input stream and read  
    } catch (FileNotFoundException e) {  
        System.err.println("Input file not found");  
    } finally {  
        ...  
        errStream.close();  
    }  
}
```

System.in, System.out, and System.err

- The **File** class is like a wrapper class for file names
 - The constructor for the class **File** takes a name, (known as the *abstract name*) as a string argument, and produces an object that represents the file with that name
 - The **File** object and methods of the class **File** can be used to determine information about the file and its properties
 - Eg. **FileClassDemo**

The File Class

Display 10.12 Some Methods in the Class File

File is in the java.io package.

```
public File(String File_Name)
```

Constructor. *File_Name* can be either a full or a relative path name (which includes the case of a simple file name). *File_Name* is referred to as the **abstract path name**.

```
public boolean exists()
```

Tests whether there is a file with the abstract path name.

```
public boolean canRead()
```

Tests whether the program can read from the file. Returns true if the file named by the abstract path name exists and is readable by the program; otherwise returns false.

(continued)

Some Methods of the Class File (Part 1 of 5)

Display 10.12 Some Methods in the Class File

```
public boolean setReadOnly()
```

Sets the file represented by the abstract path name to be read only. Returns `true` if successful; otherwise returns `false`.

```
public boolean canWrite()
```

Tests whether the program can write to the file. Returns `true` if the file named by the abstract path name exists and is writable by the program; otherwise returns `false`.

```
public boolean delete()
```

Tries to delete the file or directory named by the abstract path name. A directory must be empty to be removed. Returns `true` if it was able to delete the file or directory. Returns `false` if it was unable to delete the file or directory.

(continued)

Some Methods of the Class File (Part 2 of 5)

Display 10.12 Some Methods in the Class File

```
public boolean createNewFile() throws IOException
```

Creates a new empty file named by the abstract path name, provided that a file of that name does not already exist. Returns true if successful, and returns false otherwise.

```
public String getName()
```

Returns the last name in the abstract path name (that is, the simple file name). Returns the empty string if the abstract path name is the empty string.

```
public String getPath()
```

Returns the abstract path name as a String value.

```
public boolean renameTo(File New_Name)
```

Renames the file represented by the abstract path name to *New_Name*. Returns true if successful; otherwise returns false. *New_Name* can be a relative or absolute path name. This may require moving the file. Whether or not the file can be moved is system dependent.

(continued)

Some Methods of the Class File (Part 3 of 5)

Display 10.12 Some Methods in the Class File

```
public boolean isFile()
```

Returns true if a file exists that is named by the abstract path name and the file is a normal file; otherwise returns false. The meaning of *normal* is system dependent. Any file created by a Java program is guaranteed to be normal.

```
public boolean isDirectory()
```

Returns true if a directory (folder) exists that is named by the abstract path name; otherwise returns false.

(continued)

Some Methods of the Class File (Part 4 of 5)

Display 10.12 Some Methods in the Class File

```
public boolean mkdir()
```

Makes a directory named by the abstract path name. Will not create parent directories. See `mkdirs`. Returns `true` if successful; otherwise returns `false`.

```
public boolean mkdirs()
```

Makes a directory named by the abstract path name. Will create any necessary but nonexistent parent directories. Returns `true` if successful; otherwise returns `false`. Note that if it fails, then some of the parent directories may have been created.

```
public long length()
```

Returns the length in bytes of the file named by the abstract path name. If the file does not exist or the abstract path name names a directory, then the value returned is not specified and may be anything.

Some Methods of the Class File (Part 5 of 5)

- File I/O
- Buffered Reader
- **Binary Files**

Outline

- Binary files store data in the same format used by computer memory to store the values of variables
 - No conversion needs to be performed when a value is stored or retrieved from a binary file
- Java binary files, unlike other binary language files, are portable
 - A binary file created by a Java program can be moved from one computer to another
 - These files can then be read by a Java program, but only by a Java program

Binary Files

- The class **ObjectOutputStream** is a stream class that can be used to write to a binary file
 - An object of this class has methods to write strings, values of primitive types, and objects to a binary file
- A program using **ObjectOutputStream** needs to import several classes from package **java.io**:
import java.io.ObjectOutputStream;
import java.io.FileOutputStream;
import java.io.IOException;

Writing Simple Data to a Binary File

- An **ObjectOutputStream** object is created and connected to a binary file as follows:

```
ObjectOutputStream outputStreamName = new  
ObjectOutputStream(new  
FileOutputStream(fileName));
```

- The constructor for **FileOutputStream** may throw a **FileNotFoundException**
- The constructor for **ObjectOutputStream** may throw an **IOException**
- Each of these must be handled

Opening a Binary File for Output

- After opening the file, **ObjectOutputStream** methods can be used to write to the file
 - Methods used to output primitive values include **writeInt**, **writeDouble**, **writeChar**, and **writeBoolean**
- *UTF is an encoding scheme used to encode Unicode characters that favors the ASCII character set*
 - The method **writeUTF** can be used to output values of type **String**
- The stream should always be closed after writing

Opening a Binary File for Output

Display 10.14 Some Methods in the Class ObjectOutputStream

ObjectOutputStream and FileOutputStream are in the `java.io` package.

```
public ObjectOutputStream(OutputStream streamObject)
```

There is no constructor that takes a file name as an argument. If you want to create a stream using a file name, you use

```
new ObjectOutputStream(new FileOutputStream(File_Name))
```

This creates a blank file. If there already is a file named `File_Name`, then the old contents of the file are lost.

If you want to create a stream using an object of the class `File`, you use

```
new ObjectOutputStream(new FileOutputStream(File_Object))
```

The constructor for `FileOutputStream` may throw a `FileNotFoundException`, which is a kind of `IOException`. If the `FileOutputStream` constructor succeeds, then the constructor for `ObjectOutputStream` may throw a different `IOException`.

(continued)

Some Methods in ObjectOutputStream (Part 1 of 5)

Display 10.14 Some Methods in the Class ObjectOutputStream

```
public void writeInt(int n) throws IOException
```

Writes the int value n to the output stream.

```
public void writeShort(short n) throws IOException
```

Writes the short value n to the output stream.

```
public void writeLong(long n) throws IOException
```

Writes the long value n to the output stream.

```
public void writeDouble(double x) throws IOException
```

Writes the double value x to the output stream.

(continued)

Some Methods in ObjectOutputStream (Part 2 of 5)

Display 10.14 Some Methods in the Class ObjectOutputStream

```
public void writeFloat(float x) throws IOException
```

Writes the float value x to the output stream.

```
public void writeChar(int n) throws IOException
```

Writes the char value n to the output stream. Note that it expects its argument to be an int value. However, if you simply use the char value, then Java will automatically type cast it to an int value. The following are equivalent:

```
outputStream.writeChar((int)'A');
```

and

```
outputStream.writeChar('A');
```

(continued)

Some Methods in ObjectOutputStream (Part 3 of 5)

Display 10.14 Some Methods in the Class ObjectOutputStream

```
public void writeBoolean(boolean b) throws IOException
```

Writes the boolean value b to the output stream.

```
public void writeUTF(String aString) throws IOException
```

Writes the String value aString to the output stream. UTF refers to a particular method of encoding the string. To read the string back from the file, you should use the method readUTF of the class ObjectInputStream.

(continued)

Some Methods in ObjectOutputStream (Part 4 of 5)

Display 10.14 Some Methods in the Class ObjectOutputStream

```
public void writeObject(Object anObject) throws IOException
```

Writes its argument to the output stream. The object argument should be an object of a serializable class, a concept discussed later in this chapter. Throws various IOExceptions.

```
public void close() throws IOException
```

Closes the stream's connection to a file. This method calls `flush` before closing the file.

```
public void flush() throws IOException
```

Flushes the output stream. This forces an actual physical write to the file of any data that has been buffered and not yet physically written to the file. Normally, you should not need to invoke `flush`.

Eg. BinaryOutputDemo

Some Methods in ObjectOutputStream (Part 5 of 5)

- The class **ObjectInputStream** is a stream class that can be used to read from a binary file
 - An object of this class has methods to read strings, values of primitive types, and objects from a binary file
- A program using **ObjectInputStream** needs to import several classes from package **java.io**:

```
import java.io.ObjectInputStream;  
import java.io.FileInputStream;  
import java.io.IOException;
```

Reading Simple Data from a Binary File

- An **ObjectInputStream** object is created and connected to a binary file as follows:

```
ObjectInputStream inStreamName = new  
ObjectInputStream(new  
FileInputStream(fileName));
```

- The constructor for **FileInputStream** may throw a **FileNotFoundException**
- The constructor for **ObjectInputStream** may throw an **IOException**
- Each of these must be handled

Opening a Binary File for Reading

- After opening the file, **ObjectInputStream** methods can be used to read to the file
 - Methods used to input primitive values include **readInt**, **readDouble**, **readChar**, and **readBoolean**
 - The method **readUTF** is used to input values of type **String**
- If the file contains multiple types, each item type must be read in exactly the same order it was written to the file
- The stream should be closed after reading

Opening a Binary File for Reading

Display 10.15 Some Methods in the Class ObjectInputStream

The classes `ObjectInputStream` and `FileInputStream` are in the `java.io` package.

```
public ObjectInputStream(InputStream streamObject)
```

There is no constructor that takes a file name as an argument. If you want to create a stream using a file name, you use

```
new ObjectInputStream(new FileInputStream(File_Name))
```

Alternatively, you can use an object of the class `File` in place of the `File_Name`, as follows:

```
new ObjectInputStream(new FileInputStream(File_Object))
```

The constructor for `FileInputStream` may throw a `FileNotFoundException`, which is a kind of `IOException`. If the `FileInputStream` constructor succeeds, then the constructor for `ObjectInputStream` may throw a different `IOException`.

(continued)

Some Methods in ObjectInputStream (Part 1 of 5)

Display 10.15 Some Methods in the Class ObjectInputStream

```
public int readInt() throws IOException
```

Reads an `int` value from the input stream and returns that `int` value. If `readInt` tries to read a value from the file and that value was not written using the method `writeInt` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public int readShort() throws IOException
```

Reads a `short` value from the input stream and returns that `short` value. If `readShort` tries to read a value from the file and that value was not written using the method `writeShort` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

(continued)

Some Methods in ObjectInputStream (Part 2 of 5)

Display 10.15 Some Methods in the Class ObjectInputStream

```
public long readLong() throws IOException
```

Reads a `long` value from the input stream and returns that `long` value. If `readLong` tries to read a value from the file and that value was not written using the method `writeLong` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public double readDouble() throws IOException
```

Reads a `double` value from the input stream and returns that `double` value. If `readDouble` tries to read a value from the file and that value was not written using the method `writeDouble` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public float readFloat() throws IOException
```

Reads a `float` value from the input stream and returns that `float` value. If `readFloat` tries to read a value from the file and that value was not written using the method `writeFloat` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

(continued)

Some Methods in ObjectInputStream (Part 3 of 5)

Display 10.15 Some Methods in the Class ObjectInputStream

```
public char readChar() throws IOException
```

Reads a char value from the input stream and returns that char value. If readChar tries to read a value from the file and that value was not written using the method writeChar of the class ObjectOutputStream (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

```
public boolean readBoolean() throws IOException
```

Reads a boolean value from the input stream and returns that boolean value. If readBoolean tries to read a value from the file and that value was not written using the method writeBoolean of the class ObjectOutputStream (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

(continued)

Some Methods in ObjectInputStream (Part 4 of 5)

Display 10.15 Some Methods in the Class ObjectInputStream

```
public String readUTF() throws IOException
```

Reads a String value from the input stream and returns that String value. If readUTF tries to read a value from the file and that value was not written using the method writeUTF of the class ObjectOutputStream (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

```
Object readObject() throws ClassNotFoundException, IOException
```

Reads an object from the input stream. The object read should have been written using writeObject of the class ObjectOutputStream. Throws a ClassNotFoundException if a serialized object cannot be found. If an attempt is made to read beyond the end of the file, an EOFException is thrown. May throw various other IOExceptions.

```
public int skipBytes(int n) throws IOException
```

Skips n bytes.

```
public void close() throws IOException
```

Closes the stream's connection to a file.

Some Methods in ObjectInputStream (Part 5 of 5)

- All of the **ObjectInputStream** methods that read from a binary file throw an **EOFException** when trying to read beyond the end of a file
 - This can be used to end a loop that reads all the data in a file
- Note that different file-reading methods check for the end of a file in different ways
 - Testing for the end of a file in the wrong way can cause a program to go into an infinite loop or terminate abnormally
 - Eg. **EOFDemo**

Checking for the End of a Binary File

- Objects can also be input and output from a binary file
 - Use the **writeObject** method of the class **ObjectOutputStream** to write an object to a binary file
 - Use the **readObject** method of the class **ObjectInputStream** to read an object from a binary file
 - In order to use the value returned by **readObject** as an object of a class, it must be type cast first:

```
SomeClass someObject =  
(SomeClass) objectInputStream.readObject();
```

Binary I/O of Objects

- It is best to store the data of only one class type in any one file
 - Storing objects of multiple class types or objects of one class type mixed with primitives can lead to loss of data
- In addition, the class of the object being read or written must implement the **Serializable** interface
 - The **Serializable** interface is easy to use and requires no knowledge of interfaces
 - A class that implements the **Serializable** interface is said to be a *serializable class*

Binary I/O of Objects

- In order to make a class serializable, simply add **implements Serializable** to the heading of the class definition
`public class SomeClass implements Serializable`
- When a serializable class has instance variables of a class type, then all those classes must be serializable also
 - A class is not serializable unless the classes for all instance variables are also serializable for all levels of instance variables within classes

The Serializable Interface

- Since an array is an object, arrays can also be read and written to binary files using **readObject** and **writeObject**
 - If the base type is a class, then it must also be serializable, just like any other class type
 - Since **readObject** returns its value as type **Object** (like any other object), it must be type cast to the correct array type:

```
SomeClass[] someObject =  
(SomeClass[]) objectInputStream.readObject();
```

Array Objects in Binary Files

- The streams for sequential access to files are the ones most commonly used for file access in Java
- However, some applications require very rapid access to records in very large databases
 - These applications need to have random access to particular parts of a file

Random Access to Binary Files

- The stream class **RandomAccessFile**, which is in the **java.io** package, provides both read and write random access to a file in Java
- A random access file consists of a sequence of numbered bytes
 - There is a kind of marker called the *file pointer* that is always positioned at one of the bytes
 - All reads and writes take place starting at the *file pointer location*
 - The file pointer can be moved to a new location with the method **seek**

Reading and Writing to the Same File

- Although a random access file is byte oriented, there are methods that allow for reading or writing values of the primitive types as well as string values to/from a random access file
 - These include **readInt**, **readDouble**, and **readUTF** for input, and **writeInt**, **writeDouble**, and **writeUTF** for output
 - It does not have **writeObject** or **readObject** methods, however

Reading and Writing to the Same File

- The constructor for **RandomAccessFile** takes either a string file name or an object of the class **File** as its first argument
- The second argument must be one of four strings:
 - "**rw**", meaning the code can both read and write to the file after it is open
 - "**r**", meaning the code can read from the file, but not write to it
 - "**rws**" or "**rwd**" (See Table of methods from **RandomAccessFile**)

Opening a File

- If the file already exists, then when it is opened, the length is not reset to 0, and the file pointer will be positioned at the start of the file
 - This ensures that old data is not lost, and that the file pointer is set for the most likely position for reading (not writing)
- The length of the file can be changed with the **setLength** method
 - In particular, the **setLength** method can be used to empty the file

Pitfall: A Random Access File Need Not Start Empty

Display 10.21 Some Methods of the Class RandomAccessFile

The class RandomAccessFile is in the java.io package.

```
public RandomAccessFile(String fileName, String mode)  
public RandomAccessFile(File fileObject, String mode)
```

Opens the file, does not delete data already in the file, but does position the file pointer at the first (zeroth) location.

The mode must be one of the following:

- "r" Open for reading only.
- "rw" Open for reading and writing.
- "rws" Same as "rw", and also requires that every update to the file's content or metadata be written synchronously to the underlying storage device.
- "rwd" Same as "rw", and also requires that every update to the file's content be written synchronously to the underlying storage device.
- "rws" and "rwd" are not covered in this book.

(continued)

Some Methods of RandomAccessFile (Part 1 of 7)

Display 10.21 Some Methods of the Class RandomAccessFile

```
public long getFilePointer() throws IOException
```

Returns the current location of the file pointer. Locations are numbered starting with 0.

```
public void seek(long location) throws IOException
```

Moves the file pointer to the specified location.

```
public long length() throws IOException
```

Returns the length of the file.

```
public void setLength(long newLength) throws IOException
```

Sets the length of this file.

If the present length of the file as returned by the `length` method is greater than the `newLength` argument, then the file will be truncated. In this case, if the file pointer location as returned by the `getFilePointer` method is greater than `newLength`, then after this method returns, the file pointer location will be equal to `newLength`.

If the present length of the file as returned by the `length` method is smaller than `newLength`, then the file will be extended. In this case, the contents of the extended portion of the file are not defined.

(continued)

Some Methods of RandomAccessFile (Part 2 of 7)

Display 10.21 Some Methods of the Class RandomAccessFile

```
public void close() throws IOException
```

Closes the stream's connection to a file.

```
public void write(int b) throws IOException
```

Writes the specified byte to the file.

```
public void write(byte[] a) throws IOException
```

Writes `a.length` bytes from the specified byte array to the file.

```
public final void writeByte(byte b) throws IOException
```

Writes the byte `b` to the file.

```
public final void writeShort(short n) throws IOException
```

Writes the short `n` to the file.

(continued)

Some Methods of RandomAccessFile (Part 3 of 7)

Display 10.21 Some Methods of the Class RandomAccessFile

```
public final void writeInt(int n) throws IOException
```

Writes the int n to the file.

```
public final void writeLong(long n) throws IOException
```

Writes the long n to the file.

```
public final void writeDouble(double d) throws IOException
```

Writes the double d to the file.

```
public final void writeFloat(float f) throws IOException
```

Writes the float f to the file.

(continued)

Some Methods of RandomAccessFile (Part 4 of 7)

Display 10.21 Some Methods of the Class RandomAccessFile

```
public final void writeChar(char c) throws IOException
```

Writes the char c to the file.

```
public final void writeBoolean(boolean b) throws IOException
```

Writes the boolean b to the file.

```
public final void writeUTF(String s) throws IOException
```

Writes the String s to the file.

```
public int read() throws IOException
```

Reads a byte of data from the file and returns it as an integer in the range 0 to 255.

```
public int read(byte[] a) throws IOException
```

Reads a.length bytes of data from the file into the array of bytes a. Returns the number of bytes read or -1 if the end of the file is encountered.

(continued)

Some Methods of RandomAccessFile (Part 5 of 7)

Display 10.21 Some Methods of the Class RandomAccessFile

```
public final byte readByte() throws IOException
```

Reads a byte value from the file and returns that value. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

```
public final short readShort() throws IOException
```

Reads a short value from the file and returns that value. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

```
public final int readInt() throws IOException
```

Reads an int value from the file and returns that value. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

```
public final long readLong() throws IOException
```

Reads a long value from the file and returns that value. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

(continued)

Some Methods of RandomAccessFile (Part 6 of 7)

Display 10.21 Some Methods of the Class RandomAccessFile

```
public final double readDouble() throws IOException
```

Reads a double value from the file and returns that value. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

```
public final float readFloat() throws IOException
```

Reads a float value from the file and returns that value. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

```
public final char readChar() throws IOException
```

Reads a char value from the file and returns that value. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

```
public final boolean readBoolean() throws IOException
```

Reads a boolean value from the file and returns that value. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

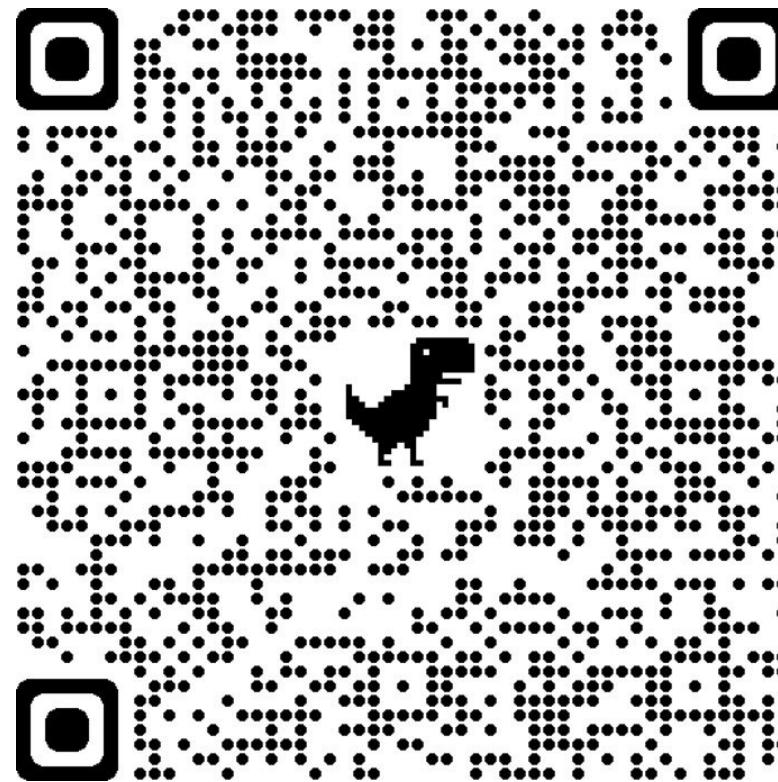
```
public final String readUTF() throws IOException
```

Reads a String value from the file and returns that value. If an attempt is made to read beyond the end of the file, an EOFException is thrown.

Some Methods of RandomAccessFile (Part 5 of 7)

- Which moment or experience from COMP90041 this week was significant or important to you?
- Why do you think this experience was significant
 - Examine your experience. Why do you care?)
- What insights have you had?
 - What can you learn from the experience?)
- How is this experience going to help you in the future?
- What questions have come up for you?

Class Reflections



<http://go.unimelb.edu.au/5o8i>

Class Reflections