Streams and File I/O

Chapter 9

JAVA: An Introduction to Problem Solving & Programming, Fourth Edition by Walter Savitch.
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Objectives

- become familiar with the concept of an I/O stream
- understand the difference between binary files and text files
- learn how to save data in a file
- learn how to read data from a file

Outline

- Overview of Streams and File I/O
- Text-File I/O
- Using the `File` Class
- Basic Binary-File I/O
- Object I/O with Object Streams
- (optional) Graphics Supplement

Objectives, cont.

- learn how use the classes `ObjectOutputStream` and `ObjectInputStream` to read and write class objects with binary files

I/O Overview

- *I/O* = Input/Output
- In this context it is input to and output from programs
- Input can be from keyboard or a file
- Output can be to display (screen) or a file
- Advantages of file I/O
  - permanent copy
  - output from one program can be input to another
  - input can be automated (rather than entered manually)

Note: Since the sections on text file I/O and binary file I/O have some similar information, some duplicate (or nearly duplicate) slides are included.

Streams

- ***Stream***: an object that either delivers data to its destination (screen, file, etc.) or that takes data from a source (keyboard, file, etc.)
  - it acts as a buffer between the data source and destination
- ***Input stream***: a stream that provides input to a program
  - `System.in` is an input stream
- ***Output stream***: a stream that accepts output from a program
  - `System.out` is an output stream
- A stream connects a program to an I/O object
  - `System.out` connects a program to the screen
  - `System.in` connects a program to the keyboard

Binary Versus Text Files

- *All* data and programs are ultimately just zeros and ones
  - each digit can have one of two values, hence *binary*
  - *bit* is one binary digit
  - *byte* is a group of eight bits
- *Text files*: the bits represent printable characters
  - one byte per character for ASCII, the most common code
  - for example, Java source files are text files
  - so is any file created with a "text editor"
- *Binary files*: the bits represent other types of encoded information, such as executable instructions or numeric data
  - these files are easily read by the computer but not humans
  - they are *not* "printable" files
    - actually, you *can* print them, but they will be unintelligible
    - "printable" means "easily readable by humans when printed"

Java: Text Versus Binary Files

- Text files are more readable by humans
- Binary files are more efficient
  - computers read and write binary files more easily than text
- Java binary files are portable
  - they can be used by Java on different machines
  - Reading and writing binary files is normally done by a program
  - text files are used only to communicate with humans

Java Text Files

- Source files
- Occasionally input files
- Occasionally output files

Java Binary Files

- Executable files (created by compiling source files)
- Usually input files
- Usually output files

Text Files vs. Binary Files

- Number: 127 (decimal)
  - Text file
    - Three bytes: “1”, “2”, “7”
    - ASCII (decimal): 49, 50, 55
    - ASCII (octal): 61, 62, 67
    - ASCII (binary): 00110001, 00110010, 00110111
  - Binary file:
    - One byte (`byte`)**:** 01111110
    - Two bytes (`short`): 00000000 01111110
    - Four bytes (`int`): 00000000 00000000 00000000 01111110

Text file: an example

[unix: od –w8 –bc <file>]

[http://www.muquit.com/muquit/software/hod/hod.html for a Windows tool]

```
127     smiley
faces



0000000 061 062 067 011 163 155 151 154
          1   2   7  \t   s   m   i   l
0000010 145 171 012 146 141 143 145 163
          e   y  \n   f   a   c   e   s
0000020 012
         \n
```

Binary file: an example [a .class file]

```
0000000 312 376 272 276 000 000 000 061
        312 376 272 276  \0  \0  \0   1
0000010 000 164 012 000 051 000 062 007
         \0   t  \n  \0   )  \0   2  \a
0000020 000 063 007 000 064 010 000 065
         \0   3  \a  \0   4  \b  \0   5
0000030 012 000 003 000 066 012 000 002
         \n  \0 003  \0   6  \n  \0 002

...
0000630 000 145 000 146 001 000 027 152
         \0   e  \0   f 001  \0 027   j
0000640 141 166 141 057 154 141 156 147
          a   v   a   /   l   a   n   g
0000650 057 123 164 162 151 156 147 102
          /   S   t   r   i   n   g   B
0000660 165 151 154 144 145 162 014 000
          u   i   l   d   e   r  \f  \0
```

Text File I/O

- Important classes for text file **output** (to the file)
  - **`PrintWriter`**
  - **`FileOutputStream`** [or **`FileWriter`**]
- Important classes for text file **input** (from the file):
  - **`BufferedReader`**
  - **`FileReader`**
- **`FileOutputStream`** and **`FileReader`** take file names as arguments.
- **`PrintWriter`** and **`BufferedReader`** provide useful methods for easier writing and reading.
- Usually need a combination of two classes
- To use these classes your program needs a line like the following:

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

Buffering

- Not buffered: each byte is read/written from/to disk as soon as possible
  - "little" delay for each byte
  - A disk operation per byte---higher overhead
- Buffered: reading/writing in "chunks"
  - Some delay for some bytes
    - Assume 16-byte buffers
    - Reading: access the first 4 bytes, need to wait for all 16 bytes are read from disk to memory
    - Writing: save the first 4 bytes, need to wait for all 16 bytes before writing from memory to disk
  - A disk operation per a buffer of bytes---lower overhead

Every File Has Two Names

1. the stream name used by Java
   - `outputStream` in the example
2. the name used by the operating system
   - `out.txt` in the example

Text File Output

- To open a text file for output: connect a text file to a stream for writing

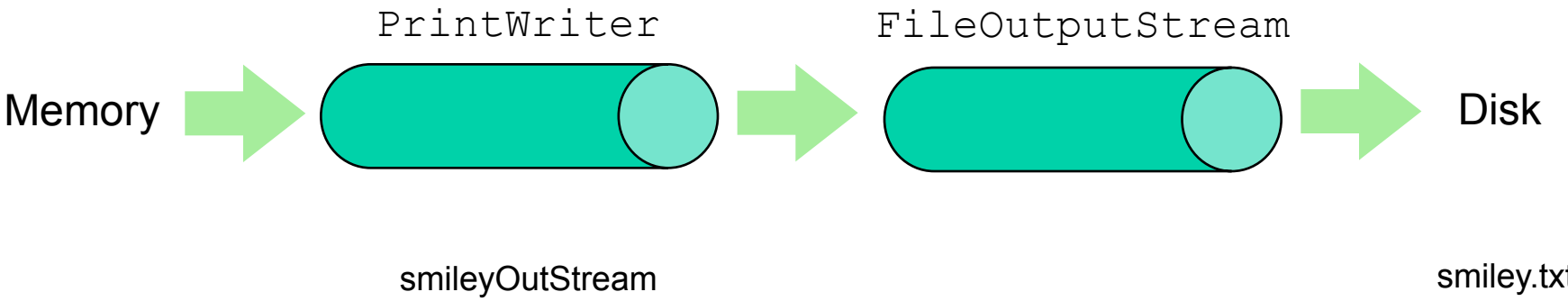
```
PrintWriter outputStream =
   new PrintWriter(new FileOutputStream("out.txt"));
```

- Similar to the long way:

```
FileOutputStream s = new FileOutputStream("out.txt");
PrintWriter outputStream = new PrintWriter(s);
```

- Goal: create a `PrintWriter` object
  - which uses `FileOutputStream` to open a text file
- `FileOutputStream` "connects" `PrintWriter` to a text file.

Output File Streams



PrintWriter smileyOutStream = new PrintWriter(new FileOutputStream(“smiley.txt”));

Methods for `PrintWriter`

- Similar to methods for `System.out`
- `println`

```
outputStream.println(count + " " + line);
```

- `print`
- `format`
- `flush`: write buffered output to disk
- `close`: close the `PrintWriter` stream (and file)

TextFileOutputDemo

Part 1

```
public static void main(String[] args)
{
    PrintWriter outputStream = null;
    try
    {
        outputStream =
              new PrintWriter(new
   FileOutputStream("out.txt"));
    }
    catch(FileNotFoundException e)
    {
        System.out.println("Error opening the file out.txt. "
                           + e.getMessage());
        System.exit(0);
    }
```

A `try`-block is a block: `outputStream` would not be accessible to the rest of the method if it were declared inside the `try`-block

Opening the file

Creating a file can cause the `FileNotFound-Exception` if the new file cannot be made.

TextFileOutputDemo

Part 2

```
System.out.println("Enter three lines of text:");
String line = null;
int count;
    for (count = 1; count <= 3; count++)
    {
        line = keyboard.nextLine();
        outputStream.println(count + " " + line);
    }
    outputStream.close();
    System.out.println("... written to out.txt.");
}
```

Writing to the file

Closing the file

The `println` method is used with two different streams: `outputStream` and `System.out`

Gotcha: Overwriting a File

- Opening an output file creates an empty file
- Opening an output file creates a new file if it does not already exist
- Opening an output file that already exists eliminates the old file and creates a new, empty one
  - data in the original file is lost
- To see how to check for existence of a file, see the section of the text that discusses the `File` class (later slides).

Java Tip: Appending to a Text File

- To add/append to a file instead of replacing it, use a different constructor for **`FileOutputStream`**:

```
outputStream =
   new PrintWriter(new FileOutputStream("out.txt", true));
```

- Second parameter: append to the end of the file if it exists?
- Sample code for letting user tell whether to replace or append:

```
System.out.println("A for append or N for new file:");
char ans = keyboard.next().charAt(0);
boolean append = (ans == 'A' || ans == 'a');
outputStream = new PrintWriter(
      new FileOutputStream("out.txt", append));
```

true if user enters 'A'

Closing a File

- An output file should be closed when you are done writing to it (and an input file should be closed when you are done reading from it).

- Use the `close` method of the class `PrintWriter` (`BufferedReader` also has a `close` method).

- For example, to close the file opened in the previous example:

```
outputStream.close();
```

- If a program ends normally it will close any files that are open.

FAQ: Why Bother to Close a File?

If a program automatically closes files when it ends normally, why close them with explicit calls to `close`?

Two reasons:

1. To make sure it is closed if a program ends abnormally (it could get damaged if it is left open).

2. A file opened for writing must be closed before it can be opened for reading.
    - Although Java does have a class that opens a file for both reading and writing, it is not used in this text.

Text File Input

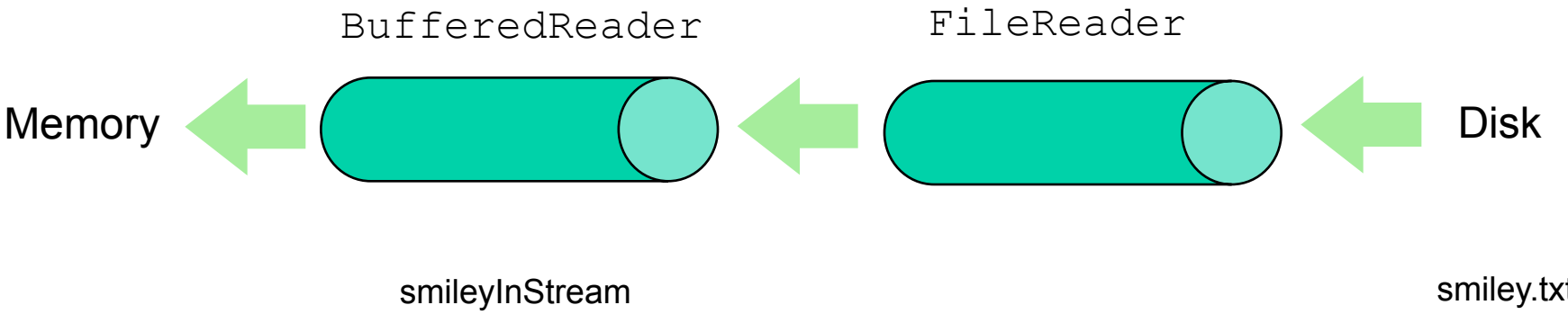
- To open a text file for input: connect a text file to a stream for reading
  - Goal: a `BufferedReader` object,
    - which uses `FileReader` to open a text file
  - `FileReader` "connects" `BufferedReader` to the text file
- For example:

```
BufferedReader smileyInStream =
  new BufferedReader(new FileReader("smiley.txt"));
```

- Similarly, the long way:

```
FileReader s = new FileReader("smiley.txt");
BufferedReader smileyInStream = new
  BufferedReader(s);
```

Input File Streams




```
BufferedReader smileyInStream = new BufferedReader( new FileReader("smiley.txt") );
```

Methods for `BufferedReader`

- `readLine`: read a line into a `String`
- no methods to read numbers directly, so read numbers as `String`s and then convert them (`StringTokenizer` later)
- `read`: read a `char` at a time
- `close`: close `BufferedReader` stream

Exception Handling with File I/O

Catching IOExceptions

- `IOException` is a predefined class
- File I/O might throw an `IOException`
- catch the exception in a catch block that at least prints an error message and ends the program
- `FileNotFoundException` is derived from `IOException`
  - therefor any catch block that catches `IOExceptions` also catches `FileNotFoundExceptions`
  - put the more specific one first (the derived one) so it catches specifically file-not-found exceptions
  - then you will know that an I/O error is something other than file-not-found

Example: Reading a File Name from the Keyboard

reading a file name from the keyboard

using the file name read from the keyboard

reading data from the file

closing the file

```
public static void main(String[] args)
  {
    String fileName = null;  // outside try block, can be used in catch
    try
    { Scanner keyboard = new Scanner(System.in);
      System.out.println("Enter file name:");
      fileName = keyboard.next();
      BufferedReader inputStream =
        new BufferedReader(new FileReader(fileName));
      String line = null;
      line = inputStream.readLine();
      System.out.println("The first line in " + filename + " is:");
      System.out.println(line);
      // . . . code for reading second line not shown here . . .
      inputStream.close();
    }
    catch(FileNotFoundException e)
    {
      System.out.println("File " + filename + " not found.");
    }
    catch(IOException e)
    {
      System.out.println("Error reading from file " + fileName);
    }
  }
```

Exception.getMessage()

```
try
{
   …
}
catch (FileNotFoundException e)
{
   System.out.println(filename + " not found");
   System.out.println("Exception: " +
                      e.getMessage());
   System.exit(-1);
}
```

Reading Words in a String: Using `StringTokenizer` Class

- There are `BufferedReader` methods to read a line and a character, but not just a single word

- `StringTokenizer` can be used to parse a line into words
  - import `java.util.*`
  - some of its useful methods are shown in the text
    - e.g. test if there are more tokens
  - you can specify *delimiters* (the character or characters that separate words)
    - the default delimiters are "white space" (space, tab, and newline)

Example: `StringTokenizer`

- Display the words separated by any of the following characters: space, new line (\n), period (.) or comma (,).

```
String inputLine = keyboard.nextLine();
StringTokenizer wordFinder =
            new StringTokenizer(inputLine, " \n.,");
//the second argument is a string of the 4 delimiters
while(wordFinder.hasMoreTokens())
{
   System.out.println(wordFinder.nextToken());
}
```

Entering "`Question,2b.or !tooBee.`" gives this output:

```
Question
2b
or
!tooBee
```

Testing for End of File in a Text File

- When `readLine` tries to read beyond the end of a text file it returns the special value *`null`*
  - so you can test for `null` to stop processing a text file
- `read` returns -1 when it tries to read beyond the end of a text file
  - the `int` value of all ordinary characters is nonnegative
- Neither of these two methods (`read` and `readLine`) will throw an `EOFException`.

Example: Using Null to Test for End-of-File in a Text File

When using **`readLine`** test for `null`

Excerpt from `TextEOFDemo`

```
int count = 0;
String line = inputStream.readLine();
while (line != null)
{
   count++;
   outputStream.println(count + " " + line);
   line = inputStream.readLine();
}
```

When using **`read`** test for -1

File I/O example

- http://www.cs.fit.edu/~pkc/classes/cse1001/FileIO/FileIO.java

Using Path Names

- ***Path name***—gives name of file and tells which directory the file is in
- ***Relative path name***—gives the path starting with the directory that the program is in
- Typical UNIX path name:

```
/user/smith/home.work/java/FileClassDemo.java
```

- Typical Windows path name:

```
D:\Work\Java\Programs\FileClassDemo.java
```

- When a backslash is used in a quoted string it must be written as two backslashes since backslash is the escape character:

```
"D:\\Work\\Java\\Programs\\FileClassDemo.java"
```

- Java will accept path names in UNIX or Windows format, regardless of which operating system it is actually running on.

`File` Class `[java.io]`

- Acts like a wrapper class for file names
- A file name like "`numbers.txt`" has only `String` properties
- `File` has some very useful methods
  - `exists`: tests if a file already exists
  - `canRead`: tests if the OS will let you read a file
  - `canWrite`: tests if the OS will let you write to a file
  - `delete`: deletes the file, returns true if successful
  - `length`: returns the number of bytes in the file
  - `getName`: returns file name, excluding the preceding path
  - `getPath`: returns the path name—the full name

```
File numFile = new File(“numbers.txt”);
if (numFile.exists())
   System.out.println(numfile.length());
```

`File` Objects and Filenames

- `FileInputStream` and `FileOutputStream` have constructors that take a `File` argument as well as constructors that take a `String` argument

```
PrintWriter smileyOutStream = new PrintWriter(new
   FileOutputStream("smiley.txt"));

File smileyFile = new File("smiley.txt");
if (smileyFile.canWrite())
   PrintWriter smileyOutStream = new
   PrintWriter(new FileOutputStream(smileyFile));
```

Alternative with Scanner

- Instead of `BufferedReader` with `FileReader`, then `StringTokenizer`
- Use `Scanner` with `File`:

```
Scanner inFile =
    new Scanner(new File("in.txt"));
```

- Similar to `Scanner` with `System.in`:

```
Scanner keyboard =
    new Scanner(System.in);
```

Reading in `int`'s

```
Scanner inFile = new Scanner(new File("in.txt"));
int number;
while (inFile.hasInt())
   {
      number = inFile.nextInt();
      // …
   }
```

Reading in lines of characters

```
Scanner inFile = new Scanner(new File(“in.txt"));
String line;
while (inFile.hasNextLine())
   {
      line = inFile.nextLine();
      // …
   }
```

Multiple types on one line

```
// Name, id, balance
Scanner inFile = new Scanner(new File(“in.txt"));
while (inFile.hasNext())
  {
    name = inFile.next();
    id = inFile.nextInt();
    balance = inFile.nextFloat();
    // …  new Account(name, id, balance);
  }
--------------------
String line;
while (inFile.hasNextLine())
  {
    line = inFile.nextLine();
    Scanner parseLine = new Scanner(line) // Scanner again!
    name = parseLine.next();
    id = parseLine.nextInt();
    balance = parseLine.nextFloat();
    // …  new Account(name, id, balance);
  }
```

Multiple types on one line

```
// Name, id, balance
Scanner inFile = new Scanner(new File(“in.txt"));
String line;
while (inFile.hasNextLine())
  {
    line = inFile.nextLine();
    Account account = new Account(line);
  }
--------------------
public Account(String line) // constructor
{
  Scanner accountLine = new Scanner(line);
  _name = accountLine.next();
  _id = accountLine.nextInt();
  _balance = accountLine.nextFloat();
}
```

`BufferedReader` vs `Scanner` (parsing primitive types)

- `Scanner`
  - `nextInt(), nextFloat(),` … for parsing types
- `BufferedReader`
  - `read(), readLine(),` … none for parsing types
  - needs `StringTokenizer` then wrapper class methods like `Integer.parseInt(token)`

`BufferedReader` vs `Scanner` (Checking End of File/Stream (EOF))

- `BufferedReader`
  - `readLine()` returns `null`
  - `read()` returns -1
- `Scanner`
  - `nextLine()` throws exception
  - needs `hasNextLine()` to check first
  - `nextInt()`, `hasNextInt()`, ...

```
BufferedReader inFile = …
line = inFile.readline();
while (line != null)
{
   // …
   line = inFile.readline();
}

--------------------

Scanner inFile = …
while (inFile.hasNextLine())
{
   line = infile.nextLine();
   // …
}
```

```
BufferedReader inFile = …
line = inFile.readline();
while (line != null)
{
   // …
   line = inFile.readline();
}

--------------------

BufferedReader inFile = …
while ((line = inFile.readline()) != null)
{
   // …
}
```

My suggestion

- Use `Scanner` with `File`
  - `new Scanner(new File("in.txt"))`
- Use `hasNext…()` to check for EOF
  - `while (inFile.hasNext…())`
- Use `next…()` to read
  - `inFile.next…()`
- Simpler and you are familiar with methods for `Scanner`

My suggestion cont…

- File input
  - `Scanner inFile =`
    `new Scanner(new File("in.txt"));`
- File output
  - `PrintWriter outFile =`
    `new PrintWriter(new File("out.txt"));`
  - `outFile.print(), println(), format(), flush(), close(), …`
- http://www.cs.fit.edu/~pkc/classes/cse1001/FileIO/FileIONew.java

Skipping binary file I/O for now; if we have time, we'll come back

Basic Binary File I/O

- Important classes for binary file **output** (to the file)
  - **`ObjectOutputStream`**
  - **`FileOutputStream`**
- Important classes for binary file **input** (from the file):
  - **`ObjectInputStream`**
  - **`FileInputStream`**
- Note that **`FileOutputStream`** and **`FileInputStream`** are used only for their constructors, which can take file names as arguments.
  - **`ObjectOutputStream`** and **`ObjectInputStream`** cannot take file names as arguments for their constructors.
- To use these classes your program needs a line like the following:

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

Java File I/O: Stream Classes

- `ObjectInputStream` and `ObjectOutputStream`:
  - have methods to either read or write data one byte at a time
  - automatically convert numbers and characters into binary
    - binary-encoded numeric files (files with numbers) are not readable by a text editor, but store data more efficiently
- Remember:
  - *input* means data into a program, not the file
  - similarly, *output* means data out of a program, not the file

When Using `ObjectOutputStream` to Output Data to Files:

- The output files are binary and can store any of the primitive data types (`int`, `char`, `double`, etc.) and the `String` type
- The files created can be read by other Java programs but are not printable
- The Java I/O library must be imported by including the line:
  `import java.io.*;`
  - it contains `ObjectOutputStream` and other useful class definitions
- An `IOException` might be thrown

Handling `IOException`

- `IOException` cannot be ignored
  - either handle it with a catch block
  - or defer it with a `throws`-clause

We will put code to open the file and write to it in a `try`-block and write a `catch`-block for this exception :

```
catch(IOException e)
{
  System.out.println("Problem with output...";
}
```

Opening a New Output File

- The file name is given as a `String`
  - file name rules are determined by your operating system

- Opening an output file takes two steps
  1. Create a `FileOutputStream` object associated with the file name `String`
  2. Connect the `FileOutputStream` to an `ObjectOutputStream` object

  This can be done in one line of code

Example: Opening an Output File

To open a file named `numbers.dat`:

```
ObjectOutputStream outputStream =
  new ObjectOutputStream(
  new FileOutputStream("numbers.dat"));
```

- The constructor for `ObjectOutputStream` requires a `FileOutputStream` argument
- The constructor for `FileOutputStream` requires a `String` argument
  - the `String` argument is the output file name
- The following two statements are equivalent to the single statement above:

```
FileOutputStream middleman =
  new FileOutputStream("numbers.dat");
ObjectOutputStream outputStream =
  new ObjectOutputSteam(middleman);
```

Some `ObjectOutputStream` Methods

- You can write data to an output file after it is connected to a stream class
  - Use methods defined in `ObjectOutputStream`
    - `writeInt(int n)`
    - `writeDouble(double x)`
    - `writeBoolean(boolean b)`
    - etc.
    - See the text for more

- Note that each write method throws `IOException`
  - eventually we will have to write a catch block for it

- Also note that each write method includes the modifier `final`
  - `final` methods cannot be redefined in derived classes

Closing a File

- An Output file should be closed when you are done writing to it
- Use the `close` method of the class `ObjectOutputStream`
- For example, to close the file opened in the previous example:

```
outputStream.close();
```

- If a program ends normally it will close any files that are open

Writing a Character to a File: an Unexpected Little Complexity

- The method `writeChar` has an annoying property:
  - it takes an `int`, not a `char`, argument
- But it is easy to fix:
  - just cast the character to an int
- For example, to write the character 'A' to the file opened previously:

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

- Or, just use the automatic conversion from `char` to `int`

Writing a **`boolean`** Value to a File

- `boolean` values can be either of two values, `true` or `false`

- `true` and `false` are not just names for the values, they actually are of type `boolean`

- For example, to write the `boolean` value `false` to the output file:

```
outputStream.writeBoolean(false);
```

Writing Strings to a File: Another Little Unexpected Complexity

- Use the `writeUTF` method to output a value of type `String`
  - there is no `writeString` method
- UTF stands for Unicode Text Format
  - a special version of Unicode
- Unicode: a text (printable) code that uses 2 bytes per character
  - designed to accommodate languages with a different alphabet or no alphabet (such as Chinese and Japanese)
- ASCII: also a text (printable) code, but it uses just 1 byte per character
  - the most common code for English and languages with a similar alphabet
- UTF is a modification of Unicode that uses just one byte for ASCII characters
  - allows other languages without sacrificing efficiency for ASCII files

When Using `ObjectInputStream` to Read Data from Files:

- Input files are binary and contain any of the primitive data types (`int`, `char`, `double`, etc.) and the `String` type
- The files can be read by Java programs but are not printable
- The Java I/O library must be imported including the line:
  `import java.io.*;`
  - it contains `ObjectInputStream` and other useful class definitions
- An `IOException` might be thrown

Opening a New Input File

- Similar to opening an output file, but replace "output" with "input"
- The file name is given as a `String`
  - file name rules are determined by your operating system
- Opening a file takes two steps
  1. Creating a `FileInputStream` object associated with the file name `String`
  2. Connecting the `FileInputStream` to an `ObjectInputStream` object
- This can be done in one line of code

Example: Opening an Input File

To open a file named `numbers.dat`:

```
ObjectInputStream inStream =
  new ObjectInputStream (new
  FileInputStream("numbers.dat"));
```

- The constructor for `ObjectInputStream` requires a `FileInputStream` argument
- The constructor for `FileInputStream` requires a `String` argument
  - the `String` argument is the input file name
- The following two statements are equivalent to the statement at the top of this slide:

```
FileInputStream middleman =
  new FileInputStream("numbers.dat");
ObjectInputStream inputStream =
  new ObjectInputStream (middleman);
```

Some `ObjectInputStream` Methods

- For every output file method there is a corresponding input file method
- You can read data from an input file after it is connected to a stream class
  - Use methods defined in `ObjectInputStream`
    - `readInt()`
    - `readDouble()`
    - `readBoolean()`
    - etc.
    - See the text for more
- Note that each write method throws `IOException`
- Also note that each write method includes the modifier `final`

Input File Exceptions

- A `FileNotFoundException` is thrown if the file is not found when an attempt is made to open a file
- Each read method throws `IOException`
  - we still have to write a catch block for it
- If a read goes beyond the end of the file an `EOFException` is thrown

Avoiding Common `ObjectInputStream` File Errors

There is no error message (or exception) if you read the wrong data type!

- Input files can contain a mix of data types
  - it is up to the programmer to know their order and use the correct read method
- `ObjectInputStream` works with binary, not text files
- As with an output file, close the input file when you are done with it

Common Methods to Test for the End of an Input File

- A common programming situation is to read data from an input file but not know how much data the file contains

- In these situations you need to check for the end of the file

- There are three common ways to test for the end of a file:
  1. Put a sentinel value at the end of the file and test for it.
  2. Throw and catch an end-of-file exception.
  3. Test for a special character that signals the end of the file (text files often have such a character).

The `EOFException` Class

- Many (but not all) methods that read from a file throw an end-of-file exception (`EOFException`) when they try to read beyond the file
  - all the `ObjectInputStream` methods in Display 9.3 do throw it
- The end-of-file exception can be used in an "infinite" (`while(true)`) loop that reads and processes data from the file
  - the loop terminates when an `EOFException` is thrown
- The program is written to continue normally after the `EOFException` has been caught

Using `EOFException`

`main` method from `EOFExceptionDemo`

```
try
{
   ObjectInputStream inputStream =
     new ObjectInputStream(new FileInputStream("numbers.dat"));
   int n;

   System.out.println("Reading ALL the integers");
   System.out.println("in the file numbers.dat.");
   try
   {
      while (true)
      {
         n = inputStream.readInt();
         System.out.println(n);
      }
   }
   catch(EOFException e)
   {
      System.out.println("End of reading from file.");
   }
   inputStream.close();
}
catch(FileNotFoundException e)
{
   System.out.println("Cannot find file numbers.dat.");
}
catch(IOException e)
{
   System.out.println("Problem with input from file numbers.dat.");
}
```

Intentional "infinite" loop to process data from input file

Loop exits when end-of-file exception is thrown

Processing continues after `EOFException`: the input file is closed

Note order of catch blocks: the most specific is first and the most general last

Binary I/O of Class Objects

- read and write class objects in binary file

- class must be ***serializable***
  - **`import java.io.*`**
  - implement **`Serializable`** interface
  - add **`implements Serializable`** to heading of class definition

```
public class Species implements Serializable
```

- **`methods used:`**

  to **write** object to file:
  `writeObject` method in
  `ObjectOutputStream`

  to **read** object from file:
  `readObject` method in
  `ObjectInputStream`

```
outputStream = new ObjectOutputStream(
        new FileOutputStream("species.records"));
...
Species oneRecord =
        new Species("Calif. Condor, 27, 0.02);
...
outputStream.writeObject(oneRecord);
```

`ClassIODemo` Excerpts

```
inputStream = new ObjectInputStream(
        new FileInputStream("species.records"));
...
Species readOne = null;
...
readOne = (Species)inputStream.readObject(oneRecord);
```

`readObject` returns a reference to type `Object` so it must be cast to `Species` before assigning to readOne

The `Serializable` Interface

- Java assigns a serial number to each object written out.
  - If the same object is written out more than once, after the first write only the serial number will be written.
  - When an object is read in more than once, then there will be more than one reference to the same object.
- If a serializable class has class instance variables then they should also be serializable.
- Why aren't all classes made serializable?
  - security issues: serial number system can make it easier for programmers to get access to object data
  - doesn't make sense in all cases, e.g., system-dependent data

Summary
Part 1

- *Text files* contain strings of printable characters; they look intelligible to humans when opened in a text editor.
- *Binary files* contain numbers or data in non-printable codes; they look *un*intelligible to humans when opened in a text editor.
- Java can process both binary and text files, but binary files are more common when doing file I/O.
- The class `ObjectOutputStream` is used to write output to a binary file.

Summary
Part 2

- The class `ObjectInputStream` is used to read input from a binary file.
- Always check for the end of the file when reading from a file. The way you check for end-of-file depends on the method you use to read from the file.
- A file name can be read from the keyboard into a `String` variable and the variable used in place of a file name.
- The class `File` has methods to test if a file exists and if it is read- and/or write-enabled.
- Serializable class objects can be written to a binary file.