File I/O

Topics:

including

- Saving Data: Serialisation *versus* Using a Text File
- Java I/O Connection and Chain Streams
- Reading from/Writing to a Text File: Java Classes
- `File` objects (`java.io.File`)

Chapter 18 – “Big Java” book
Chapter 14 – “Head First Java” book
Chapters 8,18 – “Introduction to Java Programming” book
Chapter 10 – “Java in a Nutshell” book

Saving Data/State (1/2)

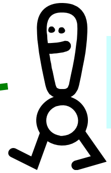
- Data stored in variables, arrays, objects is temporary: once a program has finished executing, information is lost!
  - Example: Java program that *counts the number of characters and words in a line of text*.
    - Once program has run and displayed statistics, that output is lost if not saved somewhere!

Can you think of other examples?

- *Saving data* requires information to be stored in a file on a disk/CD.
  - How a program’s data is stored depends on what the user intends to do with the data!

Saving Data/State (2/2)

- There are two ways of saving data:
  - Using *serialisation*
    - The data stored will only be used by the Java program that generated it.
    - Example: A program wants to save its current state so that it can be loaded at a later date.
  - Using a file (such as a plain text file)
    - The data stored in the file needs to be used by other programs.
    - Example: A .csv (comma separated values) file can be read by spreadsheet programs (such as Excel).



Out of scope in this course!

What is I/O?

- Computer programs need to interact with the world:
  - *Bring in* information from an external source;
  - *Send out* information to an external destination.
- This interaction is what we refer to as Input/Output:
  - *Input*: to bring in information (*read*)
  - *Output*: to send out information (*write*)
- Information for Input/Output can be:
  - *anywhere*: memory, disk, in a file, over the network, in another program …
  - *of any type* (any object): Text, Image, Audio, Video …

Examples: I/O Devices

To be completed in class …

- Monitor
- Printer
- Scanner
- Speaker
- Hard disk
- Keyboard
- Mouse

Which are input devices?
Which are output devices?

There are many other examples of I/O devices …

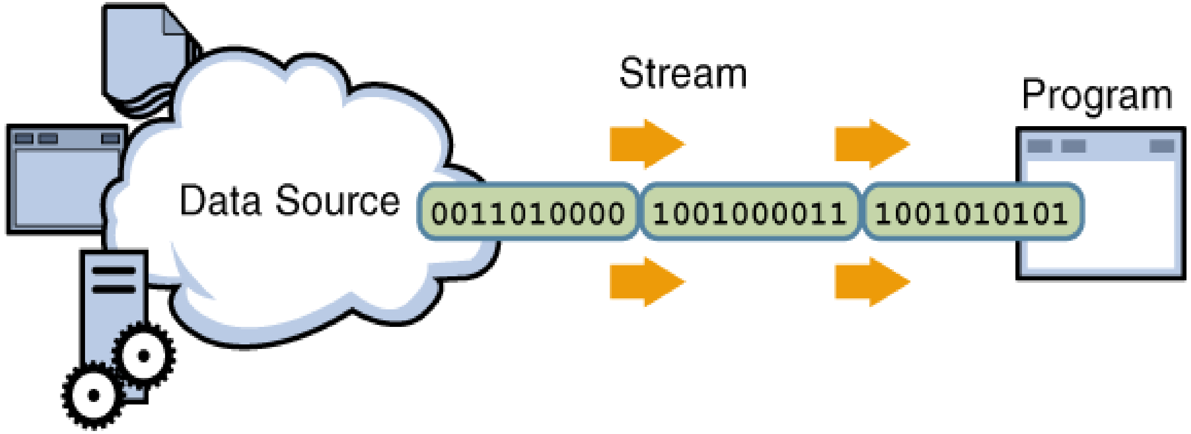
Streams

- Java input/output makes use of *streams*:
  - A stream is a connection to a source of data or to a destination for data (sometimes both).
  - Streams can represent any data, so a stream is a sequence of bytes that flow from a source to a destination.
- In a program, we *read information* from an input stream and *write information* to an output stream.
- A program can manage multiple streams simultaneously.

Input (*reading*) & Output (*writing*)

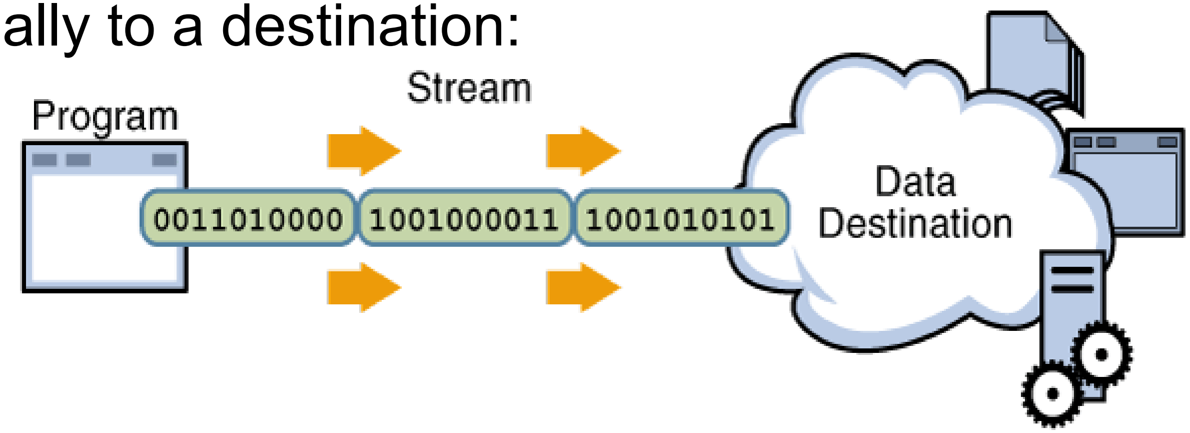
Program *reads a stream* sequentially from a source:

```
1. Open the stream.
2. Use the stream:
     while more information (data)
       read information (data)
3. Close the stream.
```

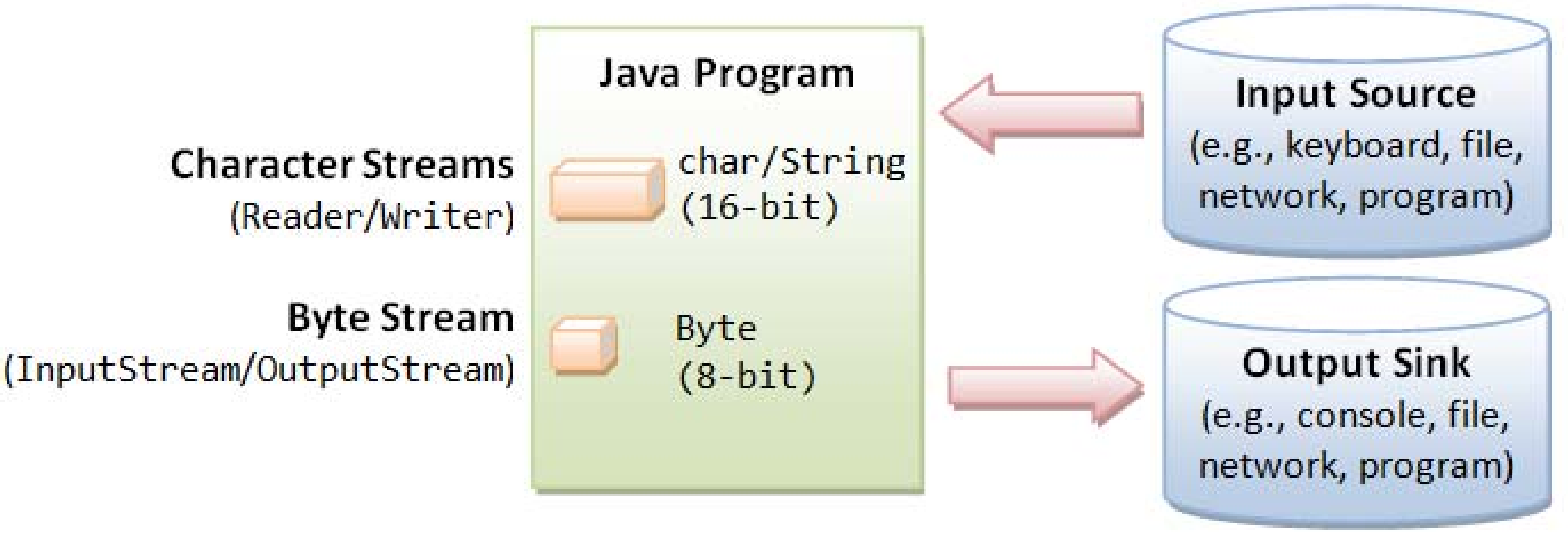


Program *writes a stream* sequentially to a destination:

```
1. Open the stream.
2. Use the stream:
     while more information (data)
       write information (data)
3. Close the stream.
```



Streams (*again …*)

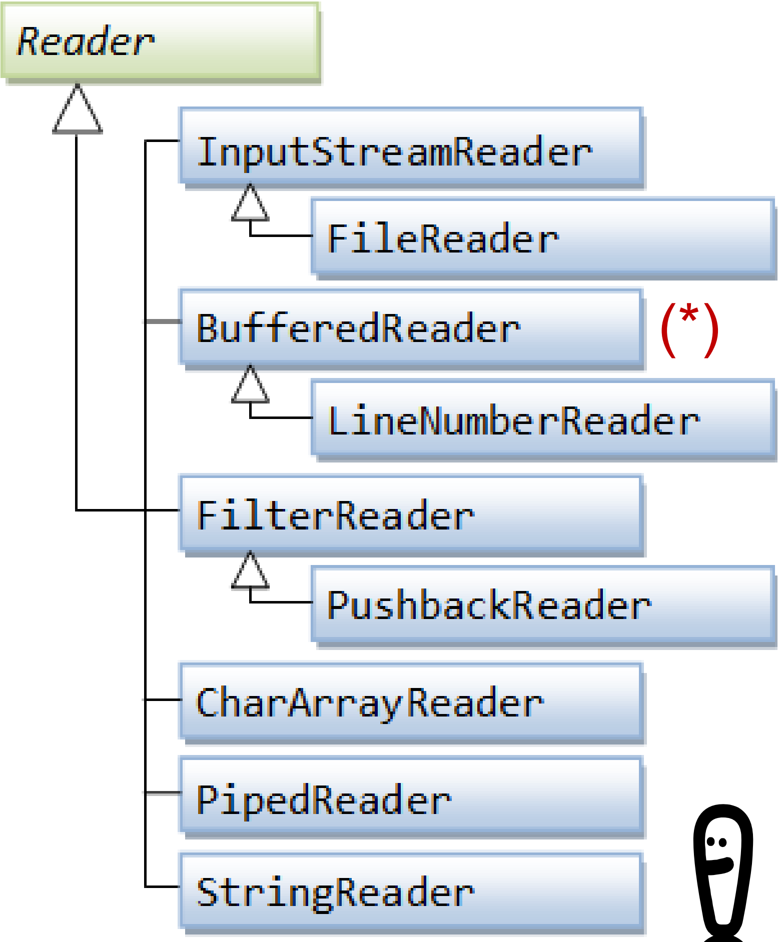


- Java has two broad categories of streams:
  - byte streams, for machine-formatted data
    - **`InputStream`**
    - **`OutputStream`**
  - character streams (textual), for human-readable data
    - **`Reader`**
    - **`Writer`**

- Binary Files (raw bytes)
- Text Files in various encodings (US-ASCII, ISO-8859-1, UCS-2, UTF-8, UTF-16, UTF-16BE, UTF16-LE, etc.)

I/O Classes

(*) I/O classes used in this course.



Reader

InputStreamReader

FileReader (*)

BufferedReader (*)

LineNumberReader

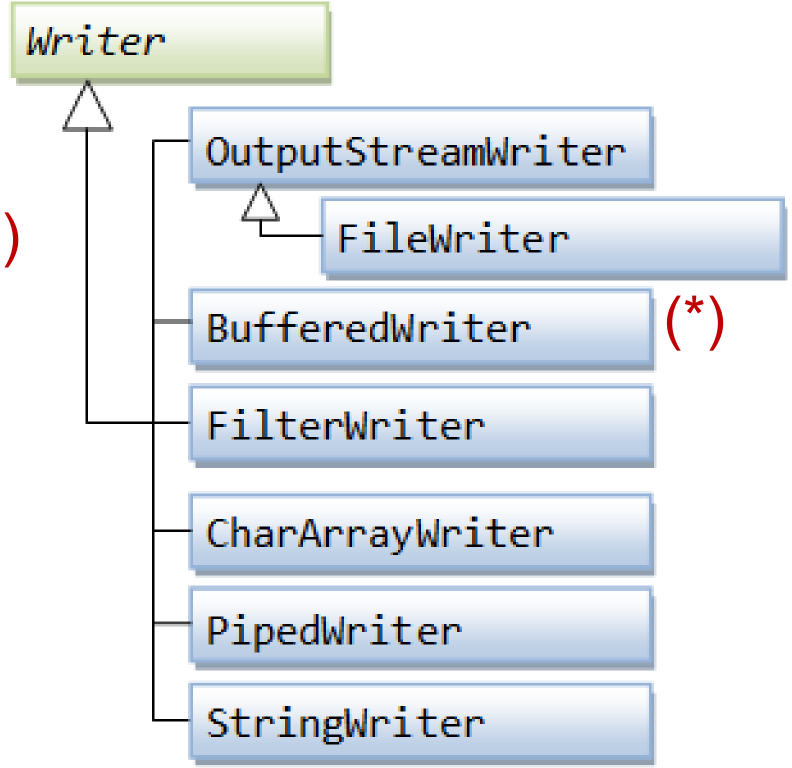
FilterReader

PushbackReader

CharArrayReader

PipedReader

StringReader



Writer

OutputStreamWriter

FileWriter (*)

BufferedWriter (*)

FilterWriter

CharArrayWriter

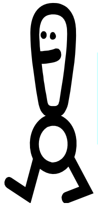
PipedWriter

StringWriter

All the methods in **`FileReader/FileWriter`** and **`BufferedReader/BufferedWriter`** are inherited from its superclasses.

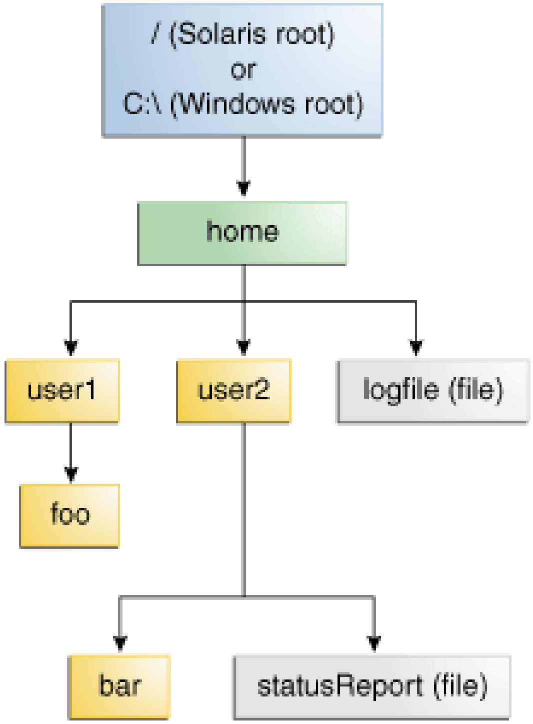
Text I/O *versus* Binary I/O

- Text files contain data represented in human-readable form.
  - A bit like a sequence of characters, e.g. decimal *199* is stored as three characters ‘1’, ‘9’, ‘9’.
  - Example: .java files.
- Binary files contain data represented in binary form.
  - A bit like a sequence of bits e.g. decimal *199* is stored as a byte-type value *C7* (199_{10} = $C7_{16}$).
  - Designed to be read by programs, but more efficient to process than text files.
  - Example: .class files.



We do not cover binary I/O.

java.io.File Class (1/2)

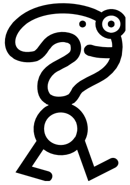


- Files live in directories within the file system.
  - Complete file name (represented by a `String`) consists of the path + name of file.

    Example:

    $$\underbrace{\texttt{c:\textbackslash Work\textbackslash JavaPrograms\textbackslash}}_{\text{directory path}}\underbrace{\texttt{MyFirstJavaProgram.java}}_{\text{file name}}$$

- `java.io.File`: contains methods to obtain file properties, for renaming and deleting files.
  - A wrapper class for a file's name and directory path: represents an abstract pathname.
  - It hides file system differences.
  - No exception is thrown if file does not exist.



Why do you think that is the case?

`java.io.File` Class (2/2)

- Constructors and methods in **`File`**:

  `File``(String pathname)`: creates file with specified pathname

  `boolean` **`exists`**`()` / `boolean` **`isDirectory`**`()` / `boolean` **`isFile`**`()`
  `boolean` **`canRead`**`()` / `boolean` **`canWrite`**`()`

  `boolean` **`delete`**`()`: returns **`true`** if file successfully deleted

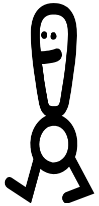
  `String` **`getAbsolutePath`**`()`: returns complete absolute file/directory name

  `boolean` **`renameTo`**`(File dest)`: returns **`true`** if operation successful

  `long` **`length`**`()`: returns length of the file in bytes

  `String[]` **`list`**`()`: returns an array of strings containing the list of files in this directory

  `boolean` **`mkdir`**`()`



`java.io.File` in Java SE6, but **`java.nio.file.Path`** from Java SE7.

Example: Using the File Class

```
import java.io.*;
public class TestFileClass {
  public static void main(String[] args) {
    File file = new File(“Examples\badger.jpg”);
    System.out.println(“Does it exist? ” + file.exists());
    System.out.println(“Can it be read? ” + file.canRead());
    System.out.println(“Can it be written? ” + file.canWrite());
    System.out.println(“What is its absolute path?” + file.getAbsolutePath());
    System.out.println(“What is its name?” + file.getName());
    System.out.println(“What is its path?” + file.getPath());
  }
}
```

create a File object

Output is …

```
> java TestFileClass
Does it exist? true
Can it be read? true
Can it be written? false
What is its absolute path? C:\EBU4201\Examples\badger.jpg
What is its name? badger.jpg
What is its path? Examples\badger.jpg
```

Steps: Reading from / Writing to files

1. *Open file*
   - Needs the file’s name and maybe its location (path).
   - Open file by creating an instance of an appropriate stream class.
2. *Perform operations*
   - Read from and/or write to the file.
   - Call instance methods that belong to the stream object’s class.
3. *Close file*
   - Any class from **`InputStream`**, **`OutputStream`**, **`Reader`** and **`Writer`** has a **`close()`** method.
   - File I/O can cause a large number of ***exceptions*** to be thrown.

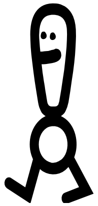
Reading a text file // Writing a text file

- **FileReader**:
  - To represent a file on the file system.
  - The file containing character data.
- **BufferedReader**:
  - Improves efficiency.
  - Provides useful methods.
- The **FileReader** and **BufferedReader** together create a convenient *text file input stream*.

- **FileWriter**:
  - To represent a file on the file system.
  - The methods are limited.
- **BufferedWriter**:
  - Improves efficiency.
  - Provides useful methods.
- The **FileWriter** and **BufferedWriter** together create a convenient *text file output stream*.

Example 1: Reading a text file (with 1 line)

```
import java.io.*;
public class FileReadTest {
  public static void main(String args[]){
    String fileName = "input.txt";
    String contents = "";
    try {
      FileReader fileReader = new FileReader(fileName);
      BufferedReader bufferedReader = new BufferedReader(fileReader);
      contents = bufferedReader.readLine();
      bufferedReader.close();
      fileReader.close();
    }
    catch (IOException e) {
      System.out.println("Errors occured");
      System.exit(1);
    }
    System.out.println(contents);
  }
}
```



This is the ‘lazy’ approach to catching IO exceptions, because this example can generate at least 2 different types of exceptions: **`FileNotFoundException`** and **`IOException`**.

Example 2: Reading a text file (with several lines)

```
// other code ...
try {
  FileReader fileReader = new FileReader(fileName);
  BufferedReader bufferedReader = new BufferedReader(fileReader);
  String oneLine = bufferedReader.readLine();
  while (oneLine != null) {
    contents = contents + oneLine;
    oneLine = bufferedReader.readLine();
  }
  bufferedReader.close();
  fileReader.close();
}
// other code ...
```

Example 3: Reading a text file (containing numbers)

```
// other code ...
int sum = 0;
String fileName = "input.txt";
try {
  FileReader fileReader = new FileReader(fileName);
  BufferedReader bufferedReader = new BufferedReader(fileReader);
  String oneLine = bufferedReader.readLine();
  while (oneLine != null) {
    sum = sum + Integer.parseInt(oneLine);
    oneLine = bufferedReader.readLine();
  }
  bufferedReader.close();    fileReader.close();
}
catch (IOException e) {
  System.out.println("Errors occured");  System.exit(1);
}
System.out.println(sum);
// other code ...
```

Example: Writing a string to a text file

```
// other code ...
String contents = "Welcome to BUPT.";
String fileName = "output.txt";
try {
  FileWriter fileWriter = new FileWriter(fileName);
  BufferedWriter bufferedWriter = new BufferedWriter(fileWriter);
  bufferedWriter.write(contents);
  bufferedWriter.close();
  fileWriter.close();
}
catch (IOException e) {
  System.out.println("Errors occured");
  System.exit(1);
}
// other code ...
```

FileReader *versus* FileWriter

- **FileReader**: A **java.io.FileNotFoundException** will occur if you attempt to create a **FileReader** with a nonexistent file.

```
public FileReader(String filename)     int read(char[] cbuf)
public FileReader(File file)           int read(char[] cbuf,int off,int len)
int read()                             void close()
```

- **FileWriter**: If the file doesn’t exist, a new file will be created.

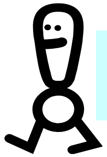
```
public FileWriter(String filename)             public FileWriter(File file)
public FileWriter(String filename, boolean append)
public FileWriter(File file, boolean append)             void write(int c)

                               void write(byte[] cbuf)
                               void write(char[] cbuf,int off,int len)
                               void write(String str)
                               void write(String str, int off,int len)
                               void close()
```

… and things for you to try out!

BufferedReader *versus* **BufferedWriter**

- Buffered stream classes inherit methods from their superclasses.
  - **BufferedReader** has a **readLine()** method to read a line.
  - **BufferedWriter** has a **newLine()** method to write a line separator. If end of stream is reached, **readLine()** returns **null**.

Type of I/O	Streams	Purpose
File	FileReader / FileWriter FileInputStream FileOutputStream	To read chars/bytes from or write to a file in the native file system.
Buffering	BufferedReader BufferedWriter	To buffer data while reading or writing, reducing the number of accesses on the data source.



There are other classes (*not covered here*) in the **java.io** package.

Exercise 1

1. Will the following code compile correctly?

```
File file = new File(“temp.txt”);
FileReader in = new FileReader(file);
```

2. Does constructing a `File` object automatically create a disk file?

3. What method ensures that data from previous calls to `write()` is sent to disk and leaves the file open?

4. What does the following constructor do?

```
FileWriter fw = new FileWriter(“myFile.txt”);
```