

Java Input/Output library

Agenda

- What is an I/O stream?
- Types of Streams
- Stream class hierarchy
- Control flow of an I/O operation using Streams
- Byte streams
- Character streams

Agenda

- Buffered streams
- Standard I/O streams
- Data streams
- Object streams
- File class
- Serialization

I/O Streams

An *I/O Stream* represents an input source or an output destination

A stream can represent many different kinds of sources and destinations:

- HDD
- Devices
- Other programs
- Network sockets

I/O Streams

- Streams support many different kinds of data
 - simple bytes, primitive data types, localized, characters, and objects
- Some streams simply pass on data; others manipulate and transform the data in useful ways.
- No matter how they work internally, all streams present the same simple model to programs that use them
 - A stream is a sequence of data

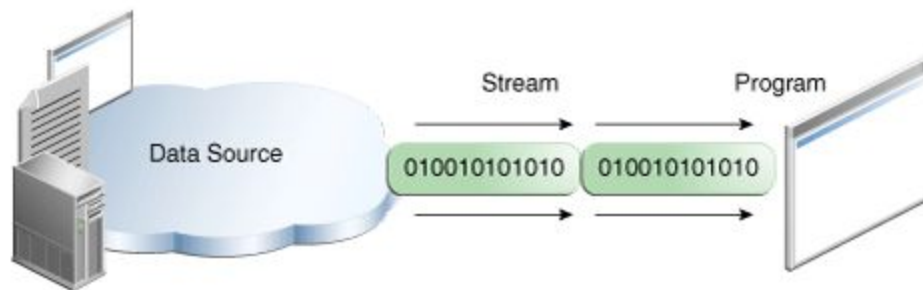
I/O Streams

Stream I/O operations involve three steps:

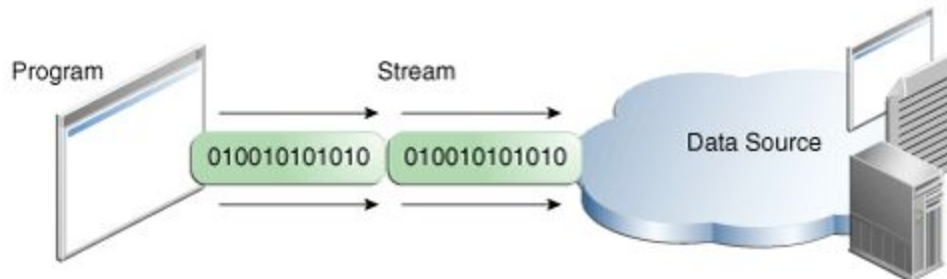
- *Open* a stream with associated source
- *Read* from the opened input stream until "end-of-stream" encountered, or *write* to the opened output.
- *Close* the stream.

I/O Streams

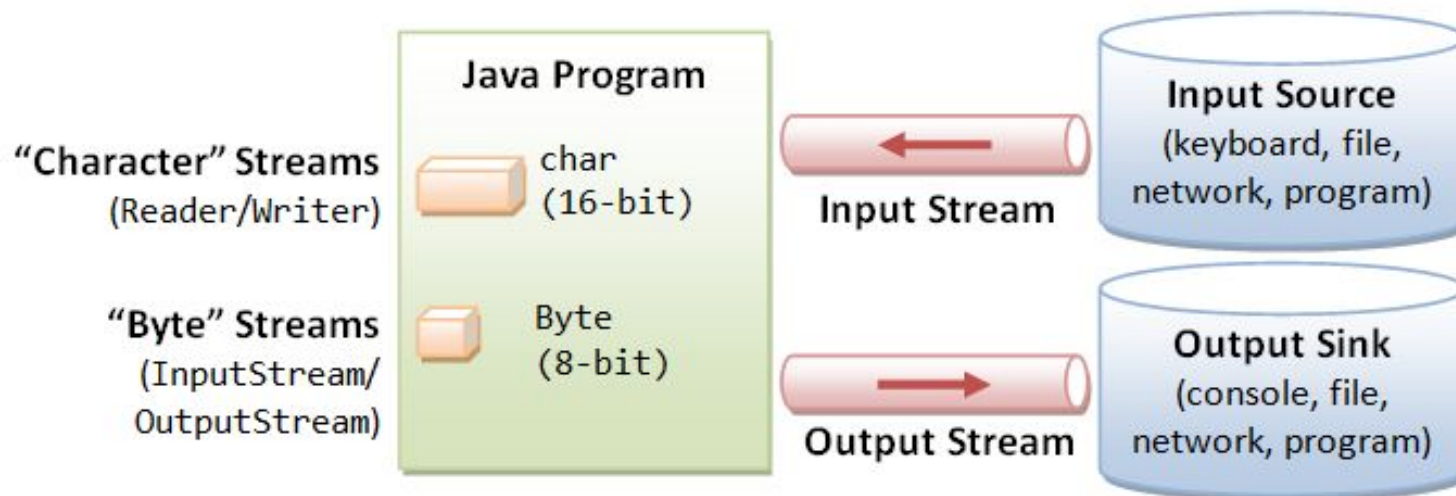
- Reading information into a program (INPUT).



- Writing information from a program (OUTPUT).



I/O Streams types



Internal Data Formats:

- Text (char): UCS-2
- int, float, double, etc.

External Data Formats:

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

Byte Streams

- 8 bits, data-based
- Two parent abstract classes:
 - `InputStream`
 - `OutputStream`

InputStream

- Reading bytes:
 - `InputStream` class defines an abstract method

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

 - Designer of a concrete input stream class overrides this method to provide useful functionality.
 - E.g. in the `FileInputStream` class, the method reads one byte from a file
 - `InputStream` class also contains nonabstract methods to read an array of bytes or skip a number of bytes

OutputStream

- Writing bytes :
 - OutputStream class defines an abstract method

```
public abstract void write(int b) throws  
IOException
```
 - OutputStream class also contains nonabstract methods for tasks such as writing bytes from a specified byte array

Example

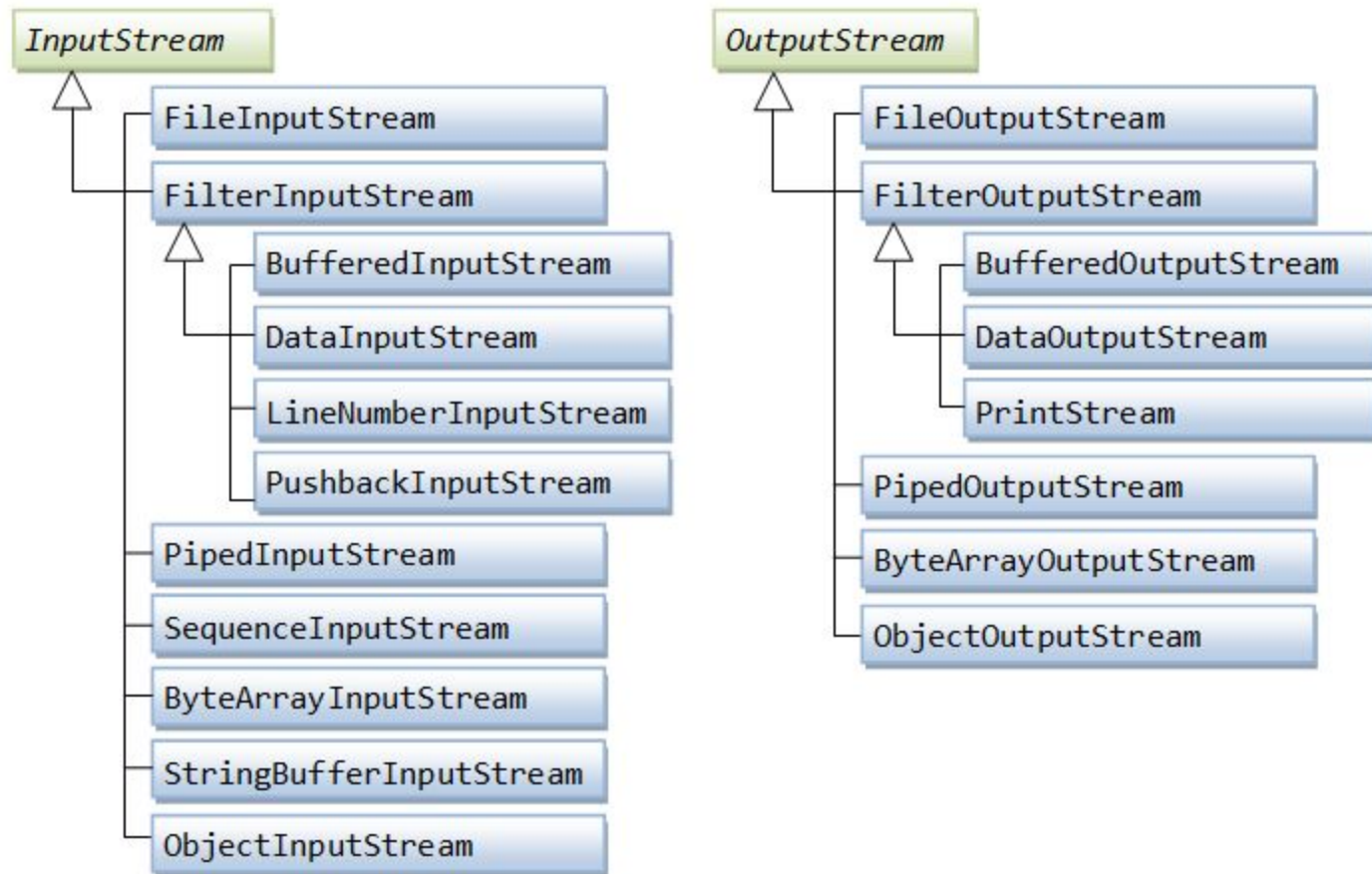
```
FileInputStream in = null;
.....
try {
    in = new FileInputStream(...); // Open stream
    .....
    .....
} catch (IOException ex) {
    ex.printStackTrace();
} finally { // always close the I/O streams
    try {
        if (in != null) in.close();
    } catch (IOException ex) {
        ex.printStackTrace();
    }
}
```

Example

- JDK 1.7 introduces a new try-with-resources syntax, which automatically closes all the opened resources after try or catch, as follows.

```
try (FileInputStream in = new FileInputStream(...)) {  
    .....  
    .....  
} catch (IOException ex) {  
    ex.printStackTrace();  
} // Automatically closes all opened resource in try (...).
```

Byte Streams implementations



File I/O Byte-Streams

FileInputStream and **FileOutputStream** are concrete implementations to the abstract classes **InputStream** and **OutputStream**, to support I/O from disk files.

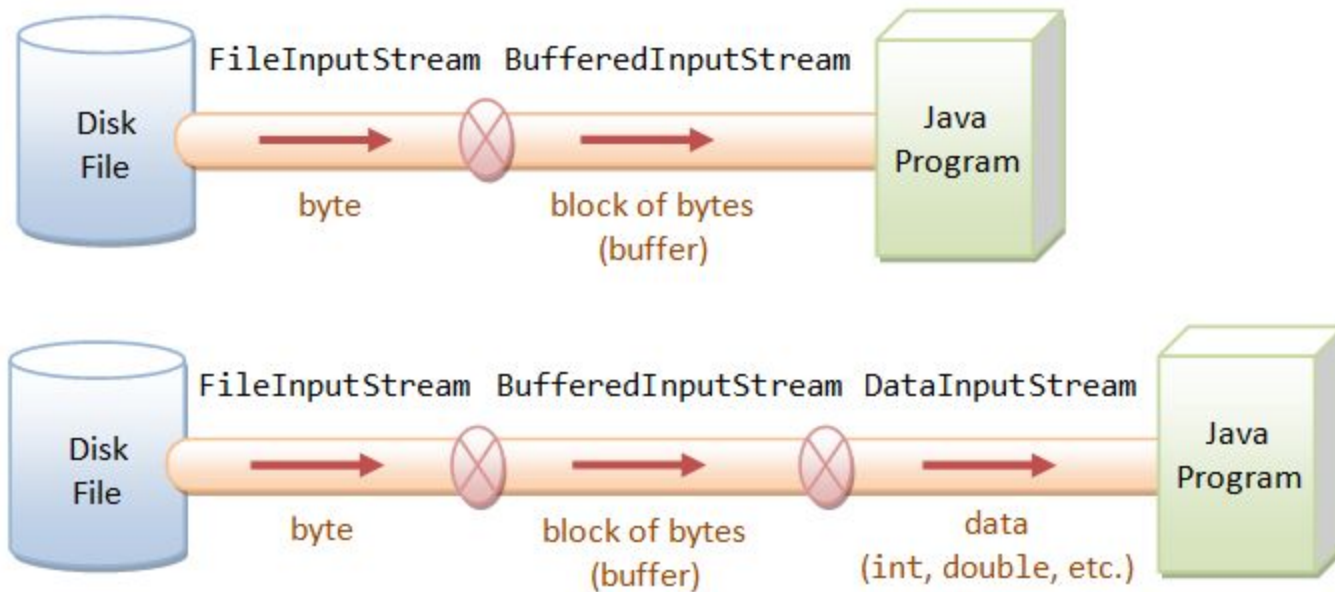
Buffered I/O Byte-Streams

BufferedInputStream & BufferedOutputStream

- *Buffering*, which reads/writes a block of bytes from the external device into/from a memory buffer in a single I/O operation, is commonly applied to speed up the I/O.

Layered (or Chained) I/O Streams

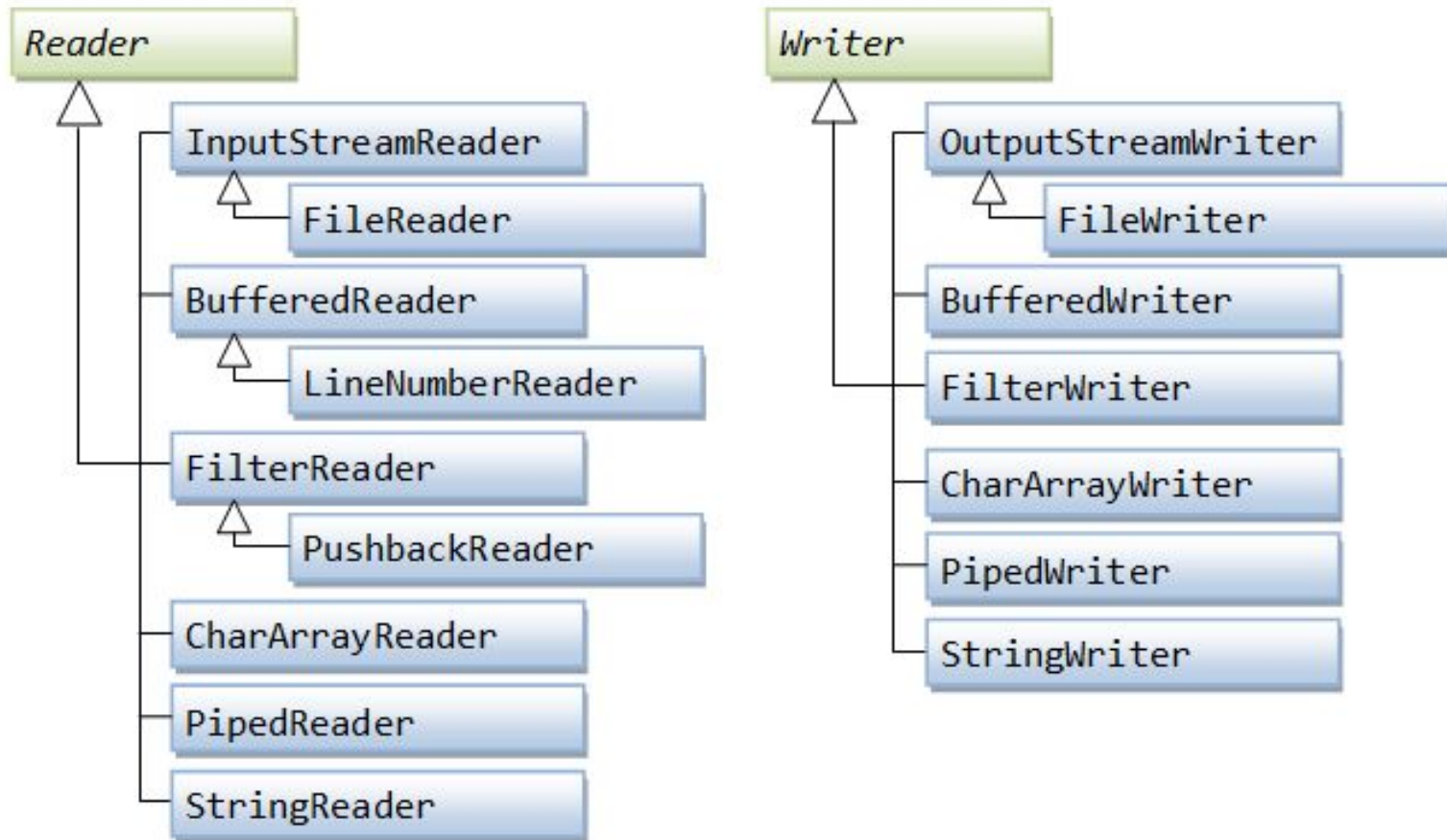
- The I/O streams are often layered or chained with other I/O streams, for purposes such as buffering, filtering, or data-format conversion (between raw bytes and primitive types)



Character Streams

- 16 bits unicode, text-based
- Two parent abstract classes for characters: `Reader` and `Writer`.

Character Streams implementations



PrintWriter/PrintStream

- The `PrintWriter` and `PrintStream` classes are designed to simplify common text output tasks.
 - The **`print()`** method is overloaded to print a `String` representation of all Java primitive types, and to automatically print the `toString()` representation of all `Objects`.
 - The **`println()`** method works in the same way as `print()`, but add a platform-specific line terminator.
 - The **`format()`** - formatted representation of one or more `Objects`
 - The class methods never throw an `IOException`. Instead, exceptional situations merely set an internal flag that can be tested via the **`checkError()`** method.

Standard Streams

- Standard Streams are a feature of many operating systems.
 - `System.in`
 - `System.out`
 - `System.err`

File class

- The path may or may not refer to an actual on-disk file or directory.
- Methods on the File class allow you to manipulate the path and perform file system operations.
- The File class is **not** used to read or write file contents.

File class

The File constructor is overloaded, allowing you to create a File object from:

- A single String representing a path
- A String or File representing a parent directory path and a second String argument representing a child directory or file

File class

- The path used to create a File object can be absolute or relative to the present working directory.
- Like String objects, File objects are *immutable*.
- Once you create one, you cannot modify the path it represents.

File class

Methods that modify the file system include:

- `createNewFile()`
- `mkdir()`
- `makedirs()`
- `renameTo()`
- `delete()`
- `deleteOnExit()`
- `setReadOnly()`
- `setLastModified()`

File class

Methods that query the file system include:

- `canRead()`
- `canWrite()`
- `exists()`
- `isDirectory()`
- `isFile()`
- `isHidden()`
- `getAbsolutePath()`
- `lastModified()`
- `length()`
- `listFiles()`
- `listRoots()`

Unix & Windows

Unix path name:

- Example: `"/user/angela/data/data.txt"`
- A `BufferedReader` input stream connected to this file is created as follows:

```
is = new BufferedReader(new FileReader("/user/sallyz/data/data.txt"));
```

Windows path name:

- Example: `C:\dataFiles\data\data.txt`
- A `BufferedReader` input stream connected to this file is created as follows:

```
is = new BufferedReader(new FileReader("C:\\dataFiles\\data\\data.txt"));
```

- Note that in Windows `\\` must be used in place of `\`, since a single backslash denotes the beginning of an escape sequence

Serialization

- Object serialization is the process of representing a "particular state of an object" in a serialized bit.

Serialization

For an object (class) to be serializable, the class must:

- Implement the `java.io.Serializable` interface, a *marker interface* with no required methods
- Contain instance fields that are serializable — primitives or other `Serializable` types — except for any fields marked as **`transient`**

Serialization

- Have a no-argument constructor
- (Optional but recommended) Implement a static final long field named **serialVersionUID** as a “version number” to identify changes to the class implementation that are incompatible with serialized objects of previous versions of the class.

```
Public static final long serialVersionUID = 1L;
```

Serialization

You can then serialize and deserialize objects with the following filter classes:

- **ObjectOutputStream** — Serialize an object to an underlying **OutputStream** with the **writeObject()** method.
- **ObjectInputStream** — Deserialize an object from an underlying **InputStream** with the **readObject()** method.

Serialization example

```
public class Car implements Serializable{  
  
    public static final long serialVersionUID = 123L;  
  
    private int serialNumber;  
    private String model;  
    private String manufacturer;  
    private Color color;  
    private double engineVolume;  
    private transient String information;  
  
    //add all getters and setter  
}
```


Serialization example - writing

```
public class Main {  
  
    public static void main(String[] args) {  
        ObjectOutputStream outputStream = null;  
        try {  
            Car car = new Car();  
            car.setColor(new Color(200, 100, 150));  
            car.setEngineVolume(2.0);  
            car.setInformation("Some car information");  
            car.setManufacturer("Audi");  
            car.setModel("A5");  
            car.setSerialNumber(123456);  
            outputStream = new ObjectOutputStream(  
                new BufferedOutputStream(  
                    new FileOutputStream(  
                        "serializable_file.txt"))));  
  
            outputStream.writeObject(car);
```

```
        } catch (FileNotFoundException e) {  
            e.printStackTrace();  
        } catch (IOException e) {  
            e.printStackTrace();  
        } finally {  
            if (outputStream != null) {  
                try {  
                    outputStream.close();  
                } catch (IOException e) {  
                    e.printStackTrace();  
                }  
            }  
        }  
    }  
}
```

Serialization example - reading

```
public class Main {

    public static void main(String[] args) {
        ObjectInputStream inputStream = null;
        Car car = null;

        try {
            File file = new File("serializable_file.txt");
            if (file.exists()) {
                inputStream = new ObjectInputStream(
                    new BufferedInputStream(
                        new FileInputStream(file)));
                car = (Car) inputStream.readObject();
                System.out.println("Color: " + car.getColor());
                System.out.println("Engine: " + car.getEngineVolume());
                System.out.println("Info: " + car.getInformation());
                System.out.println("Manufacturer: " +
car.getManufacturer());
                System.out.println("Model: " + car.getModel());
                System.out.println("Serial: " + car.getSerialNumber());
            } else {
                System.out.println("Cant find file!");
            }
        } catch (IOException e) {
            e.printStackTrace();
        } catch (ClassNotFoundException e) {
            e.printStackTrace();
        }
    }
}
```