תכנות מתקדם בשפת Java
קלט/פלט (IO)

אוהד ברזילי ואורנית דרור
אוניברסיטת תל אביב

The java.io package

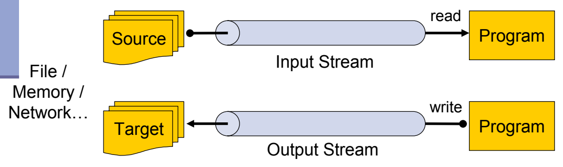
- The java.io package provides:
  - Classes for reading input
  - Classes for writing output
  - Classes for manipulating files
  - Classes for serializing objects

Online Resources

- JAVA API Specification:
  http://java.sun.com/j2se/1.5.0/docs/api/index.html
- The Java Tutorial (Sun)
  http://java.sun.com/docs/books/tutorial/essential/io/

Streams

- A ***stream*** is a sequential flow of data
- Streams are one-way streets.
  - ***Input streams*** are for reading
  - ***Output streams*** are for writing



Streams

- Usage Flow:

```
open a stream
while more information
  Read/write information
close the stream
```

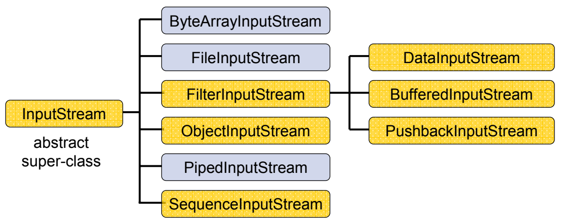
- All streams are automatically opened when created.

Streams

- There are two types of streams:
  - ***Byte streams*** for reading/writing raw bytes
  - ***Character streams*** for reading/writing text
- Class Name Suffix Convention:

	Byte	Character
Input	InputStream	Reader
Output	OutputStream	Writer

InputStreams

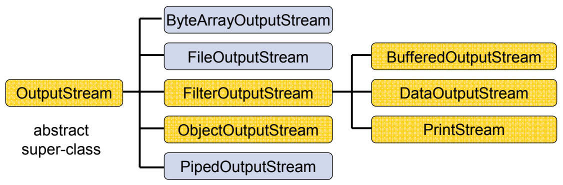


- 🟦 - read from data sinks
- 🟨 - perform some processing

The `InputStream` Methods

- The three basic `read` methods are:
  - `int read()`
  - `int read(byte[] buffer)`
  - `int read(byte[] buffer, int offset, int length)`
- Other methods include:
  - `void close()`
  - `int available()`
  - `skip(long n)`
  - `boolean markSupported()`
  - `void mark(int readlimit)`
  - `void reset()`

OutputStreams

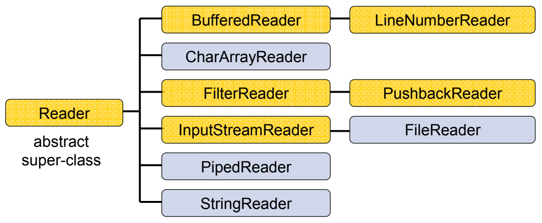


- 🟦 - write to data sinks
- 🟨 - perform some processing

The `OutputStream` Methods

- The three basic `write` methods are:
  - `void write(int c)`
  - `void write(byte[] buffer)`
  - `void write(byte[] buffer, int offset, int length)`
- Other methods include:
  - `void close()`
  - `void flush()`

Readers

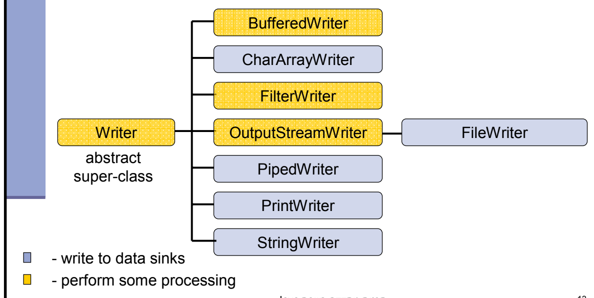


- 🟦 - read from data sinks
- 🟨 - perform some processing

The `Reader` Methods

- The three basic `read` methods are:
  - `int read()`
  - `int read(char[] cbuf)`
  - `int read(char[] cbuf, int offset, int length)`
- Other methods include:
  - `void close()`
  - `boolean ready()`
  - `skip(long n)`
  - `boolean markSupported()`
  - `void mark(int readAheadLimit)`
  - `void reset()`

Writers



The `Writer` Methods

- The basic `write` methods are:
  - `void write(int c)`
  - `void write(char[] cbuf)`
  - `void write(char[] cbuf, int offset, int length)`
  - `void write(String string)`
  - `void write(String string, int offset, int length)`
- Other methods include:
  - `void close()`
  - `void flush()`

Node Streams

Type	Character Streams	Byte Streams
File	FileReader FileWriter	FileInputStream FileOutputStream
Memory: array	CharArrayReader CharArrayWriter	ByteArrayInputStream ByteArrayOutputStream
Memory: string	StringReader StringWriter	N/A
Pipe	PipedReader PipedWriter	PipedInputStream PipedOutputStream

InputStream Example

- Reading a single byte from the standard input stream:

```
try {
    int value = System.in.read();
    ...
} catch (IOException e) {
    ...
}
```

an int with a byte information

returns -1 if a normal end of stream has been reached

is thrown in case of an error

InputStream Example

- Casting the value

```
try {
    int value = System.in.read();
    if (value != -1) {
        byte bValue = (byte) value;
    }
    ...
} catch (IOException e) {...}
```

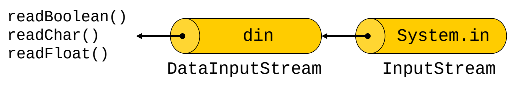
end-of-stream condition

casting

Stream Wrappers

- Some streams wrap others streams and add new features.
- A wrapper stream accepts another stream in its constructor:

```
DataInputStream din =
    new DataInputStream(System.in);
double d = din.readDouble();
```



The Scanner Class

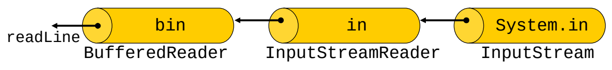
- Breaks its input into tokens using a delimiter pattern (matches whitespace by default)
- The resulting tokens may then be converted into values

```
try {
      Scanner s = new Scanner(System.in);
      int anInt = s.nextInt();
      float aFloat = s.nextfloat();
      String aString = s.next();
      String aLine = s.nextLine();
} catch (…) {…}
```

Stream Wrappers (cont.)

- Reading a text string from the standard input:

```
try {
    InputStreamReader in
       = new InputStreamReader(System.in);
    BufferedReader bin
       = new BufferedReader(in);
    String text = bin.readLine();
    ...
} catch (IOException e) {...}
```



Terminal I/O

- The System class provides references to the standard input, output and error streams:

```
InputStream stdin = System.in;
PrintStream stdout = System.out;
PrintStream stderr = System.err;
```

The File Class

- Represents a file or directory pathname
- Performs basic file-system operations:
  - removes a file: `delete()`
  - creates a new directory: `mkdir()`
  - checks if the file is writable: `canWrite()`
- No method to create a new file
- No direct access to file data
- Use file streams for reading and writing

The File Class
Constructors

- Using a full pathname:

```
File f = new File("/doc/foo.txt");
File dir = new File("/doc/tmp");
```

- Using a pathname relative to the current directory of the Java interpreter:

```
File f = new File("foo.txt");
```

Note: `System.getProperty('user.dir')` returns the current directory of the interpreter

The File Class
Constructors (cont)

- `File f = new File("/doc","foo.txt");`

  ↑ directory pathname   ↑ file name

-
  ```
  File dir = new File("/doc");
  File f = new File(dir, "foo.txt");
  ```
- A `File` object can be created for a non-existing file or directory
  - Use `exists()` to check if the file/dir exists

File Tests and Utilities

- File information:
  - `String getName()`
  - `String getPath()`
  - `String getAbsolutePath()`
  - `String getParent()`
  - `long lastModified()`
  - `long length()`
- File modification:
  - `boolean renameTo(File newName)`
  - `boolean delete()`

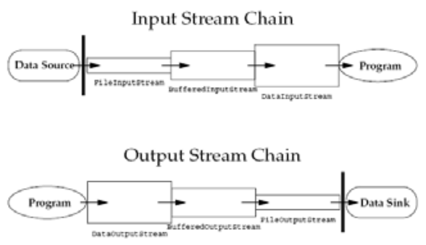
File Tests and Utilities

- Directory utilities:
  - `boolean mkdir()`
  - `String[] list()`
- File tests:
  - `boolean exists()`
  - `boolean canWrite()`
  - `boolean canRead()`
  - `boolean isFile()`
  - `boolean isDirectory()`
  - `boolean isAbsolute();`

File Stream I/O

- For file input:
  - Use the `FileReader` class to read characters.
  - Use the `BufferedReader` class to use the `readLine` method
- For file output:
  - Use the `FileWriter` class to write characters.
  - Use the `PrintWriter` class to use the `print` and `println` methods

I/O Stream Chaining



The File Class
Pathnames

- Pathnames are system-dependent
  - `"/doc/foo.txt"` (UNIX format)
  - `"D:\doc\foo.txt"` (Windows format)
- On Windows platform Java excepts path names either with `'/'` or `'\'`
- The system file separator is defined in:
  - `File.separator`
  - `File.separatorChar`

The File Class
Directory Listing

- Printing all files and directories under a given directory:

```
public static void main(String[] args) {
    File file = new File(args[0]);

    String[] files = file.list();
    for (int i=0 ; i< files.length ; i++) {
         System.out.println(files[i]);
    }
}
```

The File Class
Directory Listing (cont.)

- Printing all files and directories under a given directory with ".txt" suffix:

```
public static void main(String[] args) {
    File file = new File(args[0]);
    FilenameFilter filter =
                     new SuffixFileFilter(".txt");

   String[] files = file.list(filter);
   for (int i=0 ; i<files.length ; i++) {
            System.out.println(files[i]);
   }
}
```

The File Class
Directory Listing (cont.)

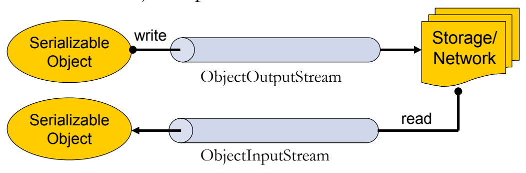
```
public class SuffixFileFilter implements FilenameFilter {
  private String suffix;

  public SuffixFileFilter(String suffix) {
   this.suffix = suffix;
  }

  public boolean accept(File dir, String name) {
    return name.endsWith(suffix);
  }
}
```

Object Serialization

- A mechanism that enable objects to be:
  - saved and restored from byte streams
  - persistent (outlive the current process)
- Useful for:
  - persistent storage
  - sending an object to a remote computer

The Default Mechanism

- The default mechanism includes:
  - The Serializable interface
  - The ObjectOutputStream
  - The ObjectInputStream



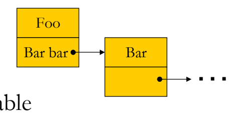
The Serializable Interface

- Objects to be serialized must implement the java.io.Serializable interface
- An empty interface (tag interface)
- Most objects are Serializable:
  - Primitives, Strings, GUI components etc.
- Subclasses of Serializable classes are also Serializable

Recursive Serialization

- Can we serialize a Foo object?

```
public class Foo implements Serializable {
        private Bar bar;
        …
}
public class Bar {…}
```



- No, since Bar is not Serializable
- Solution:
  - Implement Bar as Serializable
  - Mark the bar field of Foo as transient (will not be discussed in the course)
  - And, so on recursively

Writing Objects

- Writing a `HashMap` object (`map`) to a file*:

```
try {
    FileOutputStream fileOut =
          new FileOutputStream("map.s");
    ObjectOutputStream out =
          new ObjectOutputStream(fileOut);
    out.writeObject(map);
} catch (Exception e) {...}
```

* HashMap is Serializable

Reading Objects

```
try {
  FileInputStream fileIn = new
     FileInputStream("map.s");

  ObjectInputStream in = new
     ObjectInputStream(fileIn);

  Map h = (Map)in.readObject();
} catch (Exception e) {...}
```

Other Topics

- The `java.nio` package
- The `java.util.zip` package

The RandomAccessFile Class

- permits random access to a file's data
- is used for both reading and writing files
- Constructors:
  - RandomAccessFile(File file, String mode)
  - RandomAccessFile(String name, String mode)

  Where:

  mode – specify the access mode (e.g. "r", "rw")

The RandomAccessFile Class
File Pointer

- indicates the current location in the file.
- Explicitly manipulating the file pointer:
  - `int skipBytes(int)`

    Moves the file pointer forward the specified number of bytes
  - `void seek(long)`

    Positions the file pointer before the specified byte
  - `long getFilePointer()`

    Returns the current byte location of the file pointer