# Java Input / Output

CSE 413, Autumn 2002

Programming Languages

http://www.cs.washington.edu/education/courses/413/02au/

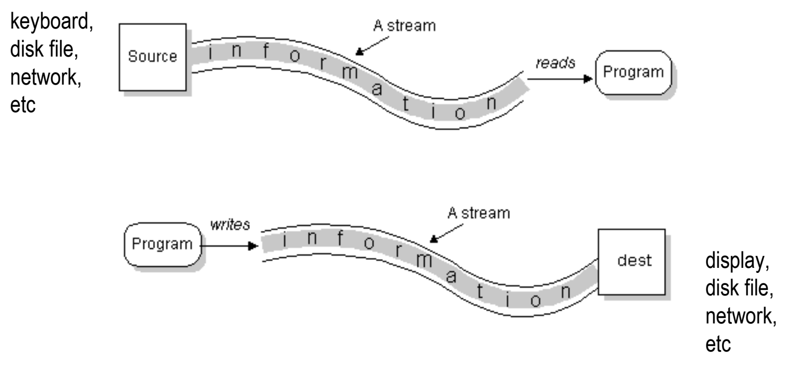
## Readings and References

- Reading
  » Chapter 12, Sections: Streams, The Complete Stream Zoo, Putting Streams to Use, File Management, *CoreJava, Volume 1, Fundamentals*, by Horstmann and Cornell
- Other References
  » Section "I/O" of the Java tutorial
  » http://java.sun.com/docs/books/tutorial/essential/io/index.html

## Input & Output

- Program input can come from a variety of places:
  » the mouse, keyboard, disk, network…
- Program output can go to a variety of places:
  » the screen, speakers, disk, network, printer…

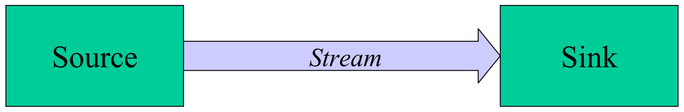
## "Streams" are the basic I/O objects



from Sun tutorial on I/O

## The stream model

- The stream model views all data as coming from a source and going to a sink



- Sources and sinks can be files, memory, the console, network ports, serial ports, etc

## Streams

- Getting data from source to sink is the job of an object of a *stream* class
- Use different streams for doing different jobs
- Streams appear in many packages
  - » java.io - basic stream functionality, files
  - » java.net - network sockets
  - » javax.comm - serial ports
  - » java.util.zip - zip files

## Streams are *layered* classes

- Inheritance and composition both play key roles in defining the various types of streams
- Each layer adds a little bit of functionality
- The nice thing about this design is that many programs don't need to know exactly what kind of stream they are working with
  - » one OutputStream is as good as another in many situations, as long as it knows how to move bytes

## OutputStream

- An OutputStream sends bytes to a sink
  - » OutputStream is an abstract class
  - » the actual "write" method depends on the device being written to
- Key methods:

```
abstract void write(int b) throws IOException
void write(byte[] b) throws IOException
void close() throws IOException
```

## OutputStream subclasses

- Subclasses differ in how they implement write() and in what kind of sink they deal with:
  - » FileOutputStream: sink is a file on disk
  - » ByteArrayOutputStream: sink is an array of bytes
  - » PipedOutputStream: sink is a pipe to another thread
- Other subclasses process output streams
  - » FilterOutputStream: process the stream in transit
  - » ObjectOutputStream: primitives and objects to a sink

## FilterOutputStream

- Constructor takes an instance of OutputStream
- Resulting object is also instance of OutputStream
- These classes *decorate* the basic OutputStream implementations with extra functionality
- Subclasses of FilterOutputStream in java.io:
  - » BufferedOutputStream: adds buffering for efficiency
  - » PrintStream: supports display of data in text form (using the default encoding only)
  - » DataOutputStream: write primitive data types and Strings (in binary form)

## InputStream

- An InputStream gets bytes from a source
  - » InputStream is an abstract class
  - » The actual "read" method depends on the source being read from
  - » Key methods:

```
abstract int read() throws IOException
int read(byte[] b) throws IOException
void close() throws IOException
```

## InputStream subclasses

- Subclasses differ in how they implement read() and in what kind of source they deal with:
  - » FileInputStream: source is a file on disk
  - » ByteArrayInputStream: source is an array of byte
  - » PipedInputStream: source is pipe from another thread
- Other subclasses process input streams
  - » FilterInputStream: process the stream in transit
  - » ObjectInputStream: primitives and objects from a source

## FilterInputStream

- Constructor takes an instance of InputStream
- Resulting object is also instance of InputStream
- These classes “decorate” the basic InputStream implementations with extra functionality
- Some useful subclasses
  - » BufferedInputStream: adds buffering for efficiency
  - » ZipInputStream: read zip files
  - » DataInputStream: read primitive data types and Strings (in binary form)

## Reader and Writer

- Reader and Writer are abstract classes that are Unicode aware and can use a specified encoding to translate Unicode to/from bytes
- Subclasses implement most of the functionality
  - » InputStreamReader, OutputStreamWriter
    rely on the underlying streams to actually move bytes
  - » BufferedReader, BufferedWriter
    add buffering for efficiency
  - » StringReader, StringWriter
  - » PipedReader, PipedWriter

## Reader and Writer guidelines

- In general:
  - » If you’re working with text (Strings and chars), use Readers and Writers
  - » If you’re working with primitive data types, use InputStreams and OutputStreams
  - » If you get an InputStream or OutputStream from somewhere else, you can convert it to a Reader or a Writer as needed by wrapping it with an InputStreamReader or OutputStreamWriter

## System.in, System.out

- System.in is a predefined InputStream
- You can convert to a BufferedReader like this:

```
BufferedReader r =
        new BufferedReader(new InputStreamReader(System.in));
```

- System.out is a predefined OutputStream
  - » actually, it's a PrintStream
- You can convert to a PrintWriter like this:

```
PrintWriter w =
        new PrintWriter(new OutputStreamWriter(System.out),true);
```

## Read a String from the console

```
/* ask for the names we were not given */

BufferedReader console =
       new BufferedReader(new InputStreamReader(System.in));

for (int i=count; i<3; i++) {
       System.out.print("name "+i+"? ");
       String petName = console.readLine();
       if (petName == null) {
              petName = "<blank>";
       }
       names.add(petName);
}
```

## Sources and Sinks - Console

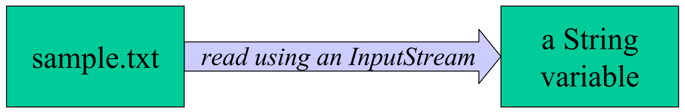
- When reading from the console
  - » the keyboard is the source
  - » a data structure in your application is the sink
- When writing to the console
  - » a data structure in your application is the source
  - » the monitor (terminal window) is the sink

## Sources and Sinks - Files

- When reading from a file
  - » the file is the source
  - » a data structure in your application is the sink
- When writing to a file
  - » a data structure in your application is the source
  - » the file is the sink

## The stream model applied to files

- The source can be a file on disk
  - » in this case, the sink is some variable in your program



## FileInputStream and FileOutputStream

- The file streams read or write from a file on the native file system
  - » FileInputStream
    retrieve bytes from a file and provide them to the program
  - » FileOutputStream
    send bytes to a file from your program
- If used by themselves, FileInputStream and FileOutputStream are for binary I/O
  - » just plain bytes in and out with no interpretation as characters or anything else

## FileInputStream methods

```
int available()
    Returns the number of bytes that can be read from this file input stream without
    blocking.
void close()
    Closes this file input stream and releases any system resources associated with
    the stream.
protected void finalize()
    Ensures that the close method of this file input stream is called when there are
    no more references to it.
FileDescriptor getFD()
    Returns the FileDescriptor object that represents the connection to the actual
    file in the file system being used by this FileInputStream.
int read()
    Reads a byte of data from this input stream.
int read(byte[] b)
    Reads up to b.length bytes of data from this input stream into an array of bytes.
int read(byte[] b, int off, int len)
    Reads up to len bytes of data from this input stream into an array of bytes.
long skip(long n)
    Skips over and discards n bytes of data from the input stream.
void mark(int readlimit)
    Marks the current position in this input stream.
boolean markSupported()
    Tests if this input stream supports the mark and reset methods.
void reset()
    Repositions this stream to the position at the time the mark method was last
    called on this input stream.
```

## "bytes from a file" and "bytes as text"

- Create new FileInputStream and connect it to a specific file
- "decorate" the stream with an InputStreamReader that will do Unicode translation for you

```
FileInputStream(String name)
    Create a FileInputStream by opening a connection to an actual file, the
    file named by the path name in the file system.

InputStreamReader(InputStream in)
    Create an InputStreamReader that uses the default character encoding.

InputStreamReader(InputStream in, String enc)
    Create an InputStreamReader that uses the named character encoding.
```

## "bytes from a file as text"

- Create new FileReader and connect it to a file
  - » FileReader is a convenience class for reading character files. The constructors of this class assume that the default character encoding and the default byte-buffer size are appropriate. To specify these values yourself, construct an InputStreamReader on a FileInputStream.

```
FileReader(File file)
    Creates a new FileReader, given the File to read from.

FileReader(FileDescriptor fd)
    Creates a new FileReader, given the FileDescriptor to read from.

FileReader(String fileName)
    Creates a new FileReader, given the name of the file to read from.
```

## prepare to read a file

1 open an InputStream connected to the filename provided

```
public TextRead(String fn) throws IOException {
        InputStream in;
        in = new FileInputStream(fn);
        textReader = new BufferedReader(new InputStreamReader(in));
}
```

3 add buffering capability so that we can read an entire line at once

2 make it a Reader so that we get valid Unicode characters

## BufferedReader constructor from Sun

```
/**
* Create a buffering character-input stream that uses an input buffer of
* the specified size.
*
* @param  in   A Reader
* @param  sz   Input-buffer size
* @exception  IllegalArgumentException  If sz is <= 0
*/
public BufferedReader(Reader in, int sz) {
    super(in);
    if (sz <= 0)
        throw new IllegalArgumentException("Buffer size <= 0");
    this.in = in;
    cb = new char[sz];
    nextChar = nChars = 0;
}
```

the buffer is allocated here as an array of characters

## readline()

- Read one line from a BufferedReader
  - » returns a String containing the contents of the line, not including any line-termination characters, or null if the end of the stream has been reached

```
/**
* Read one line from the text file and return it as a String to the caller.
* Note that the line might be null (at end of file), empty (0 characters) or
* blank (all whitespace).  Of course, it might also be a non-blank String with
* some useful characters in it.
* @return a String containing the next line or null if
* we are at the end of the file
*/
private String getNextLine() throws IOException {
        return textReader.readLine();
}
```

## Detecting end of file

- End of file is expected when using readline()
  - » you will eventually read all the characters in a file
- So the method returns `null` if we are end of file
  - » you must check for null after every readline() call

```
String myLine = tr.getNextLine();
while (myLine != null) {
        System.out.println(">> "+myLine);
        myLine = tr.getNextLine();
}
```

## close when done

- After reading through the file, you should close the stream, since an open file takes up system resources and prevents other programs from using the file

```
/**
* Close the stream.
*/
public void close() throws IOException {
        textReader.close();
}
```

## "bytes to a file as text"

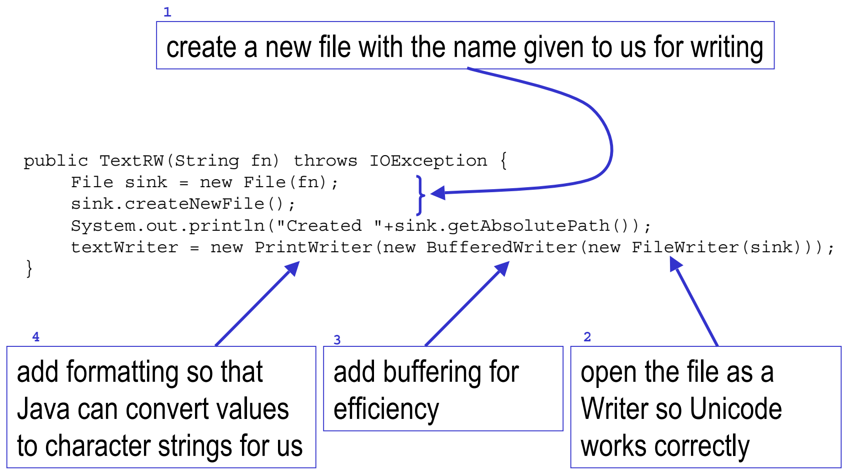
- Create new PrintWriter and connect it to a file using a FileWriter
  - » PrintWriter provides the text formatting capabilities
  - » FileWriter provides the connection between the PrintWriter and the actual file
  - » FileWriter is a convenience class like FileReader

    could use OutputStreamWriter with a FileOutputStream

```
PrintWriter(Writer out)
    Create a new PrintWriter, without automatic line flushing.

FileWriter(String fileName)
    Constructs a FileWriter object given a file name.
```

## prepare to write a file



1 create a new file with the name given to us for writing

```
public TextRW(String fn) throws IOException {
    File sink = new File(fn);
    sink.createNewFile();
    System.out.println("Created "+sink.getAbsolutePath());
    textWriter = new PrintWriter(new BufferedWriter(new FileWriter(sink)));
}
```

4 add formatting so that Java can convert values to character strings for us

3 add buffering for efficiency

2 open the file as a Writer so Unicode works correctly

## println(...)

- Print formatted representations of objects and primitive type to a text-output stream
  - » does not contain methods for writing raw bytes, for which a program should use unencoded byte streams

```
/**
* Write one line on the output file.
* @param line the line of text to write out
*/
public void writeOneLine(String s) {
        textWriter.println(s);
}
```

## close when done

- After writing the file, you should close the stream
  - » the last data that you have written may not actually have gotten all the way out to the disk - closing makes sure that the data is flushed to disk
  - » an open file takes up system resources and prevents other programs from using the file

```
/**
* Close the stream.
*/
public void close() throws IOException {
    textWriter.close();
}
```

## The File class

- Manages an entry in a directory (a pathname)
- Several constructors are available
  - » File(String pathname)
    pathname string
  - » File(String parent, String child)
    parent pathname string and a child pathname string.
  - » File(File parent, String child)
    parent abstract pathname and a child pathname string.
- The File() constructors create a pathname object in memory, NOT a new file on disk

## File class examples

```
File f = new File("c:\autoexec.bat");

File app = new File("c:\apps\JPadPro","JPadPro.exe");

File jppDir = new File("c:\apps\JPadPro");
File jppApp = new File(jppDir, "JPadPro.exe");
```

- Creating a new File object just creates a tool for managing files, it does not create a new file on disk!
  - » Creating a new Dog object did not create a new dog running around the room ...

## File class methods

- Create, rename, delete a file
  - » createNewFile(), createTempFile(), renameTo(), delete()
- Determine whether a file exists and access limitations
  - » exists(), canRead(), canWrite()
- Get file info
  - » getParent(), getCanonicalPath(), length(), lastModified()
- Create and get directory info
  - » mkdirs(), list(), listFiles(), getParent()
- Etc, etc

## Appendix

## Writing output to the console

- Java provides standard PrintStream System.out
  - » has methods to print text to the console window
- Some operations:

```
System.out.println( <expression> );
System.out.print( <expression> );
```

- expression can be
  - » primitive type: an int, double, char, boolean
  - » or an object of any class type

## Printing primitives on System.out

- System.out is a PrintStream object
- PrintStream defines a whole bunch of print(…) methods, one for each type

```
void print(boolean b)
void print(char c)
void print(char[] s)
void print(double d)
void print(float f)
void print(int i)
void print(long l)

void print(Object obj)
void print(String s)
```

## Printing objects on System.out

- Any object can be printed on System.out

```
Rectangle rect = new
   Rectangle(30,50,100,150,Color.blue,true);
System.out.println(rect);
```

- Can be very useful for debugging
  - » Put System.out.print or println method calls in your code to display a message when that place is reached during execution
  - » Particularly useful if the string version of the object has useful information in a readable format

## Object Representation on System.out

- What actually happens when an object is printed?
  - » The toString() method belonging to the object provides the string to be printed
  - » All classes have a default toString( ), the one defined by the Object class (not very descriptive)

```
public String toString() {
return getClass().getName()+"@"+Integer.toHexString(hashCode());
}
```

  - » But you can provide a custom version of toString() in any of your classes very easily