Input & Output (I/O) java.io Package

Programs read inputs from data sources (e.g., keyboard, file, network, memory buffer, or another program) and write outputs to data sinks (e.g., display console, file, network, memory buffer, or another program).

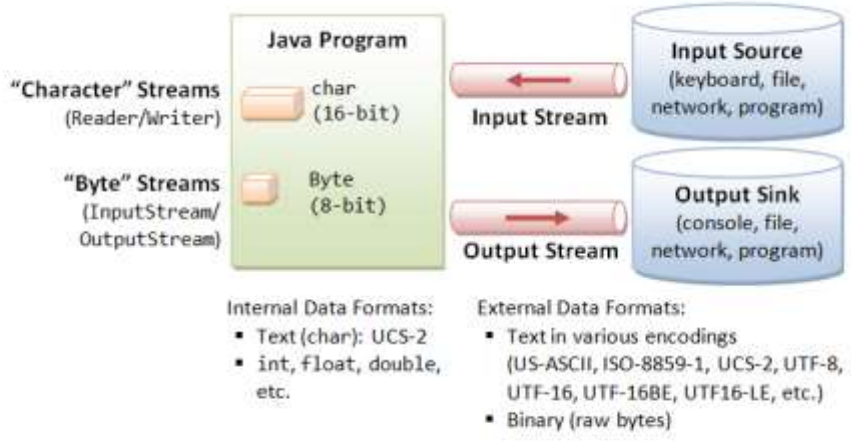
In Java standard I/O, inputs and outputs are handled by the so-called **streams**. A stream is a sequential and contiguous one-way flow of data (just like water or oil flows through the pipe). It is important to mention that Java does not differentiate between the various types of data sources or sinks (e.g., file or network) in stream I/O. They are all treated as a sequential flow of data.

Input and output streams can be established from/to any data source/sink, such as files, network, keyboard/console or another program. The Java program receives data from a source by opening an input stream, and sends data to a sink by opening an output stream.

Stream I/O operations involve three steps:

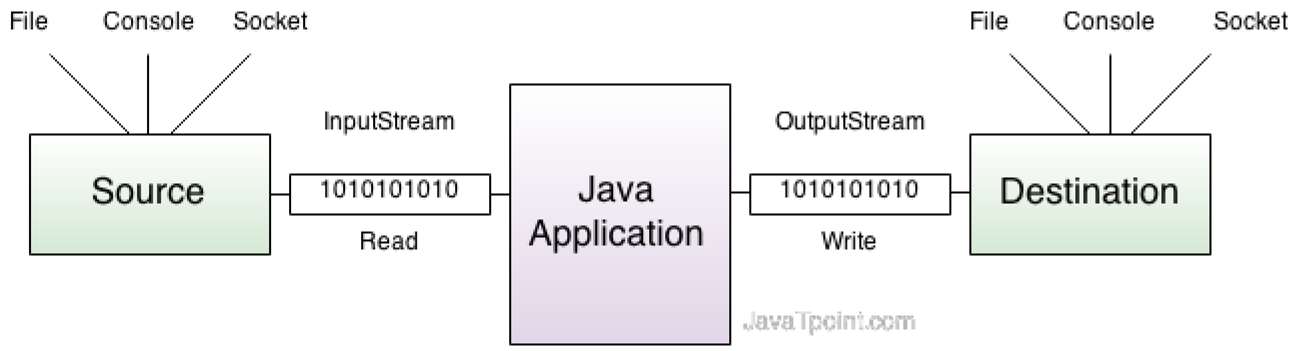
1. *Open* an input/output stream associated with a physical device (e.g., file, network, console/keyboard), by constructing an appropriate I/O stream instance.
2. *Read* from the opened input stream until "end-of-stream" encountered, or *write* to the opened output stream (and optionally flush the buffered output).
3. *Close* the input/output stream.

As a consequence, Java needs to differentiate between byte-based I/O for processing *raw bytes* or *binary data*, and character-based I/O for processing *texts* made up of characters.



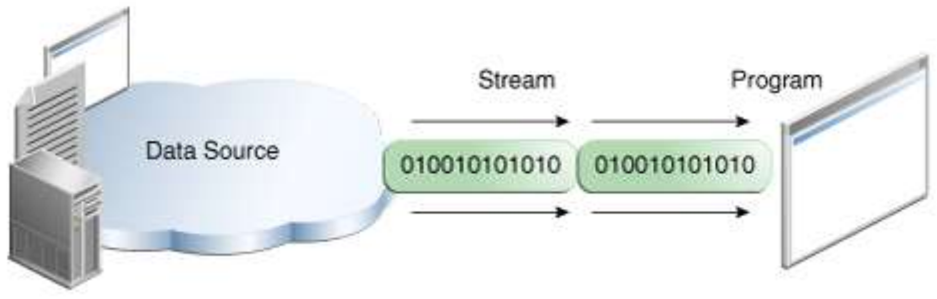
A Stream presents a uniform, easy-to-use, object oriented interface between the program and input/output devices. A Stream in java is a path along which data flows. It has a source (of data) and a destination (for that data). Both the source and destination may a physical devices or programs or other streams in the same program

The term stream refers to a sequence of values from any input source of data (keyboard, file, port, and so on), or to any output destination for data (screen, file, port, and so on). The actual physical source or destination must be supplied as an argument to an appropriate constructor of an appropriate class, during the construction of the actual object that will do the physical reading or writing of data.



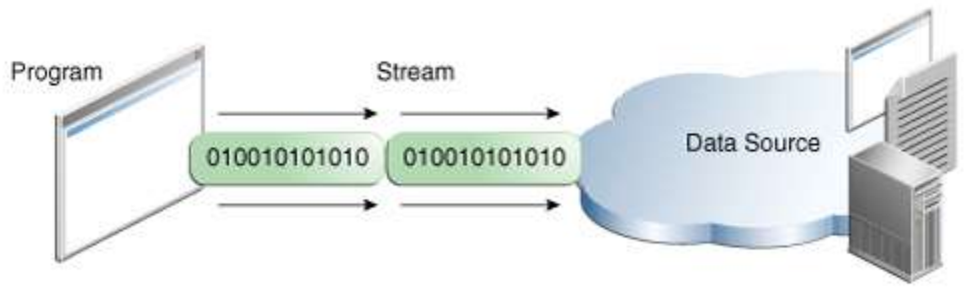
Streams support many different kinds of data, including simple bytes, primitive data types, localized characters, and objects. Some streams simply pass on data; others manipulate and transform the data in useful ways.

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**. A program uses an *input stream* to read data from a source, one item at a time:



Reading information into a program.

A program uses an output stream to write data to a destination, one item at time:



Writing information from a program.

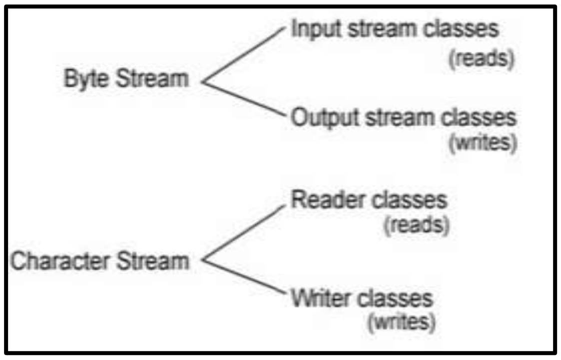
The data source and data destination pictured above can be anything that holds, generates, or consumes data. Obviously this includes disk files, but a source or destination can also be another program, a peripheral device, a network socket, or an array.

I/O Streams

The classes in java.io package may be categorized into two groups based on the data type on which they operate

- Byte Stream classes – provides support for handling I/O operations on bytes
- Character stream Class - provides support for managing I/O operations on characters

These two groups may be further classified bases based on their purpose.



Byte Streams and Character Stream classes contains specialized classes to deal with input and output operations on various types of devices

Keyboard Input Using DataInputStream

```
DataInputStream dis = new DataInputStream(System.in);
```

What is "System.in"?

" **in**" is an object of " **InputStream**" class defined in System class (like "out" is an object of PrintStream class defined in System class). It is declared as static and final object. The **in** object is connected implicitly to the " **standard input stream**" of the underlying OS

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Keyboard Input using DataInputStream

```
import java.io.*;



public class JavaIODemo
{
        public static void main(String[] args)throws IOException
        {
                //Scanner scan = new Scanner(System.in);
                DataInputStream dis = new DataInputStream(System.in);
                String str;
                System.out.print("\n\t Enter a string :");
                str = dis.readLine();

                int age;
                System.out.println("\n\t Enter age :");
                age = Integer.parseInt(dis.readLine());

                System.out.println("\n\t Str = " + str);
                System.out.println("\n\t Age = " + age);
        }
}
```

The **readLine()** method of **DataInputStream** reads a line at a time and returns as a string, irrespective of what the line contains. Depending on the input value, the string is to be parsed into an **int** or **double** etc.

Keyboard input using InputStreamReader

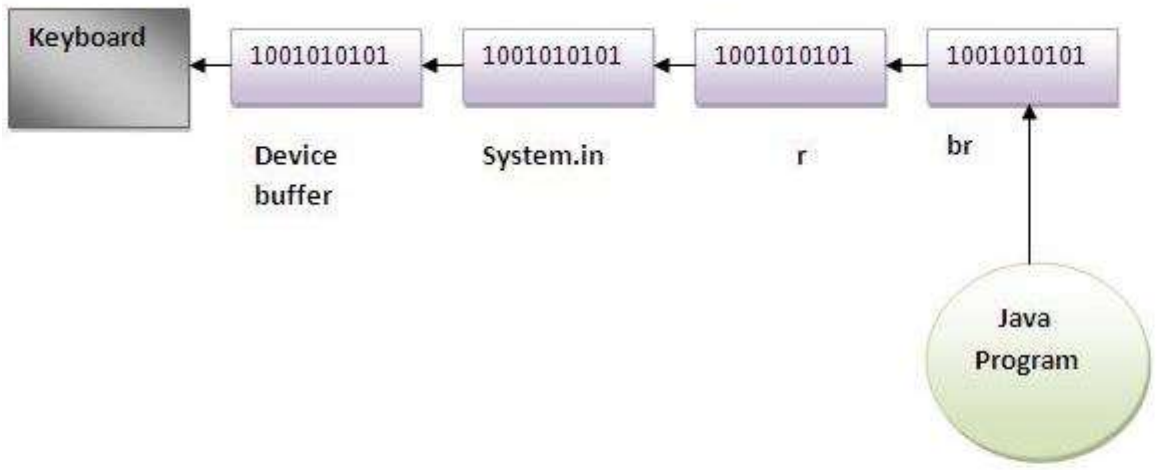
By wrapping the **System.in** (standard input stream) in an **InputStreamReader** which is wrapped in a BufferedReader, we can read input from the user in the command line. Here's an example:

InputStreamReader class can be used to read data from keyboard.It performs two tasks:

1. connects to input stream of keyboard
2. converts the byte-oriented stream into character-oriented stream

BufferedReader class can be used to read data line by line by readLine() method.

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



- The **System.in** is a byte stream and cannot be chained to BufferedReader as BufferedReader is a character stream
- **Note :** (this problem, we did not face with DataInputStream as DataInputStream and System.in are both byte streams)
- The byte stream **System.in** should be converted (wrapped) into a character stream and then passed to BufferedReader constructor. This is done by **InputStreamReader**.

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Keyboard Input using InputStreamReader

```
import java.io.*;


public class JavaIODemo1_138
{
        public static void main(String[] args)throws IOException
        {
                InputStreamReader in = new InputStreamReader(System.in);
                BufferedReader br = new BufferedReader(in);

                String str;
                System.out.print("\n\t Enter a string :");
                str = br.readLine();
```

```
                        int age;
                        System.out.println("\n\t Enter age :");
                        age = Integer.parseInt(br.readLine());

                        System.out.println("\n\t Str = " + str);
                        System.out.println("\n\t Age = " + age);
            }
}
```

- InputStreamReader, is neither an input stream nor a reader. It is not a carrier of data
- It is simply a wrapper around input stream to give a reader functionality.
- The InputStreamReader is used to link an input stream with character stream on reading-side

Advantages: The input is buffered for efficient reading.

Drawbacks: The wrapping code is hard to remember.

Keyboard Input Using Scanner Class

The main purpose of the **Scanner** class (available since Java 1.5) is to parse primitive types and strings using regular expressions, however it is also can be used to read input from the user in the command line. Here's an example:

```
Scanner scanner = new Scanner(System.in);
System.out.print("Enter your nationality: ");
String nationality = scanner.nextLine();

System.out.print("Enter your age: ");
int age = scanner.nextInt();
```

Advantages:

- Convenient methods for parsing primitives (`nextInt()`, `nextFloat()`, …) from the tokenized input.
- Regular expressions can be used to find tokens.

Drawbacks:

- The reading methods are not synchronized.

Keyboard input using Console class

The Java Console class is used to get input from console. It provides methods to read text and password. If you read password using Console class, it will not be displayed to the user. System class provides a static method console() that returns the unique instance of Console class.

The java.io.Console class is attached with system console internally. The Console class is introduced since 1.5.

Methods of Console class

Method	Description
public String readLine()	It is used to read a single line of text from the console.

public String readLine(String fmt,Object... args)	It provides a formatted prompt then reads the single line of text from the console.
public char[] readPassword()	It is used to read password that is not being displayed on the console.
public char[] readPassword(String fmt,Object... args)	it provides a formatted prompt then reads the password that is not being displayed on the console

Advantages:

- Reading password without echoing the entered characters.
- Reading methods are synchronized.
- Format string syntax can be used.

Drawbacks:

- Does not work in non-interactive environment (such as in an IDE).

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Keyboard Input using Console class

```
import java.io.*;

public class ReadStringTest
{
        public static void main(String args[])
        {
                Console c=System.console();

                System.out.print("Enter your name: ");
                String n=c.readLine();

                System.out.print("Enter password: ");
                char[] ch=c.readPassword();
                String pass=String.valueOf(ch);//converting char array into string

                System.out.println("Welcome "+n);
                System.out.println("Password is: "+pass);
        }
}
```

java.io.PrintStream class:

The PrintStream class provides methods to write data to another stream. The PrintStream class automatically flushes the data so there is no need to call flush() method. Moreover, its methods don't throw IOException

Methods of PrintStream class

- `public void print(DataType value):` it prints the specified value.
- `public void println(DataType value):` it prints the specified value and terminates the line

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Write Ouput on Console Screen using PrintStream

```
import java.io.*;

public class PrintStreamDemo
{
        public static void main(String args[])
        {
                PrintStream pout = new PrintStream(System.out);
                pout.println("Helloworld");
                pout.print("This is PrintStream Example");

        }
}
```

File and Directory

Class java.io.File

The class `java.io.File` can represents either a **file** or a **directory**.

A **path string** is used to locate a **file** or a **directory**. Unfortunately, path strings are system dependent, e.g., "`c:\myproject\java\Hello.java`" in Windows or "`/myproject/java/Hello.java`" in Unix/Mac.

- Windows use back-slash `'\'` as the directory separator; while Unixes/Mac use forward-slash `'/'`.
- Windows use semi-colon `';'` as path separator to separate a list of paths; while Unixes/Mac use colon `':'`.
- Windows use "`\r\n`" as line delimiter for text file; while Unixes use "`\n`" and Mac uses "`\r`".
- The "`c:\`" or "`\`" is called the *root*. Windows supports multiple roots, each maps to a drive (e.g., "`c:\`", "`d:\`"). Unixes/Mac has a single root ("`\`")

A path could be *absolute* (beginning from the root) or *relative* (which is relative to a reference directory). Special notations "`.`" and "`..`" denote the current directory and the parent directory, respectively.

The `java.io.File` class maintains these system-dependent properties, for you to write programs that are portable:

- **Directory Separator**: in `static` fields `File.separator` (as `String`) and `File.separatorChar`. [They failed to follow the Java naming convention for constants adopted since JDK 1.2.] As mentioned, Windows use backslash `'\'`; while Unixes/Mac use forward slash `'/'`.
- **Path Separator:** in `static` fields `File.pathSeparator` (as `String`) and `File.pathSeparatorChar`. As mentioned, Windows use semi-colon `';'` to separate a list of paths; while Unixes/Mac use colon `':'`.

You can construct a `File` instance with a path string or URI, as follows. Take note that the physical file/directory may or may not exist. A file URL takes the form of `file://...`, e.g., `file:///d:/docs/programming/java/test.html`.

```
public File(String pathString)
public File(String parent, String child)
public File(File parent, String child)
```
// Constructs a File instance based on the given path string.

```
public File(URI uri)
```
// Constructs a File instance by converting from the given file-URI "file://...."

For examples,

```
File file = new File("in.txt");        // A file relative to the current working directory
File file = new File("d:\\myproject\\java\\Hello.java");  // A file with absolute path
File dir  = new File("c:\\temp");     // A directory
```

For applications that you intend to distribute as JAR files, you should use the `URL` class to reference the resources, as it can reference disk files as well as JAR'ed files , for example,

```
java.net.URL url = this.getClass().getResource("icon.png");
```

Methods of java.io.File class

Method Name	Description
public boolean **`exists`**()	Tests if this file/directory exists.
public long **`length`**()	Returns the length of this file.
public boolean **`isDirectory`**()	Tests if this instance is a directory.
public boolean **`isFile`**()	Tests if this instance is a file.
public boolean **`canRead`**()	Tests if this file is readable.
public boolean **`canWrite`**()	Tests if this file is writable.
public boolean **`delete`**()	Deletes this file/directory.
public void **`deleteOnExit`**()	Deletes this file/directory when the program terminates.
public boolean **`renameTo`**(File *`dest`*)	Renames this file.
public boolean **`mkdir`**()	Makes (Creates) this directory.
public Boolean **`createNewFile`**()	Crates new file

List Directory

For a directory, you can use the following methods to list its contents:

```
public String[] list()        // List the contents of this directory in a String-array
public File[] listFiles()    // List the contents of this directory in a File-array
```

Example: The following program recursively lists the contents of a given directory

```
import java.io.File;
public class ListDirectoryRecusive {
   public static void main(String[] args) {
      File dir = new File("d:\\myproject\\test");   // Escape sequence needed for '\'
      listRecursive(dir);
   }

   public static void listRecursive(File dir) {
      if (dir.isDirectory()) {
         File[] items = dir.listFiles();
         for (File item : items) {
            System.out.println(item.getAbsoluteFile());
            if (item.isDirectory())
                  listRecursive(item);   // Recursive call
         }
      }
   }
}
```

List Directory with Filter

You can apply a filter to `list()` and `listFiles()`, to list only files that meet a certain criteria.

```
public String[] list(FilenameFilter filter)
public File[] listFiles(FilenameFilter filter)
public File[] listFiles(FileFilter filter)
```

The `interface java.io.FilenameFilter` declares one `abstract` method:

```
public boolean accept(File dirName, String fileName)
```

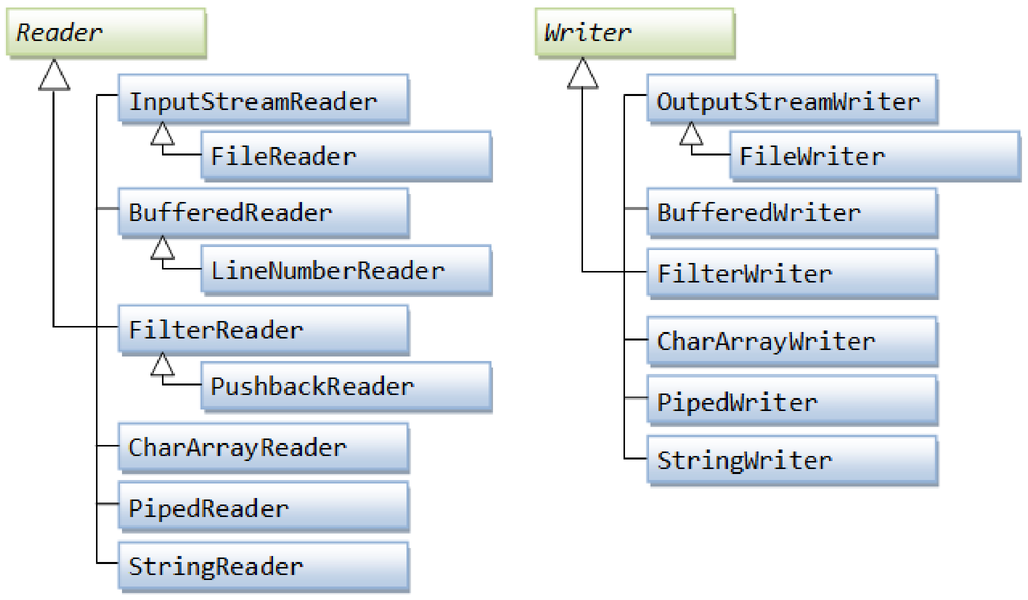
The `list()` and `listFiles()` methods does a *call-back* to `accept()` for each of the file/sub-directory produced. You can program your filtering criteria in `accept()`. Those files/sub-directories that result in a `false` return will be excluded.

Example: The following program lists only files that meet a certain filtering criteria.

```
// List files that end with ".java"
```

```
import java.io.File;
import java.io.FilenameFilter;
public class ListDirectoryWithFilter {
   public static void main(String[] args) {
      File dir = new File(".");    // current working directory
      if (dir.isDirectory()) {
         // List only files that meet the filtering criteria
  //  programmed in accept() method of FilenameFilter.
         String[] files = dir.list(new FilenameFilter(){
                              public boolean accept(File dir, String file)
                              {
                                    return file.endsWith(".java");
                              }
                        });   // an anonymous inner class as FilenameFilter
         for (String file : files) {
            System.out.println(file);
         }
      }
   }
}
```

Character-Based I/O



Some important Charcter stream classes.

Stream class	Description
Reader	Abstract class that define character stream input
Writer	Abstract class that define character stream output
BufferedReader	Handles buffered input stream.
BufferedWriter	Handles buffered output stream.
FileReader	Input stream that reads from file.
FileWriter	Output stream that writes to file.
InputStreamReader	Input stream that translate byte to character
OutputStreamWriter	Output stream that translate character to byte.
PrintWriter	Output Stream that contain `print()` and `println()` method.

Abstract superclass Reader and Writer

The `abstract` superclass `Reader` operates on `char`. It declares an `abstract` method `read()` to read one character from the input source. `read()` returns the character as an `int` between 0 to 65535 (a `char` in Java can be treated as an unsigned 16-bit integer); or -1 if end-of-stream is detected; or throws an `IOException` if I/O error occurs. There are also two variations of `read()` to read a block of characters into `char`-array

```
public abstract int read() throws IOException
public int read(char[] chars, int offset, int length) throws IOException
public int read(char[] chars) throws IOException
```

Writer is the abstract class for writing character streams. It implements the following fundamental methods:

- write(int): writes a single character.
- write(char[]): writes an array of characters.
- write(String): writes a string.
- close(): closes the stream.

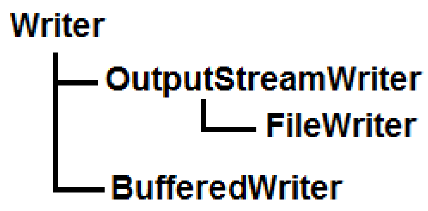
OutputStreamWriter, FileWriter, BufferedWriter

`OutputStreamWriter` is a bridge from byte streams to character streams. Characters are encoded into bytes using a specified charset. The charset can be default character encoding of the operating system, or can be specified explicitly when creating an `OutputStreamWriter`.

`FileWriter` is a convenient class for writing text files using the default character encoding of the operating system.

BufferedWriter writes text to a character stream with efficiency (characters, arrays and strings are buffered to avoid frequently writing to the underlying stream) and provides a convenient method for writing a line separator: `newLine()`.

The following diagram show relationship of these writer classes in the `java.io` package:



Character Encoding and Charset

When constructing a reader or writer object, the default character encoding of the operating system is used (e.g. Cp1252 on Windows):

```
FileReader reader = new FileReader("MyFile.txt");
FileWriter writer = new FileWriter("YourFile.txt");
```

So if we want to use a specific charset, use an **InputStreamReader** or **OutputStreamWriter** instead. For example:

```
InputStreamReader reader = new InputStreamReader(
                    new FileInputStream("MyFile.txt"), "UTF-16");
```

That creates a new reader with the Unicode character encoding UTF-16.

And the following statement constructs a writer with the UTF-8 encoding:

```
OutputStreamWriter writer = new OutputStreamWriter(
                    new FileOutputStream("YourFile.txt"), "UTF-8");
```

In case we want to use a **BufferedReader**, just wrap the **InputStreamReader** inside, for example:

```
InputStreamReader reader = new InputStreamReader(
        new FileInputStream("MyFile.txt"), "UTF-16");
BufferedReader bufReader = new BufferedReader(reader);
```

And for a **BufferedWriter** example:

```
OutputStreamWriter writer = new OutputStreamWriter(
                    new FileOutputStream("YourFile.txt"), "UTF-8");
```

```
BufferedWriter bufWriter = new BufferedWriter(writer);
```

Reading from Text File Example

The following small program reads every single character from the file `MyFile.txt` and prints all the characters to the output console:

```
import java.io.FileReader;
import java.io.IOException;

public class TextFileReadingExample1 {
    public static void main(String[] args) {
        try {
            FileReader reader = new FileReader("MyFile.txt");
            int character;

            while ((character = reader.read()) != -1) {
                System.out.print((char) character);
            }
            reader.close();

        } catch (IOException e) {
            e.printStackTrace();
        }
    }
}
```

The following example reads a text file with assumption that the encoding is UTF-16:

```
import java.io.FileInputStream;
import java.io.IOException;
import java.io.InputStreamReader;

public class TextFileReadingExample2 {
    public static void main(String[] args) {
        try {
            FileInputStream inputStream = new FileInputStream("MyFile.txt");
            InputStreamReader reader = new InputStreamReader(inputStream, "UTF-16");
            int character;

            while ((character = reader.read()) != -1) {
                System.out.print((char) character);
            }
            reader.close();

        } catch (IOException e) {
            e.printStackTrace();
        }
    }
}
```

Buffered I/O Character-Streams
- BufferedReader & BufferedWriter

BufferedReader and BufferedWriter can be stacked on top of FileReader/FileWriter or other character streams to perform buffered I/O, instead of character-by-character. BufferedReader provides a new method readLine(), which reads a line and returns a String

And the following example uses a **BufferedReader** to read a text file line by line (this is the most efficient and preferred way):

```
import java.io.BufferedReader;
import java.io.FileReader;
import java.io.IOException;

public class TextFileReadingExample3 {
     public static void main(String[] args) {
        try {
            FileReader reader = new FileReader("MyFile.txt");
            BufferedReader bufferedReader = new BufferedReader(reader);

            String line;

            while ((line = bufferedReader.readLine()) != null) {
                System.out.println(line);
            }
            reader.close();

        } catch (IOException e) {
            e.printStackTrace();
        }
    }
}
```

Writing to Text File Example

In the following example, a **FileWriter** is used to write two words “Hello World” and “Good Bye!” to a file named MyFile.txt:

```
import java.io.FileWriter;
import java.io.IOException;

public class TextFileWritingExample1 {
    public static void main(String[] args) {
        try {
            FileWriter writer = new FileWriter("MyFile.txt", true);
            writer.write("Hello World");
            writer.write("\r\n");   // write new line
            writer.write("Good Bye!");
            writer.close();
        } catch (IOException e) {
            e.printStackTrace();
        }
    }
 }
```

Note that, a writer uses default character encoding of the operating system by default. It also creates a new file if not exits, or overwrites the existing one. If you want to append text to an existing file, pass a boolean flag of true to constructor of the writer class:

```
FileWriter writer = new FileWriter("MyFile.txt", true);
```

The following example uses a **BufferedReader** that wraps a **FileReader** to append text to an existing file:

```
import java.io.BufferedWriter;
import java.io.FileWriter;
import java.io.IOException;
public class TextFileWritingExample2 {
    public static void main(String[] args) {
        try {
            FileWriter writer = new FileWriter("MyFile.txt", true);
            BufferedWriter bufferedWriter = new BufferedWriter(writer);

            bufferedWriter.write("Hello World");
            bufferedWriter.newLine();
            bufferedWriter.write("See You Again!");

            bufferedWriter.close();
        } catch (IOException e) {
            e.printStackTrace();
        }

    }
}
```

This is the preferred way to write to text file because the **BufferedReader** provides efficient way for writing character streams.

InputStreamReader and OutputStreamWriter

As mentioned, Java internally stores characters (`char` type) in 16-bit UCS-2 character set. But the external data source/sink could store characters in other character set (e.g., US-ASCII, ISO-8859-x, UTF-8, UTF-16, and many others), in fixed length of 8-bit or 16-bit, or in variable length of 1 to 4 bytes. The `FileReader`/`FileWriter` introduced earlier uses the default charset for decoding/encoding, resulted in non-portable programs.

`InputStreamReader` and `OutputStreamWriter` are considered to be byte-to-character "bridge" streams.

You can choose the character set in the `InputStreamReader`'s constructor:

public **`InputStreamReader`**(InputStream *`in`*) `// Use default charset`

public **`InputStreamReader`**(InputStream *`in`*, String *charsetName*) throws UnsupportedEncodingException

public **`InputStreamReader`**(InputStream *`in`*, Charset *`cs`*)

You can list the available charsets via `static` method `java.nio.charset.Charset.availableCharsets()`. The commonly-used `Charset` names supported by Java are:

- "`US-ASCII`": 7-bit ASCII (aka ISO646-US)
- "`ISO-8859-1`": Latin-1
- "`UTF-8`": Most commonly-used encoding scheme for Unicode
- "`UTF-16BE`": Big-endian (big byte first) (big-endian is usually the default)
- "`UTF-16LE`": Little-endian (little byte first)
- "`UTF-16`": with a 2-byte BOM (Byte-Order-Mark) to specify the byte order. FE FF indicates big-endian, FF FE indicates little-endian.

As the `InputStreamReader`/`OutputStreamWriter` often needs to read/write in multiple bytes, it is best to wrap it with a `BufferedReader`/`BufferedWriter`.

And the following example specifies specific character encoding (UTF-16) when writing to the file:

```
import java.io.BufferedWriter;
import java.io.FileOutputStream;
import java.io.IOException;
import java.io.OutputStreamWriter;
```

```
public class TextFileWritingExample3 {
    public static void main(String[] args) {
        try {
            FileOutputStream outputStream = new FileOutputStream
                                            ("MyFile.txt");
            OutputStreamWriter outputStreamWriter = new OutputStreamWriter
                                            (outputStream, "UTF-16");
            BufferedWriter bufferedWriter = new BufferedWriter
                                            (outputStreamWriter);

            bufferedWriter.write("Hello world!");
            bufferedWriter.newLine();
            bufferedWriter.write("Welcome to my program");

            bufferedWriter.close();
        } catch (IOException e) {
            e.printStackTrace();
        }
    }
}
```

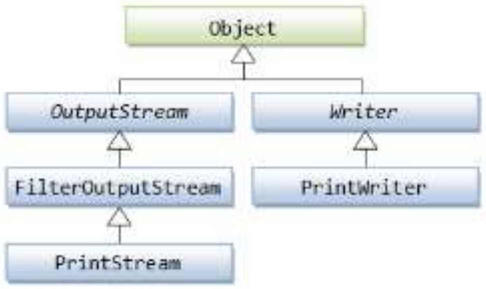
This program writes some Unicode string to the specified text file.

NOTE: From Java 7, you can use try-with-resources statement to simplify the code of opening and closing the reader/writer. For example:

```
try (FileReader reader = new FileReader("MyFile.txt")) {
    int character;

    while ((character = reader.read()) != -1) {
        System.out.print((char) character);
    }
} catch (IOException e) {
    e.printStackTrace();
}
```

java.io.PrintStream & java.io.PrintWriter



The byte-based `java.io.printSteam` supports convenient printing methods such as `print()` and `println()` for printing primitives and text string. Primitives are converted to their string representation for printing. The `printf()` and `format()` were introduced in JDK 1.5 for formatting output with former specifiers. `printf()` and `format()` are identical.

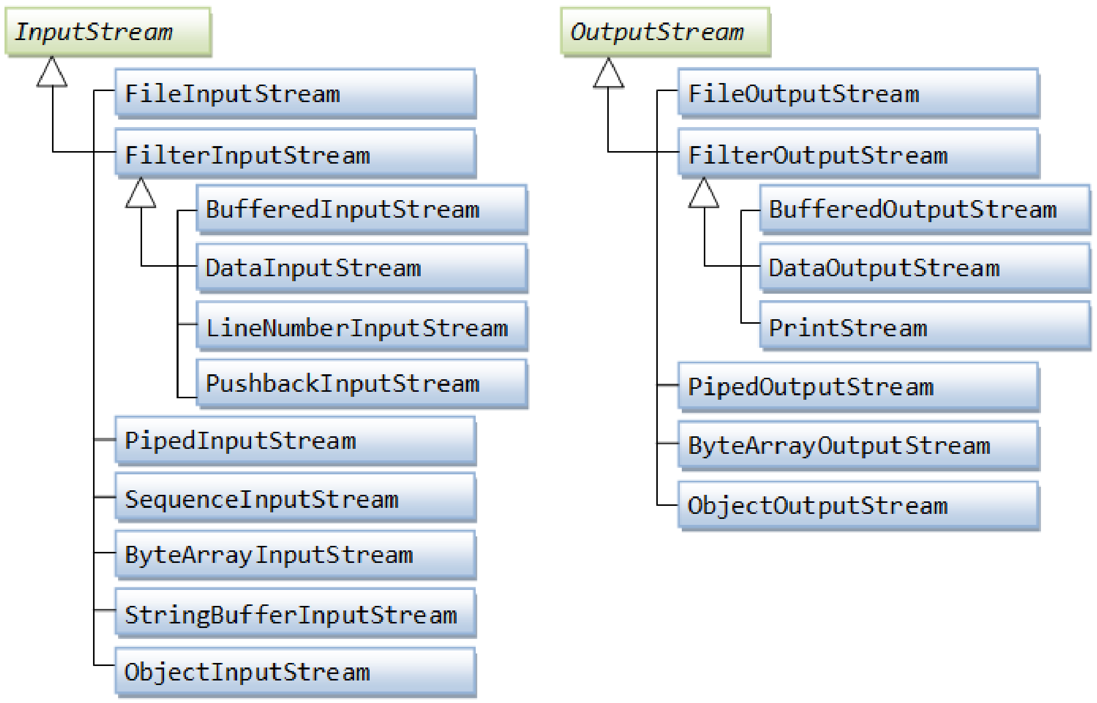
A `PrintStream` never throws an `IOException`. Instead, it sets an internal flag which can be checked via the `checkError()` method. A `PrintStream` can also be created to flush the output automatically. That is, the `flush()`method is automatically invoked after a byte array is written, one of the `println()` methods is invoked, or after a newline (`'\n'`) is written.

The standard output and error streams (`System.out` and `System.err`) belong to `PrintStream`.

All characters printed by a `PrintStream` are converted into bytes using the default character encoding. The `PrintWriter` class should be used in situations that require writing characters rather than bytes.

The character-stream `PrintWriter` is similar to `PrintStream`, except that it write in characters instead of bytes. The `PrintWriter` also supports all the convenient printing methods `print()`, `println()`, `printf()` and `format()`. It never throws an `IOException` and can optionally be created to support automatic flushing

InputStream and OutputStream



Some important Byte stream classes.

Stream class	Description
InputStream	Abstract class that describe stream input.
OutputStream	Abstract class that describe stream output.
PrintStream	Output Stream that contain `print()` and `println()` method
BufferedInputStream	Used for Buffered Input Stream.
BufferedOutputStream	Used for Buffered Output Stream.
DataInputStream	Contains method for reading java standard datatype
DataOutputStream	An output stream that contain method for writing java standard data type
FileInputStream	Input stream that reads from a file
FileOutputStream	Output stream that write to a file.

InputStream class

InputStream class is an abstract class. It is the superclass of all classes representing an input stream of bytes.

Commonly used methods of InputStream class

Method	Description
public abstract int read()throws IOException:	Reads the next byte of data from the input stream. It returns -1 at the end of file.
public int available()throws IOException:	Returns an estimate of the number of bytes that can be read from the current input stream.
public void close()throws IOException:	It is used to close the current input stream.

OutputStream class

OutputStream class is an abstract class. It is the superclass of all classes representing an output stream of bytes. An output stream accepts output bytes and sends them to some sink.

Commonly used methods of OutputStream class

Method	Description
public void write(int)throws IOException:	It is used to write a byte to the current output stream.
public void write(byte[])throws IOException:	It is used to write an array of byte to the current output stream.
public void flush()throws IOException:	It flushes the current output stream.
public void close()throws IOException:	It is used to close the current output stream.

Reading from an InputStream

The `abstract` superclass `InputStream` declares an `abstract` method `read()` to read one data-byte from the input source:

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

The `read()` method:

- returns the input byte read as an `int` in the range of 0 to 255, or
- returns -1 if "end of stream" condition is detected, or
- throws an `IOException` if it encounters an I/O error.

The read() method returns an int instead of a byte, because it uses -1 to indicate end-of-stream.

The read() method blocks until a byte is available, an I/O error occurs, or the "end-of-stream" is detected. The term "block" means that the method (and the program) will be suspended. The program will resume only when the method returns.

Two variations of read() methods are implemented in the InputStream for reading a block of bytes into a byte-array. It returns the number of bytes read, or -1 if "end-of-stream" encounters.

```
public int read(byte[] bytes, int offset, int length) throws IOException
```

// Read "length" number of bytes, store in bytes array starting from offset of index.

`public int read(byte[] bytes) throws IOException`

// Same as read(bytes, 0, bytes.length)

Writing to an OutputStream

Similar to the input counterpart, the `abstract` superclass `OutputStream` declares an abstract method `write()` to write a data-byte to the output sink. `write()` takes an `int`. The least-significant byte of the `int` argument is written out; the upper 3 bytes are discarded. It throws an `IOException` if I/O error occurs (e.g., output stream has been closed).

`public void abstract void write(int unsignedByte) throws IOException`

Similar to the `read()`, two variations of the `write()` method to write a block of bytes from a byte-array are implemented:

`public void write(byte[] bytes, int offset, int length) throws IOException`

// Write "*length*" number of bytes, from the *bytes* array starting from offset of *index*.

`public void write(byte[] bytes) throws IOException`

// Same as write(*bytes*, 0, *bytes*.length)

Opening & Closing I/O Streams

You open an I/O stream by constructing an instance of the stream. Both the InputStream and the OutputStream provides a close() method to close the stream, which performs the necessary clean-up operations to free up the system resources.

`public void close() throws IOException` // close this Stream

It is a good practice to explicitly close the I/O stream, by running `close()` in the `finally` clause of `try-catch-finally` to free up the system resources immediately when the stream is no longer needed. This could prevent serious resource leaks. Unfortunately, the `close()` method also throws a`IOException`, and needs to be enclosed in a nested `try-catch` statement, as follows. This makes the codes somehow ugly.

```
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();
   }
}
```

FileInputStream & FileOutputStream

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

FileOutputStream class

Java FileOutputStream is an output stream for writing data to a file.

If you have to write primitive values then use FileOutputStream.Instead, for character-oriented data, prefer FileWriter.But you can write byte-oriented as well as character-oriented dat

Program N0.

File OutputStream Demo

```
import java.io.*;
public class FileOutputStreamDemo
{
  public static void main(String args[])
  {
   try
   {
     FileOutputStream fout=new FileOutputStream("abc.txt");
     String s="Sachin Tendulkar is my favourite player";
     byte b[]=s.getBytes();//converting string into byte array
     fout.write(b);
     fout.close();
     System.out.println("success...");
    }
    catch(Exception e)
    {
      System.out.println(e);
    }
  }
}
```

FileInputStream class

Java FileInputStream class obtains input bytes from a file.It is used for reading streams of raw bytes such as image data. For reading streams of characters, consider using FileReader.

It should be used to read byte-oriented data for example to read image, audio, video etc

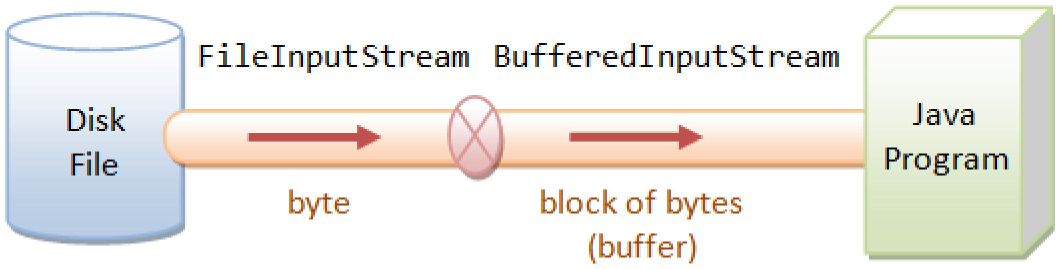
Program N0.

File InputStream Demo

```
import java.io.*;
public class SimpleRead
{
  public static void main(String args[])
  {
       try
       {
         FileInputStream fin=new FileInputStream("abc.txt");
         int i=0;
         while((i=fin.read())!=-1)
         {
             System.out.println((char)i);
         }
       fin.close();
       }
       catch(IOException e)
       {
             System.out.println(e);
       }
 }
}
```

BufferedInputStream & BufferedOutputStream

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). For example, we can layer a `BufferedInputStream` to a `FileInputStream` for buffered input,



The `read()/write()` method in `InputStream/OutputStream` are designed to read/write a single byte of data on each call. This is grossly inefficient, as each call is handled by the underlying operating system (which may trigger a disk access, or other expensive operations). *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.

`FileInputStream/FileOutputStream` is not buffered. It is often chained to a `BufferedInputStream` or `BufferedOutputStream`, which provides the buffering. To chain the streams together, simply pass an instance of one stream into the constructor of another stream. For example, the following codes chain a `FileInputStream` to a `BufferedInputStream`, and finally, a `DataInputStream`:

```
FileInputStream fileIn = new FileInputStream("in.dat");
BufferedInputStream bufferIn = new BufferedInputStream(fileIn);
DataInputStream dataIn = new DataInputStream(bufferIn);
// or
DataInputStream in = new DataInputStream(
                        new BufferedInputStream(
                           new FileInputStream("in.dat")));
```

Program N0.

Copying a file byte-by-byte without Buffering.

```
import java.io.*;
public class FileCopyNoBuffer {   // Pre-JDK 7
   public static void main(String[] args) {
      String inFileStr = "test-in.jpg";
      String outFileStr = "test-out.jpg";

      FileInputStream in = null;
      FileOutputStream out = null;
      long startTime, elapsedTime;  // for speed benchmarking

      // Print file length
      File fileIn = new File(inFileStr);
      System.out.println("File size is " + fileIn.length() + " bytes");

      try {
         in = new FileInputStream(inFileStr);
         out = new FileOutputStream(outFileStr);

         startTime = System.nanoTime();
         int byteRead;
         // Read a raw byte, returns an int of 0 to 255.
         while ((byteRead = in.read()) != -1)
         {
          // Write the least-significant byte of int, drop the upper 3 bytes
            out.write(byteRead);
         }
         elapsedTime = System.nanoTime() - startTime;
         System.out.println("Elapsed Time is" + (elapsedTime/1000000.0)+
                                                                     " msec");
      } catch (IOException ex) {
         ex.printStackTrace();
      } finally {  // always close the I/O streams
         try {
            if (in != null) in.close();
            if (out != null) out.close();
         } catch (IOException ex) {
            ex.printStackTrace();
         }
      }
   }
}
```

This example copies a file by reading a byte from the input file and writing it to the output file. It uses `FileInputStream` and `FileOutputStream` directly without buffering. Notice that most the I/O methods "throws" `IOException`, which must be caught or declared to be thrown. The method`close()` is programmed inside the `finally` clause. It is guaranteed to be run after `try` or `catch`. However, method `close()` also throws an `IOException`, and therefore must be enclosed inside a nested `try-catch` block, which makes the codes a little ugly.

We used `System.nanoTime()`, which was introduced in JDK 1.5, for a more accurate measure of the elapsed time, instead of the legacy not-so-precise `System.currentTimeMillis()`. The output shows that it took about 4 seconds to copy a 400KB file.

Program NO. 138

Copying a file with a Programmer-Managed Buffer.

```
import java.io.*;
public class FileCopyUserBuffer {  // Pre-JDK 7
   public static void main(String[] args) {
      String inFileStr = "test-in.jpg";
      String outFileStr = "test-out.jpg";
      FileInputStream in = null;
      FileOutputStream out = null;
      long startTime, elapsedTime;  // for speed benchmarking

      // Check file length
      File fileIn = new File(inFileStr);
      System.out.println("File size is " + fileIn.length() + " bytes");

      try {
         in = new FileInputStream(inFileStr);
         out = new FileOutputStream(outFileStr);
         startTime = System.nanoTime();
         byte[] byteBuf = new byte[4096];    // 4K byte-buffer
         int numBytesRead;
         while ((numBytesRead = in.read(byteBuf)) != -1) {
            out.write(byteBuf, 0, numBytesRead);
         }
         elapsedTime = System.nanoTime() - startTime;
         System.out.println("Elapsed Time is " + (elapsedTime / 1000000.0) +
" msec");
      } catch (IOException ex) {
         ex.printStackTrace();
      } finally {  // always close the streams
         try {
            if (in != null) in.close();
            if (out != null) out.close();
         } catch (IOException ex) { ex.printStackTrace(); }
      }
   }
}
```

This example again uses FileInputStream and FileOutputStream directly. However, instead of reading/writing one byte at a time, it reads/writes a 4KB block. This program took only 3 millisecond - a more than 1000 times speed-up compared with the previous example.

Larger buffer size, up to a certain limit, generally improves the I/O performance. However, there is a trade-off between speed-up the the memory usage. For file copying, a large buffer is certainly recommended. But for reading just a few bytes from a file, large buffer simply wastes the memory.

re-write the program using JDK 1.7, and try on various buffer size on a much bigger file of 26MB.

```java
import java.io.*;

public class FileCopyUserBufferLoopJDK7 {
   public static void main(String[] args) {
      String inFileStr = "test-in.jpg";
      String outFileStr = "test-out.jpg";
      long startTime, elapsedTime;  // for speed benchmarking

      // Check file length
      File fileIn = new File(inFileStr);
      System.out.println("File size is " + fileIn.length() + " bytes");

      int[] bufSizeKB = {1, 2, 4, 8, 16, 32, 64, 256, 1024};  // in KB
      int bufSize;  // in bytes

      for (int run = 0; run < bufSizeKB.length; ++run) {
         bufSize = bufSizeKB[run] * 1024;
         try (FileInputStream in = new FileInputStream(inFileStr);
              FileOutputStream out = new FileOutputStream(outFileStr)) {
            startTime = System.nanoTime();
            byte[] byteBuf = new byte[bufSize];
            int numBytesRead;
            while ((numBytesRead = in.read(byteBuf)) != -1) {
               out.write(byteBuf, 0, numBytesRead);
            }
            elapsedTime = System.nanoTime() - startTime;
            System.out.printf("%4dKB: %6.2fmsec%n", bufSizeKB[run], (elapsedTime / 1000000.0));
            //System.out.println("Elapsed Time is " + (elapsedTime / 1000000.0) + " msec");
         } catch (IOException ex) {
            ex.printStackTrace();
         }
      }
   }
}
```

Copying File with Buffered Streams

Program NO.

Copying a file with Buffered Streams.

```java
import java.io.*;
public class FileCopyBufferedStream {  // Pre-JDK 7
   public static void main(String[] args) {
      String inFileStr = "test-in.jpg";
      String outFileStr = "test-out.jpg";
      BufferedInputStream in = null;
      BufferedOutputStream out = null;
      long startTime, elapsedTime;  // for speed benchmarking

      // Check file length
      File fileIn = new File(inFileStr);
      System.out.println("File size is " + fileIn.length() + " bytes");

      try {
         in  = new BufferedInputStream(new FileInputStream(inFileStr));
         out = new BufferedOutputStream(new FileOutputStream(outFileStr));
         startTime = System.nanoTime();
         int byteRead;
         while ((byteRead = in.read()) != -1) {  // Read byte-by-byte from
buffer
            out.write(byteRead);
         }
         elapsedTime = System.nanoTime() - startTime;
         System.out.println("Elapsed Time is " + (elapsedTime / 1000000.0) +
" msec");
      } catch (IOException ex) {
         ex.printStackTrace();
      } finally {            // always close the streams
         try {
            if (in != null) in.close();
            if (out != null) out.close();
         } catch (IOException ex) { ex.printStackTrace(); }
      }
   }
}
```

In this example, the **FileInputStream** with **BufferedInputStream**, **FileOutputStream** with **BufferedOutputStream**, and read/write byte-by-byte. The JRE decides on the buffer size. The program took 62 milliseconds, about 60 times speed-up compared with example 1, but slower than the programmer-managed buffer.

The JDK 1.7 version of the above example is as follows:

```
import java.io.*;

public class FileCopyBufferedStreamJDK7 {

   public static void main(String[] args) {

      String inFileStr = "test-in.jpg";

      String outFileStr = "test-out.jpg";

      long startTime, elapsedTime;  // for speed benchmarking

      // Check file length
      File fileIn = new File(inFileStr);
      System.out.println("File size is " + fileIn.length() + " bytes");

      try (BufferedInputStream in = new BufferedInputStream(new FileInputStream(inFileStr));
           BufferedOutputStream out = new BufferedOutputStream(new FileOutputStream(outFileStr)))
{
         startTime = System.nanoTime();
         int byteRead;
         while ((byteRead = in.read()) != -1) {
            out.write(byteRead);
         }
         elapsedTime = System.nanoTime() - startTime;
         System.out.println("Elapsed Time is " + (elapsedTime / 1000000.0) + " msec");
      } catch (IOException ex) {
         ex.printStackTrace();
      }
   }
}
```

Formatted Data-Streams: DataInputStream & DataOutputStream

The DataInputStream and DataOutputStream can be stacked on top of any InputStream and OutputStream to parse the raw bytes to perform I/O operations in the desired data format, such as int and double.

To use DataInputStream for formatted input, you can chain up the input streams as follows:

```
DataInputStream in = new DataInputStream(
                        new BufferedInputStream(
                           new FileInputStream("in.dat")));
```

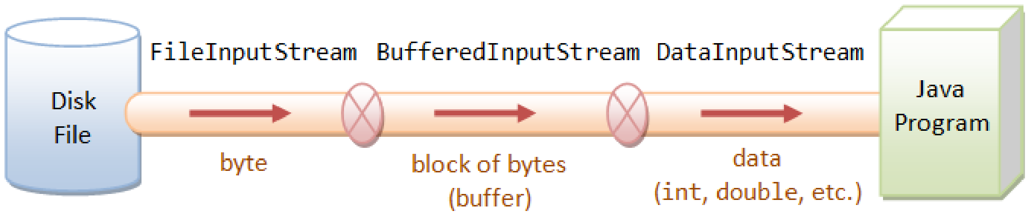
DataInputStream implements DataInput interface, which provides methods to read formatted primitive data and String, such as:

Method	Description
public final int **readInt**() throws IOExcpetion;	Read 4 bytes and convert into int
public final double **readDoube**() throws IOExcpetion;	Read 8 bytes and convert into double
public final byte **readByte**() throws IOExcpetion;	
public final char **readChar**() throws IOExcpetion;	
public final short **readShort**() throws IOExcpetion;	
public final long **readLong**() throws IOExcpetion;	
public final boolean **readBoolean**() throws IOExcpetion;	Read 1 byte. Convert to false if zero
public final float **readFloat**() throws IOExcpetion;	
public final int **readUnsignedByte**() throws IOExcpetion;	Read 1 byte in [0, 255] upcast to int
public final int **readUnsignedShort**() throws IOExcpetion;	Read 2 bytes in [0, 65535], same as char, upcast to int
public final void **readFully**(byte[] *b*, int *off*, int *len*) throws IOException;	
public final void **readFully**(byte[] *b*) throws IOException;	

public final String **readLine**() throws IOException;	Read a line (until newline), convert each byte into a char - no unicode support
public final String **readUTF**() throws IOException;	read a UTF-encoded string with first two bytes indicating its UTF bytes length
public final int **skipBytes**(int n)	Skip a number of bytes

Similarly, you can stack the `DataOutputStream` as follows:

```
    DataOutputStream out = new DataOutputStream(
                                 new BufferedOutputStream(
                                    new FileOutputStream("out.dat")));
```



`DataOutputStream` implements `DataOutput` interface, which provides methods to write formatted primitive data and `String`. For examples,

Method	Description
public final void **`writeInt`**(int *`i`*) throws IOExcpetion;	Write the int as 4 bytes
public final void **`writeFloat`**(float *`f`*) throws IOExcpetion;	
public final void **`writeDoube`**(double *`d`*) throws IOExcpetion;	Write the double as 8 bytes
public final void **`writeByte`**(int *`b`*) throws IOExcpetion;	least-significant byte
public final void **`writeShort`**(int *`s`*) throws IOExcpetion;	two lower bytes
public final void **`writeLong`**(long *`l`*) throws IOExcpetion;	
public final void **`writeBoolean`**(boolean *`b`*) throws IOExcpetion;	
public final void **`writeChar`**(int *`i`*) throws IOExcpetion;	
public final void **`writeBytes`**(String *`str`*) throws IOExcpetion;	least-significant byte of each char
public final void **`writeChars`**(String *`str`*) throws IOExcpetion;	Write String as UCS-2 16-bit char, Big-endian (big byte first)
public final void **`writeUTF`**(String *`str`*) throws IOException;	Write String as UTF, with first two bytes indicating UTF bytes length
public final void **`write`**(byte[] *`b`*, int *`off`*, int *`len`*) throws IOException public final void **`write`**(byte[] *`b`*) throws IOException	

public final void **write**(int *b*) throws IOException	Write the least-significant byte

Example: The following program writes some primitives to a disk file. It then reads the raw bytes to check how the primitives were stored. Finally, it reads the data as primitives.

```
import java.io.*;
public class TestDataIOStream {
   public static void main(String[] args) {
      String filename = "data-out.dat";
      String message = "Hi,您好!";

      // Write primitives to an output file
      try (DataOutputStream out =
              new DataOutputStream(
                 new BufferedOutputStream(
                    new FileOutputStream(filename)))) {
         out.writeByte(127);
         out.writeShort(0xFFFF);  // -1
         out.writeInt(0xABCD);
         out.writeLong(0x1234_5678);  // JDK 7 syntax
         out.writeFloat(11.22f);
         out.writeDouble(55.66);
         out.writeBoolean(true);
         out.writeBoolean(false);
         for (int i = 0; i < message.length(); ++i) {
            out.writeChar(message.charAt(i));
         }
         out.writeChars(message);
         out.writeBytes(message);
         out.flush();
      } catch (IOException ex) {
         ex.printStackTrace();
      }

      // Read raw bytes and print in Hex
      try (BufferedInputStream in =
              new BufferedInputStream(
                 new FileInputStream(filename))) {
         int inByte;
         while ((inByte = in.read()) != -1) {
            System.out.printf("%02X ", inByte);   // Print Hex codes
         }
         System.out.printf("%n%n");
      } catch (IOException ex) {
         ex.printStackTrace();
      }

      // Read primitives
      try (DataInputStream in =
              new DataInputStream(
                 new BufferedInputStream(
                    new FileInputStream(filename)))) {
         System.out.println("byte:    " + in.readByte());
         System.out.println("short:   " + in.readShort());
         System.out.println("int:     " + in.readInt());
         System.out.println("long:    " + in.readLong());
         System.out.println("float:   " + in.readFloat());
         System.out.println("double:  " + in.readDouble());
         System.out.println("boolean: " + in.readBoolean());
         System.out.println("boolean: " + in.readBoolean());
```

```
            System.out.print("char:    ");
            for (int i = 0; i < message.length(); ++i) {
               System.out.print(in.readChar());
            }
            System.out.println();

            System.out.print("chars:   ");
            for (int i = 0; i < message.length(); ++i) {
               System.out.print(in.readChar());
            }
            System.out.println();

            System.out.print("bytes:   ");
            for (int i = 0; i < message.length(); ++i) {
               System.out.print((char)in.readByte());
            }
            System.out.println();
         } catch (IOException ex) {
            ex.printStackTrace();
         }
      }
   }
```

Data streams support binary I/O of primitive data type values (`boolean`, `char`, `byte`, `short`, `int`, `long`, `float`, and `double`) as well as String values. All data streams implement either the `DataInput` interface or the `DataOutput` interface. This section focuses on the most widely-used implementations of these interfaces, `DataInputStream` and `DataOutputStream`.

The `DataStreams` example demonstrates data streams by writing out a set of data records, and then reading them in again. Each record consists of three values related to an item on an invoice, as shown in the following table:

Order in record	Data type	Data description	Output Method	Input Method	Sample Value
1	Double	Item price	DataOutputStream.writeDouble	DataInputStream.readDouble	19.99
2	Int	Unit count	DataOutputStream.writeInt	DataInputStream.readInt	12
3	String	Item description	DataOutputStream.writeUTF	DataInputStream.readUTF	"Java T-Shirt"

Let's examine crucial code in `DataStreams`. First, the program defines some constants containing the name of the data file and the data that will be written to it:

```
static final String dataFile = "invoicedata";
static final double[] prices = { 19.99, 9.99, 15.99, 3.99, 4.99 };
static final int[] units = { 12, 8, 13, 29, 50 };
static final String[] descs = {
    "Java T-shirt",
    "Java Mug",
    "Duke Juggling Dolls",
    "Java Pin",
    "Java Key Chain"
};
```

Then `DataStreams` opens an output stream. Since a `DataOutputStream` can only be created as a wrapper for an existing byte stream object, `DataStreams` provides a buffered file output byte stream.

```
out = new DataOutputStream(new BufferedOutputStream(
              new FileOutputStream(dataFile)));
```

`DataStreams` writes out the records and closes the output stream.

```
for (int i = 0; i < prices.length; i ++) {
```

```
            out.writeDouble(prices[i]);
            out.writeInt(units[i]);
            out.writeUTF(descs[i]);
        }
```

The writeUTF method writes out String values in a modified form of UTF-8. This is a variable-width character encoding that only needs a single byte for common Western characters.

Now DataStreams reads the data back in again. First it must provide an input stream, and variables to hold the input data. Like DataOutputStream, DataInputStream must be constructed as a wrapper for a byte stream.

```
        in = new DataInputStream(new
                    BufferedInputStream(new FileInputStream(dataFile)));
        double price;
        int unit;
        String desc;
        double total = 0.0;
```

Now DataStreams can read each record in the stream, reporting on the data it encounters.

```
        try {
            while (true) {
                price = in.readDouble();
                unit = in.readInt();
                desc = in.readUTF();
                System.out.format("You ordered %d" + " units of %s at $%.2f%n",
                    unit, desc, price);
                total += unit * price;
            }
        } catch (EOFException e) {
        }
```

Notice that DataStreams detects an end-of-file condition by catching EOFException, instead of testing for an invalid return value. All implementations of DataInput methods use EOFException instead of return values.

Also notice that each specialized write in DataStreams is exactly matched by the corresponding specialized read. It is up to the programmer to make sure that output types and input types are matched in this way: The input stream consists of simple binary data, with nothing to indicate the type of individual values, or where they begin in the stream.

DataStreams uses one very bad programming technique: it uses floating point numbers to represent monetary values. In general, floating point is bad for precise values. It's particularly bad for decimal fractions, because common values (such as 0.1) do not have a binary representation.

Object Streams and Object Serialization

Data streams (DataInputStream and DataOutputStream) allow you to read and write primitive data (such as int, double) and String, rather than individual bytes. Just as data streams support I/O of primitive data types, object streams support I/O of objects

The object stream classes are ObjectInputStream and ObjectOutputStream. These classes implement ObjectInput and ObjectOutput, which are subinterfaces of DataInput and DataOutput.

Most of the core Java classes implement Serializable, such as all the wrapper classes, collection classes, and GUI classes. In fact, the only core Java classes that do not implement Serializable are ones that should not be serialized. Arrays of primitives or serializable objects are themselves serializable.

transient & static

- static fields are not serialized, as it belongs to the class instead of the particular instance to be serialized.
- To prevent certain fields from being serialized, mark them using the keyword **transient**. This could cut down the amount of data traffic.

- The `writeObject()` method writes out the class of the object, the class signature, and values of non-`static` and non-`transient` fields

Object streams

(`ObjectInputStream` and `ObjectOutputStream`) go one step further to allow you to read and write entire objects (such as `Date`, `ArrayList` or any custom objects).

Object serialization is the process of representing a "particular state of an object" in a serialized bit-stream, so that the bit stream can be written out to an external device (such as a disk file or network). The bit-stream can later be re-constructed to recover the state of that object. Object serialization is necessary to save a state of an object into a disk file for persistence or sent the object across the network for applications such as Web Services, Distributed-object applications, and Remote Method Invocation (RMI).

In Java, object that requires to be serialized must implement `java.io.Serializable` or `java.io.Externalizable` interface. `Serializable` interface is an empty interface (or *tagged* interface) with nothing declared. Its purpose is simply to declare that particular object is serializable.

ObjectInputStream & ObjectOutputStream

We use object streams to read and write Java objects in binary format. `ObjectInputStream` and `ObjectOutputStream` are the main object stream classes provided by the Java File I/O API.

The `ObjectOutputStream` class implements the `ObjectOutput` interface that defines a method for writing an object to an output stream:

- `writeObject(Object):` writes an object to the underlying storage or stream. This method throws `IOException` if an I/O error occurs.

The process of writing an object to an output stream is called **`Serialization`**

The `ObjectOutput` interface extends from the `DataOutput` interface, which means an `ObjectOutputStream` inherits all behaviors of writing primitive types and Strings like a `DataOutputStream`.

Likewise, the `ObjectInputStream` class implements the `ObjectInput` interface that defines a method for reading an object from an input stream:

- **`readObject():`** reads and returns an object. This method throws `ClassNotFoundException` if the class of the serialized object cannot be found, and throws `IOException` if an I/O error occurs.

The process of reconstructing an object from an input stream is called **`deserialization`**.

The `ObjectInput` interface extends from the `DataInput` interface, which means an `ObjectInputStream` also has behaviors of reading primitive types and Strings like a `DataInputStream`.

Which kinds of object are eligible for serialization?

Note that only objects of classes that implement the `java.io.Serializable` interface can be written to and read from an output/input stream. `Serializable` is a marker interface, which doesn't define any methods. Only objects that are marked 'serializable' can be used with `ObjectOutputStream` and `ObjectInputStream`.

Most classes in Java (including `Date` and primitive wrappers `Integer, Double, Long`, etc) implement the `Serializable` interface. We have to implement this interface for our custom classes only, such as the `Student` class we see in the previous email about data streams.

If we attempt to write an object of a non-serializable class, we will get a `java.io.NotSerializableException`.

```
import java.util.Date;
import java.io.Serializable;
public class Student implements Serializable {
      private String name;
      private Date birthday;
      private boolean gender; // true is male, false is female
      private int age;
      private float grade;
      public Student() {
      }
      public Student(String name, Date birthday,
                  boolean gender, int age, float grade) {
            this.name = name;
            this.birthday = birthday;
            this.gender = gender;
            this.age = age;
            this.grade = grade;
      }
      // getters and setters go here...
}
```

As you can see, we make this class implements the `Serializable` interface and add another member variable call birthday which is of type `java.util.Date`.

Rewrite the `StudentRecordWriter` program to use an `ObjectOutputStream` like this:

```
import java.util.*;
import java.text.*;
import java.io.*;
public class StudentRecordWriter {
      public static void main(String[] args) {
            if (args.length < 1) {
                  System.out.println("Please provide output file");
                  System.exit(0);
            }
            String outputFile = args[0];
```

```
                DateFormat dateFormat = new SimpleDateFormat("MM-dd-yyyy");
                try (
                      ObjectOutputStream objectOutput
                            = new ObjectOutputStream(new FileOutputStream(outputFile));
                      ) {
                      List listStudent = new ArrayList<>();
                      listStudent.add(new Student("Alice", dateFormat.parse("02-15-1993"),
                                                         false, 23, 80.5f));
                      listStudent.add(new Student("Brian", dateFormat.parse("10-03-1994"),
                                                         true, 22, 95.0f));
                      listStudent.add(new Student("Carol", dateFormat.parse("08-22-1995"),
                                                         false, 21, 79.8f));
                      for (Student student : listStudent) {
                            objectOutput.writeObject(student);
                      }
                } catch (IOException | ParseException ex) {
                      ex.printStackTrace();
                }
          }
    }
```

Run this program via command line:

```
    java StudentRecordWriter Student.db
```

And rewrite the `StudentRecordReader` program like this:

```
    import java.text.*;
    import java.io.*;
    public class StudentRecordReader {
          public static void main(String[] args) {
                if (args.length < 1) {
                      System.out.println("Please provide input file");
                      System.exit(0);
                }
                String inputFile = args[0];
                DateFormat dateFormat = new SimpleDateFormat("MM-dd-yyyy");
                try (
                            ObjectInputStream objectInput
                                  = new ObjectInputStream(new FileInputStream(inputFile));
                      ){
                      while (true) {
                            Student student = (Student) objectInput.readObject();
                            System.out.print(student.getName() + "\t");
                            System.out.print(dateFormat.format(student.getBirthday()) + "\t");
                            System.out.print(student.getGender() + "\t");
                            System.out.print(student.getAge() + "\t");
                            System.out.println(student.getGrade());
                        }
                } catch (EOFException eof) {
                        System.out.println("Reached end of file");
                } catch (IOException | ClassNotFoundException ex) {
                        ex.printStackTrace();
                }
        }
}
```

Run this program via command line:

```
java StudentRecordReader Student.db
```

Output:

```
Alice   02-15-1993      false   23      80.5
Brian   10-03-1994      true    22      95.0
Carol   08-22-1995      false   21      79.8
Reached end of file
```

java.io.Externalizable Interface

The `Serializable` has a sub-interface called `Externalizable`, which you could used if you want to customize the way a class is serialized. Since `Externalizable` extends `Serializable`, it is also a `Serializable` and you could invoke `readObject()` and `writeObject()`.

`Externalizable` declares two `abstract` methods:

```
void writeExternal(ObjectOutput out) throws IOException
void readExternal(ObjectInput in) throws IOException, ClassNotFoundException
```

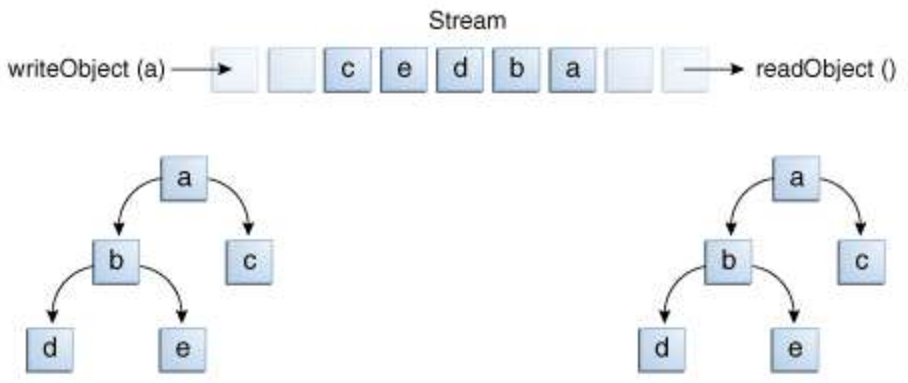
`ObjectOutput` and `ObjectInput` are interfaces that are implemented by `ObjectOutputStream` and `ObjectInputStream`, which define the `writeObject()` and `readObject()` methods, respectively. When an instance of `Externalizable` is passed to an `ObjectOutputStream`, the default serialization procedure is bypassed; instead, the stream calls the instance's `writeExternal()` method. Similarly, when an `ObjectInputStream` reads a `Exteranlizabled` instance, it uses `readExternal()` to reconstruct the instance.

`Externalizable` is useful if you want complete control on how your objects shall be serialized/deserialized. For example, you could encrypt sensitive data before the object is serialized

Output and Input of Complex Objects

The `writeObject` and `readObject` methods are simple to use, but they contain some very sophisticated object management logic. This isn't important for a class like Calendar, which just encapsulates primitive values. But many objects contain references to other objects. If `readObject` is to reconstitute an object from a stream, it has to be able to reconstitute all of the objects the original object referred to. These additional objects might have their own references, and so on. In this situation, `writeObject` traverses the entire web of object references and writes all objects in that web onto the stream. Thus a single invocation of `writeObject` can cause a large number of objects to be written to the stream.

This is demonstrated in the following figure, where `writeObject` is invoked to write a single object named **a**. This object contains references to objects **b** and **c**, while **b** contains references to **d** and **e**. Invoking `writeobject(a)` writes not just **a**, but all the objects necessary to reconstitute **a**, so the other four objects in this web are written also. When **a** is read back by `readObject`, the other four objects are read back as well, and all the original object references are preserved.



I/O of multiple referred-to objects

You might wonder what happens if two objects on the same stream both contain references to a single object. Will they both refer to a single object when they're read back? The answer is "yes." A stream can only contain one copy of an object, though it can contain any number of references to it. Thus if you explicitly write an object to a stream twice, you're really writing only the reference twice. For example, if the following code writes an object `ob` twice to a stream:

```
Object ob = new Object();
out.writeObject(ob);
out.writeObject(ob);
```

Each `writeObject` has to be matched by a `readObject`, so the code that reads the stream back will look something like this:

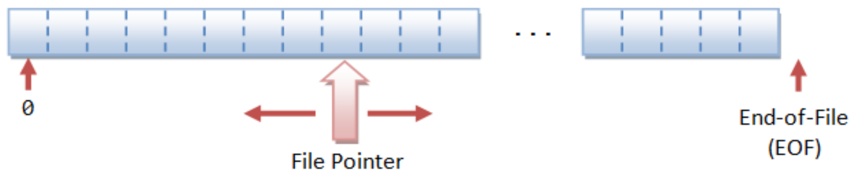
```
Object ob1 = in.readObject();
Object ob2 = in.readObject();
```

This results in two variables, `ob1` and `ob2`, that are references to a single object.

Random Access Files

All the I/O streams covered so far are one-way streams. That is, they are either read-only input stream or write-only output stream. Furthermore, they are all sequential-access (or serial) streams, meant for reading and writing data sequentially. Nonetheless, it is sometimes necessary to read a file record directly as well as modifying existing records or inserting new records. The class `RandomAccessFile` provides supports for non-sequential, direct (or random) access to a disk file. `RandomAccessFile` is a two-way stream, supporting both input and output operations in the same stream.

`RandomAccessFile` can be treated as a huge byte array. You can use a file pointer (of type `long`), similar to array index, to access individual byte or group of bytes in primitive types (such as int and double). The file pointer is located at 0 when the file is opened. It advances automatically for every read and write operation by the number of bytes processed.



In constructing a `RandomAccessFile`, you can use flags `'r'` or `'rw'` to indicate whether the file is "read-only" or "read-write" access, e.g.,

```
RandomAccessFile f1 = new RandomAccessFile("filename", "r");
RandomAccessFile f2 = new RandomAccessFile("filename", "rw");
```

The following methods are available:

Method	Description
public void seek(long pos) throws IOException	Positions the file pointer for subsequent read/write operation
public int skipBytes(int numBytes) throws IOException	Moves the file pointer forward by the specified number of bytes
public long getFilePointer() throws IOException	Gets the position of the current file pointer, in bytes, from the beginning of the file.
public long length() throws IOException	Returns the length of this file

`RandomAccessFile` does not inherit from `InputStream` or `OutputStream`. However, it implements `DataInput` and `DataOutput` interfaces (similar to `DataInputStream` and`DataOutputStream`). Therefore, you can use various methods to read/write primitive types to the file, e.g.,

```
public int readInt() throws IOException;
public double readDouble() throws IOException;
public void writeInt(int i) throws IOException;
public void writeDouble(double d) throws IOException;
```

Example: Read and write records from a `RandomAccessFile`. (A student file consists of student record of name (`String`) and id (`int`)).

Formatted-Text Input via java.util.Scanner

JDK 1.5 introduces `java.util.Scanner` class, which greatly simplifies formatted text input from input source (e.g., files, keyboard, network). `Scanner`, as the name implied, is a simple text scanner which can parse the input text into primitive types and strings using regular expressions. It first breaks the text input into tokens using a delimiter pattern, which is by default the white spaces (blank, tab and newline).

The tokens may then be converted into primitive values of different types using the various `nextXxx()` methods (`nextInt()`, `nextByte()`, `nextShort()`, `nextLong()`, `nextFloat()`, `nextDouble()`, `nextBoolean()`, `next()` for `String`, and `nextLine()` for an input line). You can also use the `hasNextXxx()` methods to check for the availability of a desired input.

The commonly-used constructors are as follows. You can construct a `Scanner` to parse a byte-based `InputStream` (e.g., `System.in`), a disk file, or a given `String`.

// Scanner piped from a disk File

```
public Scanner(File source) throws FileNotFoundException
public Scanner(File source, String charsetName) throws FileNotFoundException
```

// Scanner piped from a byte-based InputStream, e.g., System.in

```
public Scanner(InputStream source)
public Scanner(InputStream source, String charsetName)
```

// Scanner piped from the given source string (NOT filename string)

```
public Scanner(String source)
```

For examples,

```
// Construct a Scanner to parse an int from keyboard
Scanner in1 = new Scanner(System.in);
int i = in1.nextInt();
```

// Construct a Scanner to parse all doubles from a disk file

```
Scanner in2 = new Scanner(new File("in.txt"));   // need to handle FileNotFoundException
while (in2.hasNextDouble()) {
   double d = in.nextDouble();
}
```

// Construct a Scanner to parse a given text string

```
Scanner in3 = new Scanner("This is the input text String");
while (in3.hasNext()) {
   String s = in.next();
}
```

Example 1: The most common usage of Scanner is to read primitive types and String form the keyboard (System.in), as follows:

```
import java.util.Scanner;
public class TestScannerSystemIn {
   public static void main(String[] args) {
      Scanner in = new Scanner(System.in);

      System.out.print("Enter an integer: ");
      int anInt = in.nextInt();
      System.out.println("You entered " + anInt);

      System.out.print("Enter a floating-point number: ");
      double aDouble = in.nextDouble();
      System.out.println("You entered " + aDouble);

      System.out.print("Enter 2 words: ");
      String word1 = in.next();    // read a string delimited by white space
```

```
        String word2 = in.next();    // read a string delimited by white space
        System.out.println("You entered " + word1 + " " + word2);

        in.nextLine();      // flush the "enter" before the next readLine()

        System.out.print("Enter a line: ");
        String line = in.nextLine();    // read a string up to line delimiter
        System.out.println("You entered " + line);
    }
}
```

The `nextXxx()` methods throw `InputMismatchException` if the next token does not match the type to be parsed.

Example 2: You can easily modify the above program to read the inputs from a text file, instead of keyboard (`System.in`).

```
import java.util.Scanner;
import java.io.*;
public class TestScannerFile {
    public static void main(String[] args) throws FileNotFoundException {
        Scanner in = new Scanner(new File("in.txt"));

        System.out.print("Enter an integer: ");
        int anInt = in.nextInt();
        System.out.println("You entered " + anInt);

        System.out.print("Enter a floating-point number: ");
        double aDouble = in.nextDouble();
        System.out.println("You entered " + aDouble);

        System.out.print("Enter 2 words: ");
        String word1 = in.next();    // read a string delimited by white space
        String word2 = in.next();    // read a string delimited by white space
        System.out.println("You entered " + word1 + " " + word2);

        in.nextLine();      // flush the "enter" before the next readLine()

        System.out.print("Enter a line: ");
        String line = in.nextLine();    // read a string up to line delimiter
        System.out.println("You entered " + line);
        }
    }
```

nextXxx() and hasNextXxx()

The `Scanner` class implements `iterator<String>` interface. You can use `hasNext()` coupled with `next()` to iterate through all the `String` tokens. You can also directly iterate through the primitive types via methods `hasNextXxx()` and `nextXxx()`. `Xxx` includes all primitive types (`byte`, `short`, `int`, `long`, `float`, `double` and `Boolean`), `BigInteger`, and `BigNumber`. `char` is not included but can be retrieved from `String` via `charAt()`.