Programming in Java – Basics of Input and Output

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Agenda

Input and Output streams
Reading and writing binary data

Data streams
Reading and writing Java types

Readers and Writers
Reading and writing text

Input and Output stream

Reading and writing binary data

I/O Streams

I/O in java is bases on streams. Not to be confused with the streams in java.util.stream
The abstraction is the same, but the implementation is different

I/O streams represents a flow of binary data

Input streams are used to read from data sources.
Output streams are used to write to data targets

Introducing InputStream

```
public class InputStream implements Closeable {
…
  public abstract int read() throws IOException;
…
}
```

try-with-resources

```
try (InputStream is = …) {
    int read;
    while ((read = is.read()) != -1) {
        System.out.println("Read: " + read);
    }
}
```

Reads the next byte of data from the input stream

The value byte is returned as an int in the range 0 to 255

If no byte is available because the end of the stream has been reached, the value -1 is returned

The method blocks until
- *input data is available*
- *the end of the stream is detected*
- *an exception is thrown*

Examples of InputStream 1/3

```java
String fileName = "G:\\My Drive\\ … \\Input and Output.pptx";
try (InputStream fis = new FileInputStream(fileName)) {
    int count = 0;
    while (fis.read() != -1) {
        count++;
    }
    System.out.println("Read: " + count);
}
```

Examples of InputStream 2/3

```
URL url = new URL("https://www.google.it");
try (InputStream urlStream = url.openStream()) {
    int read;
    while ((read = urlStream.read()) != -1) {
        System.out.print((char) read);
    }
}
```

WARNING we are converting a stream of bytes into chars

Examples of InputStream 3/3

```
byte[] byteArray = …
try (InputStream is = new ByteArrayInputStream(byteArray)) {
    int read;
    while ((read = is.read()) != -1) {
        System.out.print(read);
    }
}
```

Other methods in InputStream

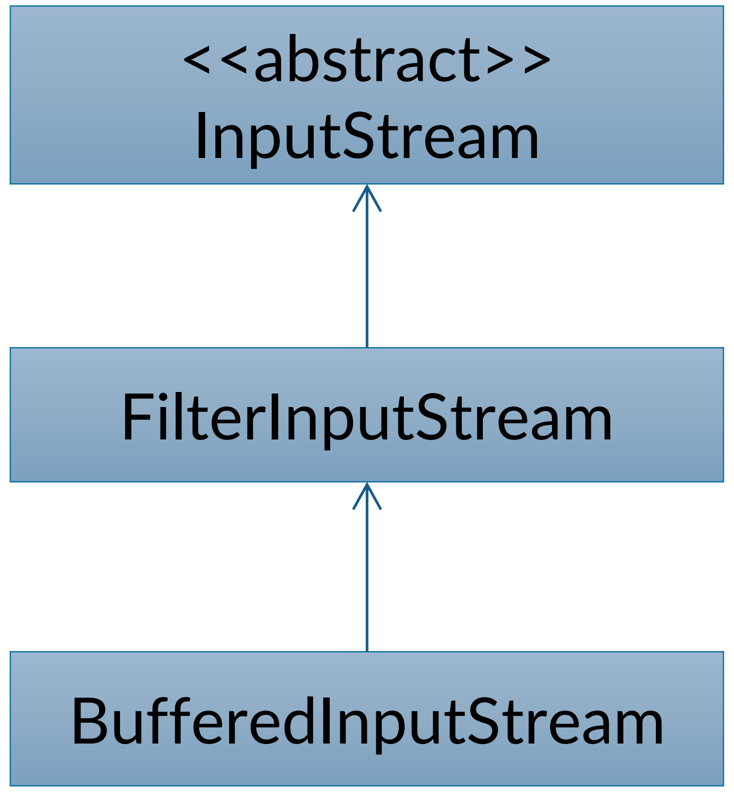
```
public int read(byte b[]) throws IOException
public int read(byte b[], int off, int len) throws IOException
public byte[] readNBytes(int len) throws IOException
public int readNBytes(byte[] b, int off, int len) throws IOException
public byte[] readAllBytes() throws IOException
public long skip(long n) throws IOException
public void skipNBytes(long n) throws IOException
public long transferTo(OutputStream out) throws IOException
public int available() throws IOException
public synchronized void mark(int readlimit)
public synchronized void reset() throws IOException
public boolean markSupported()
public void close() throws IOException
```

BufferedInputStream

When reading from the filesystem or from the network, the reading of small chunks of data can be very inefficient

Java offers buffered input to speedup the reading of small chunks of data

The BufferedInputStream reads data in advance in a buffer of a specified size



```java
public class BufferedInputStream extends FilterInputStream {

    public BufferedInputStream(InputStream in)
    public BufferedInputStream(InputStream in, int size)
    …
}
```

A BufferedInputStream is an InputStream wrapping another input stream

Working with BufferedInputStream

```java
String fileName = "G:\\My Drive\\ … \\Input and Output.pptx";
try (InputStream fis = new BufferedInputStream(new FileInputStream(fileName))) {
    int count = 0;
    while (fis.read() != -1) {
        count++;
    }
    System.out.println("Read: " + count);
}
```

```java
URL url = new URL("https://www.google.it"):
try (InputStream urlStream = new BufferedInputStream(url.openStream())) {
    int read;
    while ((read = urlStream.read()) != -1) {
        System.out.print((char) read);
    }
}
```

Introducing OutputStream

```
public class OutputStream implements Closeable {
…
  public abstract void write(int b)
     throws IOException;
…
}
```

Writes the specified byte to this output stream

The byte to be written is the 8 low-order bits of the argument b

The 24 high-order bits of b are ignored

try-with-resources

```
try (OutputStream os = …) {
    int[] data = …;
    for (int datum : data) {
        os.write(datum);
    }
}
```

Examples of OutputStream

```java
try (OutputStream fos = new FileOutputStream("A:\\git\\sdm\\pippo.dat")) {
    for (int i = 0; i < 10; i++) {
        fos.write(i);
    }
}
```

```java
byte[] byteBuffer = new byte[10];
try (OutputStream os = new ByteArrayOutputStream(byteBuffer)) {
    for (int i = 0; i < 10; i++) {
        os.write(i);
    }
}
```

Other methods of OutputStream

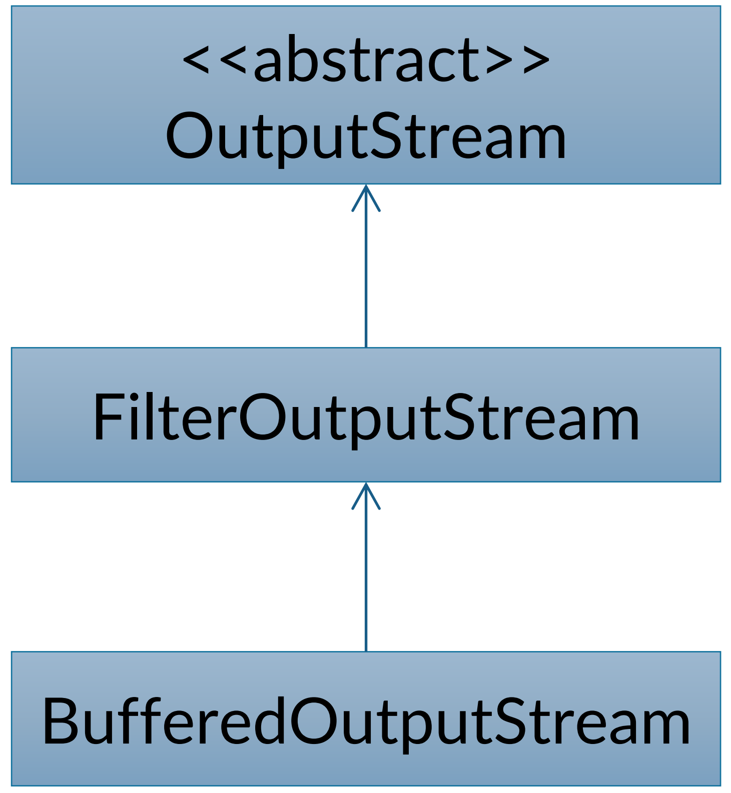
```
public void write(byte b[]) throws IOException

public void write(byte b[], int off, int len) throws IOException

public void flush() throws IOException

public void close() throws IOException
```

BufferedOutputStream

When writing to the filesystem or to the network, the writing of small chunks of data can be very inefficient

Java offers buffered output to speedup the writing of small chunks of data

The BufferedOutputStream writes data to the wrapped stream only when the buffer is full or when flush() is invoked



```
public class BufferedOutputStream extends FilterOutputStream {

    public BufferedOutputStream(OutputStream out)
    public BufferedOutputStream(OutputStream out, int size)
    …
}
```

A BufferedOutputStream is an OutputStream wrapping another output stream

Working with BufferedOutputStream

```
String fileName = "A:\\git\\sdm\\pippo.dat";
try (OutputStream fos = new BufferedOutputStream(new FileOutputStream("…")) {
    for (int i = 0; i < 10; i++) {
        fos.write(i);
    }
}
```

Streams must be closed

Use try-with-resources if you open (create) and use the stream from the same method

Explicitly invoke close() if you open (create) and use the stream in different methods

Data streams

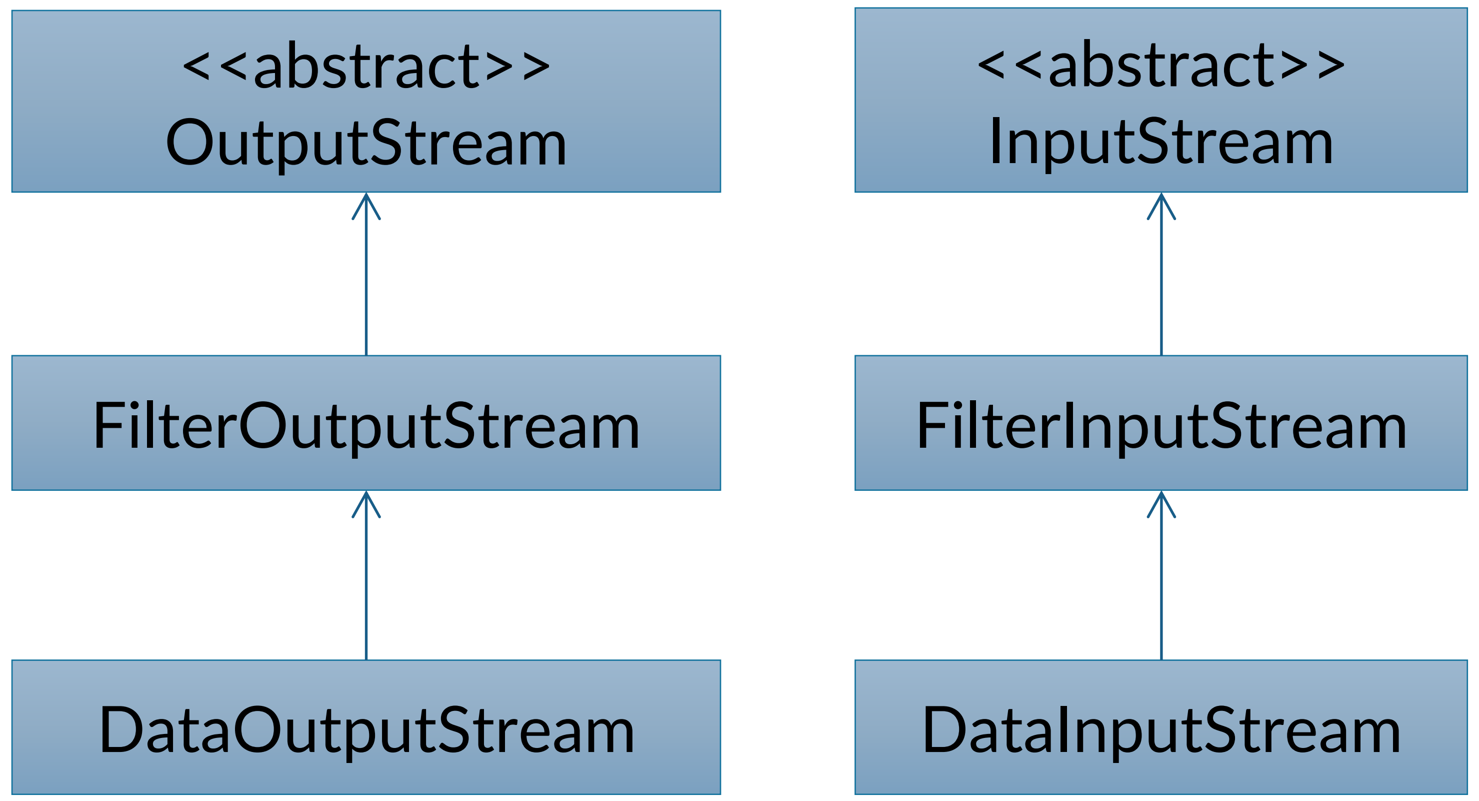
Reading and writing Java types

Primitive types I/O

DataOutputStream and DataInputStream enable you to write or read primitive data to or from a stream

They implement the DataOutput and DataInput interfaces, respectively. These interfaces define methods that convert primitive values to or from a sequence of bytes

These streams make it easy to store binary data, such as integers or floating-point values, in a file



DataInputStream

```
public class DataInputStream extends FilterInputStream implements DataInput {
   public DataInputStream(InputStream in)
    public final boolean readBoolean() throws IOException
    public final byte readByte() throws IOException
    public final int readUnsignedByte() throws IOException
    public final short readShort() throws IOException
    public final int readUnsignedShort() throws IOException
    public final char readChar() throws IOException
    public final int readInt() throws IOException
    public final long readLong() throws IOException
    public final float readFloat() throws IOException
    public final double readDouble() throws IOException
    public final String readUTF() throws IOException
    …
}
```

DataOutputStream

```
public class DataOutputStream extends FilterOutputStream implements DataOutput {
    public DataOutputStream(OutputStream out)
    public void flush() throws IOException
    public final void writeBoolean(boolean v) throws IOException
    public final void writeByte(int v) throws IOException
    public final void writeShort(int v) throws IOException
    public final void writeChar(int v) throws IOException
    public final void writeInt(int v) throws IOException
    public final void writeLong(long v) throws IOException
    public final void writeFloat(float v) throws IOException
    public final void writeDouble(double v) throws IOException
    public final void writeBytes(String s) throws IOException
    public final void writeChars(String s) throws IOException
    public final void writeUTF(String str) throws IOException
    …
}
```

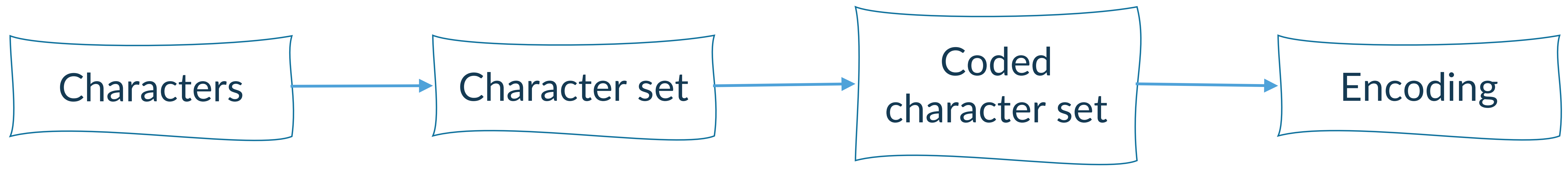
Readers and Writers

Reading and writing text

Text streams

What about reading and writing text?

Character sets and encoding



To know everything about character sets and encodings:
https://www.joelonsoftware.com/2003/10/08/the-absolute-minimum-every-software-developer-absolutely-positively-must-know-about-unicode-and-character-sets-no-excuses/

Unicode terminology – Coded character set

A *coded character set* is a character set where each character is assigned a unique number (code point).

US-ASCII

Code point	Character
0	NUL
1	SOH
…	…
65	A
66	B
67	C
…	…
126	~
127	DEL

Windows-1252/ISO-8859-1

Code point	Character
0	NUL
1	SOH
…	…
65	A
66	B
67	C
…	…
254	þ
255	ÿ

Windows-1250

Code point	Character
0	NUL
1	SOH
…	…
65	A
66	B
67	C
…	…
254	ţ
255	˙

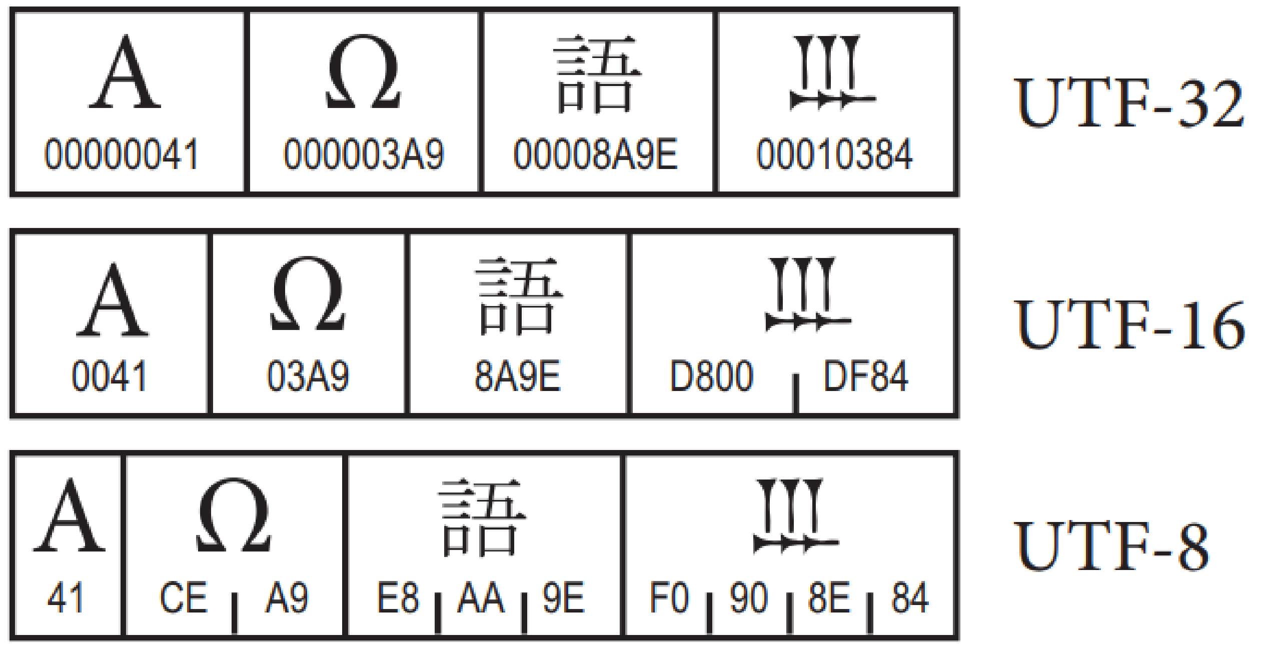
Windows-1252 and ISO-8859-1 are not the same character set, but they differs for some code points assigned to control codes
For HTML5 they can be considered the same https://www.w3.org/TR/encoding/

Encodings

1 byte is enough to encode the whole US-ASCII and ISO-8859-1 character sets.

For characters sets with more than 256 characters with need to use multibyte encodings.

Generally, a character sets define its own encoding and so the term charset is used to refer to both the character set and the encoding. E. g. HTTP and HTML define a charset parameter and attribute, respectively, to define the combination character set/encoding.
UCS is currently the most important character sets and it has multiple encodings, so this character set is represented by the name of the encoding, UTF-8, UTF-16, or UTF-32.



Encodings supported by Java

Every implementation of the Java platform is required to support the following standard charsets. Usually, every implementation supports many more charsets.

Charset	Description
US-ASCII	Seven-bit ASCII, a.k.a. ISO646-US, a.k.a. the Basic Latin block of the Unicode character set
ISO-8859-1	ISO Latin Alphabet No. 1, a.k.a. ISO-LATIN-1
UTF-8	Eight-bit UCS Transformation Format
UTF-16BE	Sixteen-bit UCS Transformation Format, big-endian byte order
UTF-16LE	Sixteen-bit UCS Transformation Format, little-endian byte order
UTF-16	Sixteen-bit UCS Transformation Format, byte order identified by an optional byte-order mark

When in doubt, use UTF-8.

Text streams

To write (read) text to (from) an output(input) stream we need to encode (decode) the text into (from) a binary stream

Fortunately, Java is doing this for us, given we provide a very tiny piece of information, the encoding/charset of the stream

Unfortunately, Java defines default methods that let us skip this step by using by default the default charset

Don't use such methods unless you really know what you are doing

Unfortunately, the default charset might vary depending on the internationalization settings or depending on the operating system

E.g., the default charset on Linux can be UTF-8 while on Windows can be Windows-1252 (in Italy)

Introducing Reader

```
public abstract class Reader implements Closeable {
    …
    public int read() throws IOException;
    …
}
```

```
try (Reader reader = … )) {
    int ch = -1;
    while ((ch = reader.read()) != -1) {
        System.out.print((char) ch);
    }
}
```

Reads a single character as an integer in the range 0 to 65535 or -1 if the end of the stream has been reached

This method will block until

- *a character is available*
- *an I/O error occurs*
- *or the end of the stream is reached.*

Examples of Reader 1/2

```
String fileName = "A:\\git\\sdm\\src\\it\\units\\sdm\\iostreams\\Examples.java";
try (Reader reader = new InputStreamReader(new FileInputStream(fileName), UTF_8)) {
    int ch = -1;
    while ((ch = reader.read()) != -1) {
        System.out.print((char) ch);
    }
}
```

```
try (Reader reader = new FileReader(fileName, StandardCharsets.UTF_8)) {
    int ch = -1;
    while ((ch = reader.read()) != -1) {
        System.out.print((char) ch);
    }
}
```

Examples of Reader 2/2

```java
URL url = new URL("https://www.google.it"):
try (InputStream urlStream = url.openStream()) {
    int read;
    while ((read = urlStream.read()) != -1) {
        System.out.print((char) read);
    }
}
```

We guess the encoding to be UTF-8

```java
URL url = new URL("https://www.google.it");
try (Reader reader = new InputStreamReader(url.openStream(), StandardCharsets.UTF_8)) {
    int ch;
    while ((ch = reader.read()) != -1) {
        System.out.print((char) ch);
    }
}
```

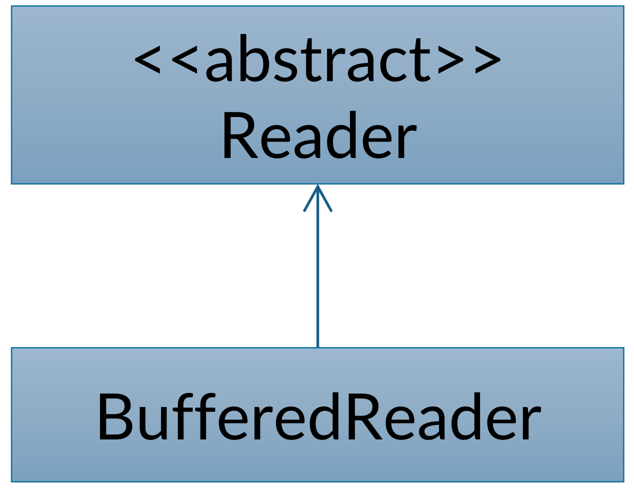
BufferedReader

When reading from the filesystem or from the network, the reading of small chunks of data can be very inefficient

Java offers buffered input to speedup the reading of small chunks of data

The BufferedReader reads data in advance in a buffer of a specified size

```
public class BufferedReader extends Reader {

    public BufferedReader(Reader in)
    public BufferedReader(Reader in, int size)
    …
}
```



A BufferedReader is a Reader wrapping another reader

Working with BufferedReader

```java
try (Reader reader = new BufferedReader(new FileReader(fileName, UTF_8))) {
    int ch = -1;
    while ((ch = reader.read()) != -1) {
        System.out.print((char) ch);
    }
}
```

```java
try (BufferedReader reader = new BufferedReader(new FileReader(fileName, UTF_8))) {
    String line;
    while ((line = reader.readLine()) != null) {
        System.out.println(line);
    }
}
```

```java
try (BufferedReader reader = new BufferedReader(new FileReader(fileName, UTF_8))) {
    reader.lines().forEach(System.out::println);
}
```

Introducing Writer

```
public abstract class Writer implements Closeable {
    …
    public void write(int c) throws IOException
    public void write(String str) throws IOException
    …
}
```

Writes a single character. The character to be written is contained in the 16 low-order bits of the given integer value; the 16 high-order bits are ignored

```
String data = "some data";

try (Writer writer = …) {
    writer.write(data);
}

try (Writer writer = …) {
    for (int i = 0; i < data.length(); i++) {
        writer.write(data.charAt(i));
    }
}
```

Examples of Writer

```
String data = "some data";
try (Writer writer = new FileWriter("A:\\git\\sdm\\pippo.txt", StandardCharsets.UTF_8)) {
    writer.write(data);
}
```

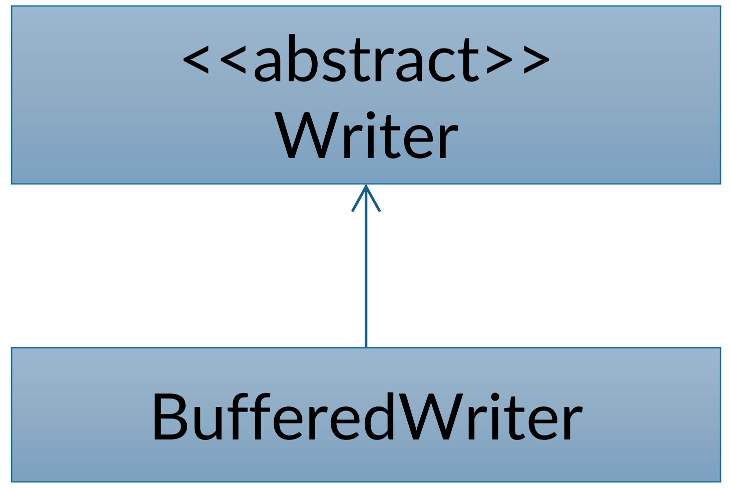
```
try (Writer writer = new OutputStreamWriter(new FileOutputStream(fileName1), UTF_8)) {
    writer.write(data);
}
```

BufferedWriter

When writing to the filesystem or to the network, the writing of small chunks of data can be very inefficient

Java offers buffered output to speedup the writing of small chunks of data

The BufferedWriter writes data to the wrapped writer only when the buffer is full or when flush() is invoked



```
public class BufferedWriter extends Writer {

    public BufferedWriter(Writer writer)
    public BufferedWriter(Writer writer, int size)
    …
}
```

A BufferedWriter is a Writer wrapping another writer

Readers and Writers must be closed

Use try-with-resources if you open (create) and use the stream from the same method

Explicitly invoke close() if you open (create) and use the stream from different methods

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Thank you!

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