

# Java IOs

RES, Lecture 1

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Olivier Liechti

heig-vd

Haute Ecole d'Ingénierie et de Gestion  
du Canton de Vaud

**1**

Est-ce que vous avez déjà utilisé les classes d'entrées/sorties en Java (InputStream, Reader, OutputStream, Writer, etc.)?

**Réponse****Moyenne****Total**

Oui, je les utilise régulièrement. Par contre, NIO?	 12%	6
J'en ai déjà utilisé, mais je ne pense pas maîtriser tous les concepts.	 41%	20
Je sais que ça existe, mais je n'en ai jamais utilisé.	 39%	19
Les entrées-sorties en Java, c'est quoi?	 8%	4
<b>Total</b>	 100%	<b>49/49</b>

# Agenda

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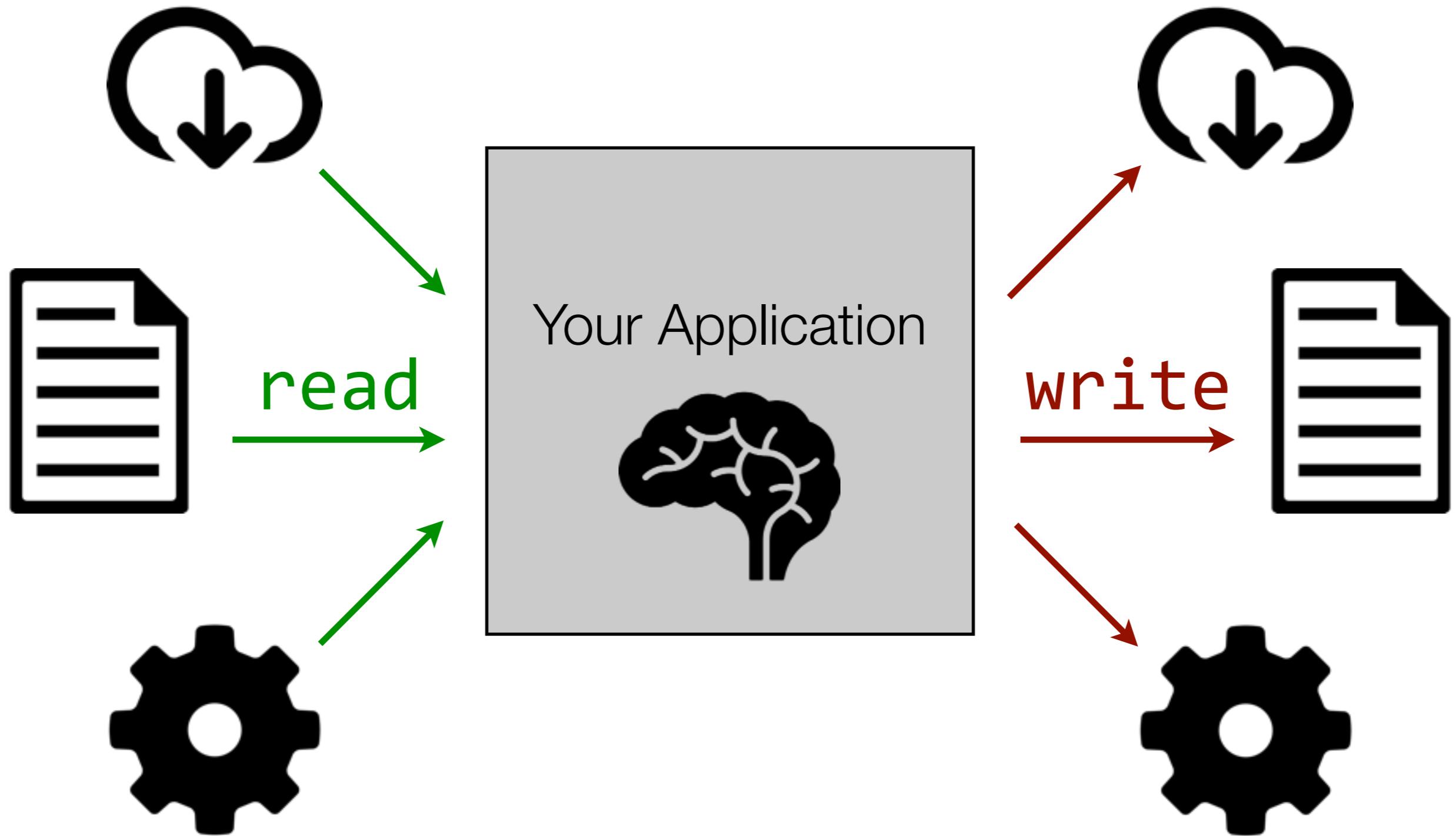
- **Week 1**
  - Universal API
  - Sources, Sinks and Streams
  - The Decorator Pattern and The Mighty Filter Classes
- **Week 2**
  - Performance and Buffering
  - Binary vs. Character-Oriented IOs
  - Shit Happens... Dealing with IO Exceptions

# Universal API



# What do we mean by IO?

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# A Universal API

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*At the end of the day, whether you are "talking" to a **file**, to a **network endpoint** or to a **process** does not matter.*

*You are always doing the same thing: **reading** and/or **writing** bytes or characters.*

*The Java IO API is the **toolbox** that you need for that purpose.*

# Sources, Sinks & Streams



# System.out.println("I like IO");

## out

```
public static final PrintStream out
```

The "standard" output stream. This stream is already open and ready to accept output data. Typically this stream corresponds to display output or another output destination specified by the host environment or user.

For simple stand-alone Java applications, a typical way to write a line of output data is:

```
System.out.println(data)
```

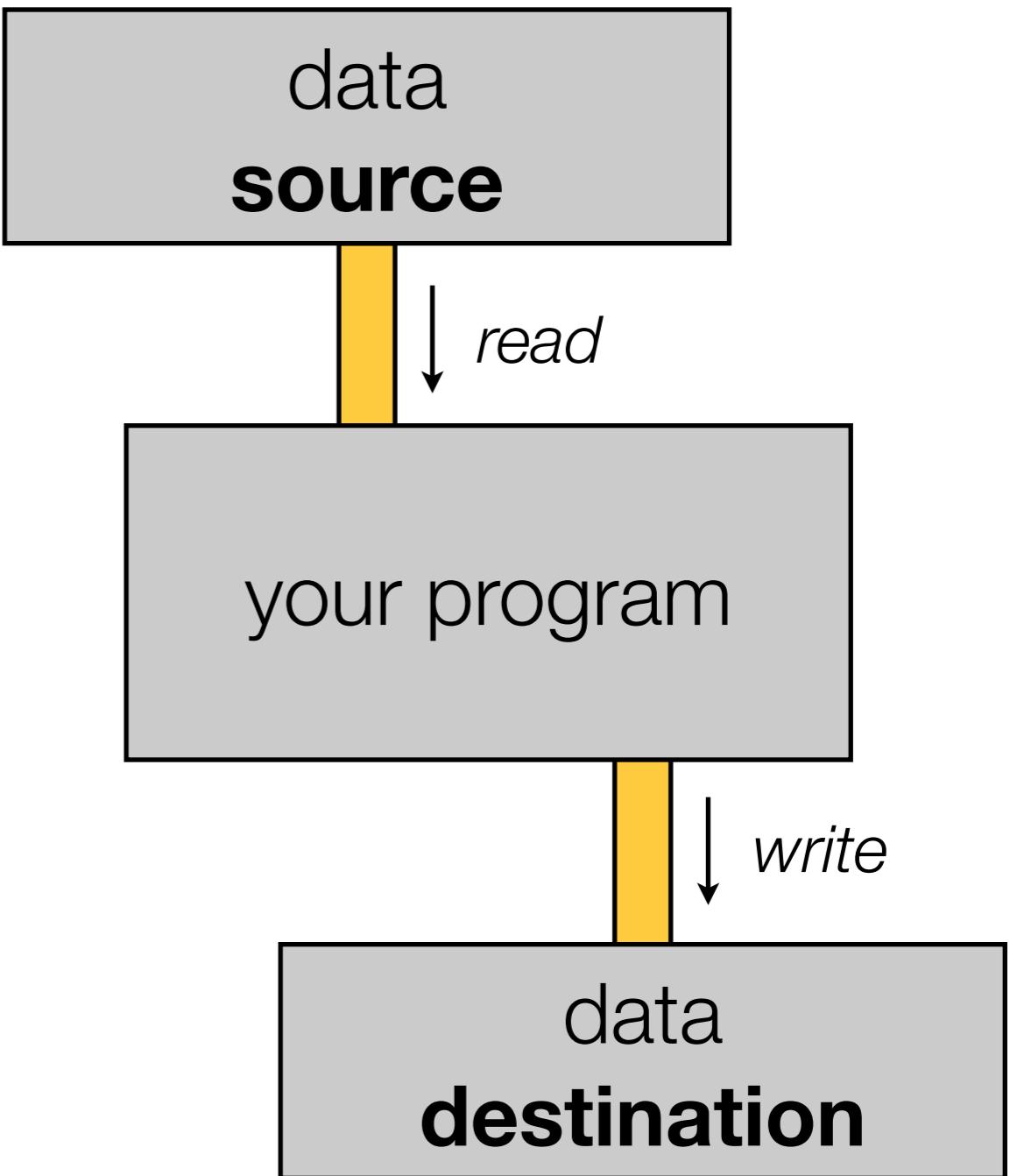
See the `println` methods in class `PrintStream`.

### See Also:

`PrintStream.println()`, `PrintStream.println(boolean)`, `PrintStream.println(char)`,  
`PrintStream.println(char[])`, `PrintStream.println(double)`, `PrintStream.println(float)`,  
`PrintStream.println(int)`, `PrintStream.println(long)`,  
`PrintStream.println(java.lang.Object)`, `PrintStream.println(java.lang.String)`

# Streams

- When we talk about “input/output”, or IOs, we think about **producing** and **consuming streams of data**.
- There are different **sources** that contain or produce data.
- There are also different **destinations** that receive or consume data.
- Think about **files, network endpoints, memory, processes, etc.**
- Your **program** can **read data** from a stream. Your program can **write data** to a stream.



# What can you do with IO streams?

- **Read data from a file.** Think about a program that reads an XML configuration file at start-up. Think about your favorite text editor.
- **Write data to a file.** Think about a java compiler that produces .class files.
- **Receive data over the network.** Think about a web server receiving requests from clients.
- **Send data over the network.** Think about the same server sending responses to the clients.
- **Exchange data with other programs** (processes) running on the same machine.
- **Etc.**

In the end, it's **always the same thing...** it's about **reading** and **writing** data!

If it's the same thing, then we want to have a **single API** for dealing with all sorts of IOs!

# Classes in the `java.io` package (1)

`InputStream`

`OutputStream`

`FileInputStream`

`FileOutputStream`

`ByteArrayInputStream`

`ByteArrayOutputStream`

`PipedInputStream`

`PipedOutputStream`

`FilterInputStream`

`FilterOutputStream`

`BufferedInputStream`

`BufferedOutputStream`

# Classes in the `java.io` package (2)

Reader

FileReader

CharArrayReader

StringReader

FilterReader

BufferedReader

writer

FileWriter

CharArrayWriter

StringWriter

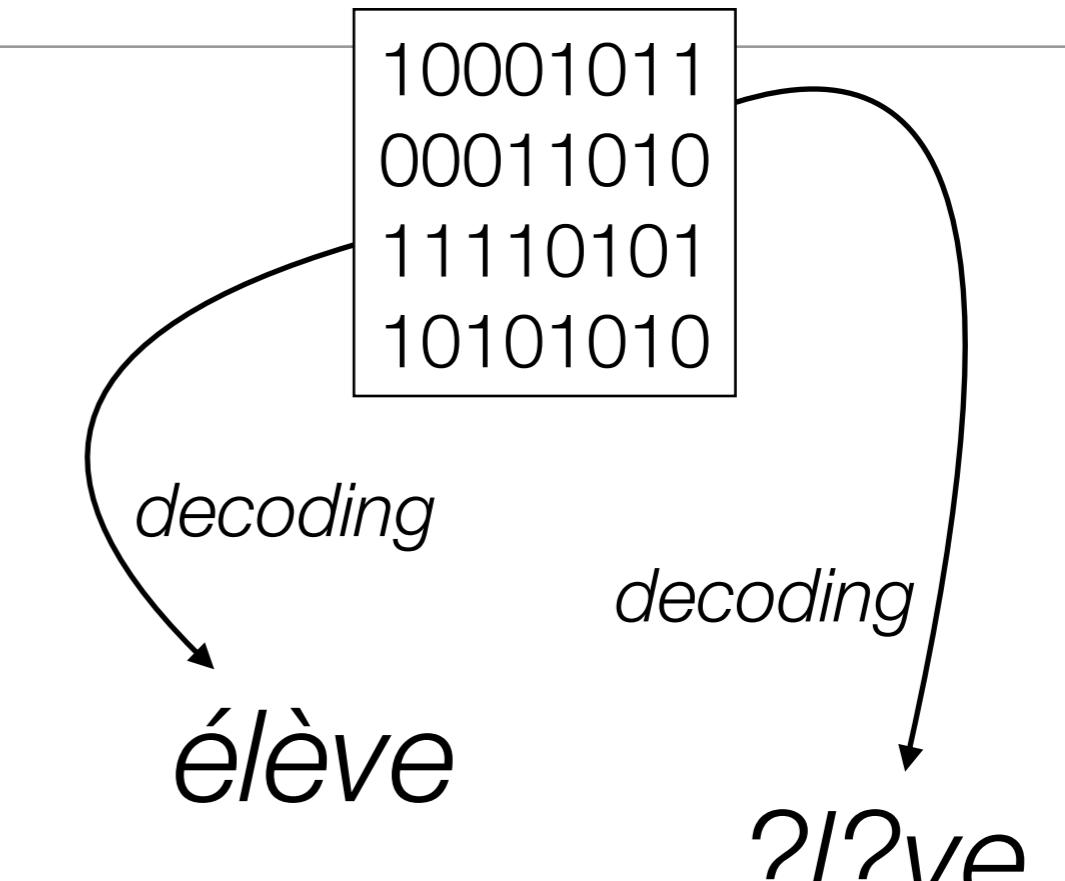
FilterWriter

PrintWriter

BufferedWriter

# Bytes vs. Characters

- There are different types of data sources. Some sources produce **binary data**. Other sources produce **textual data**.
- It's always a **series of 0's and 1's**. The real question is : “how do you interpret these bits”?
- When you deal with **textual data**, the interpretation is not always the same. It depends on the “**character encoding system**”?
- When you deal with IOs, you have to **use different classes** for processing binary, respectively textual data. **Otherwise, you will corrupt data!**



For binary data, use **inputStreams** and **outputStreams**.  
For text data, use **readers** and **writers**.

# Reading Bytes, One at The Time

```
int b = fis.read();
while ( b != -1 ) {

    // b has an int value between -1 and 255
    // -1 indicates that we are at the end of the stream
    // b can be casted to a byte, remember that in Java,
    // bytes are signed and have values in the range [-128..127].

    b = fis.read();
}
```

*Or if you absolutely want to save 1 line...*

```
int b;
while ( (b = fis.read()) != -1 ) {

}
```

# Reading Bytes, in Blocks

```
final int BUFFERSIZE = 255;
byte[] buffer = new byte[BUFFERSIZE];

int numberOfNewBytes = fis.read(buffer);

// we know that numberOfNewBytes bytes have been read
// we know that these bytes are available in the buffer
// WARNING: there might be left-over junk after these bytes!

while ( numberOfNewBytes != -1 ) {

    // do something with the bytes in buffer[0..numberOfNewBytes-1]
    // ignore what is left in buffer[numberOfNewBytes.. BUFFERSIZE]
    // read the next chunk of bytes
    numberOfNewBytes = fis.read(buffer);

}
```

## *Write 1 byte*

```
OutputStream os = ...;  
int b;  
// The byte to be written is the eight low-order b.  
// The 24 high-order bits of b are ignored. So, b can have an  
// int value in the range [0..255]  
os.write(b);
```

## *Write a block of bytes*

```
OutputStream os = ...;  
byte[] data = new byte[BLOCK_SIZE];  
  
data[3] = 22; data[4] = 5; data[5] = 9; data[6] = 7;  
// data[0..2] contains junk, data[7..BLOCK_SIZE-1] too  
  
int offset = 3; // because we have started to fill at slot 3  
int length = 4; // because we have filled 4 slots  
os.write(data, offset, length);
```

# Design Your Code to Be Universal

```
/**  
 * This interface will work only for data sources on the file  
 * system. In the method implementation, I would need to create  
 * a FileInputStream from f and read bytes from it.  
 */  
public interface IPoorlyDesignedService {  
    public void readAndProcessBinaryDataFromFile(File f);  
}
```

← data source

VS

```
/**  
 * This interface is much better. The client using the service  
 * has a bit more responsibility (and work). It is up to the  
 * client to select a data source (which can still be a file,  
 * but can be something else). The method implementation  
 * will ignore where it is reading bytes from. Nice for reuse.  
 * nice for testing.  
 */  
public interface INicelyDesignedService {  
    public void readAndProcessBinaryData(InputStream is);  
}
```

stream

# Example: **02-FileIOExample** (1)



# The Mighty Filter Classes

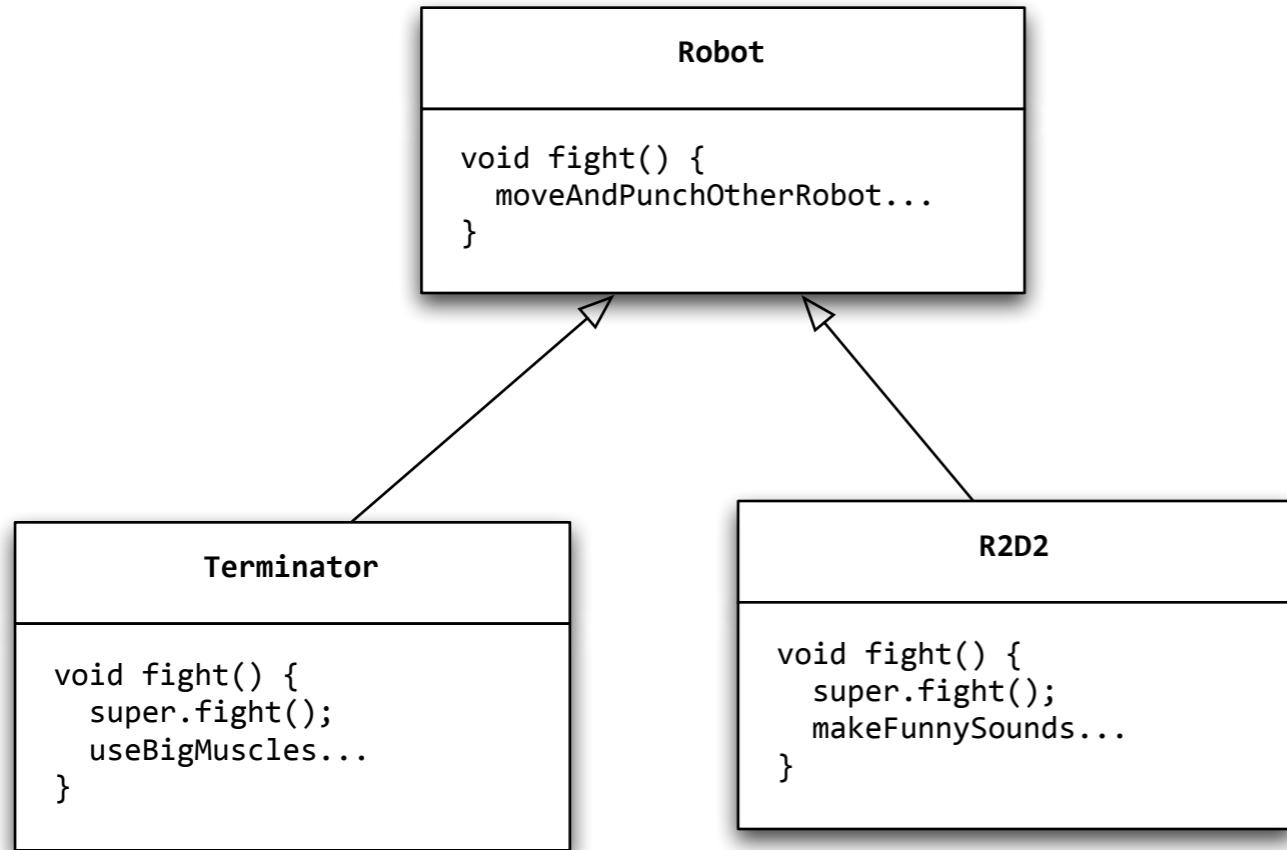


# The Decorator Design Pattern

- The **decorator design pattern** is a solution that is often used when creating object-oriented models.
- It makes it possible to **add behavior to an existing class**, without modifying the code of this class. In other words, it makes it possible to **decorate** an existing class with additional behaviors.
- The design pattern also makes it possible to **define a collection of decorators**, and to **combine** them in arbitrary ways at runtime. In other words, it is possible to decorate a class with several behaviors.



# Example : Fighting Robots

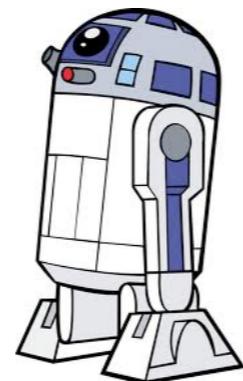
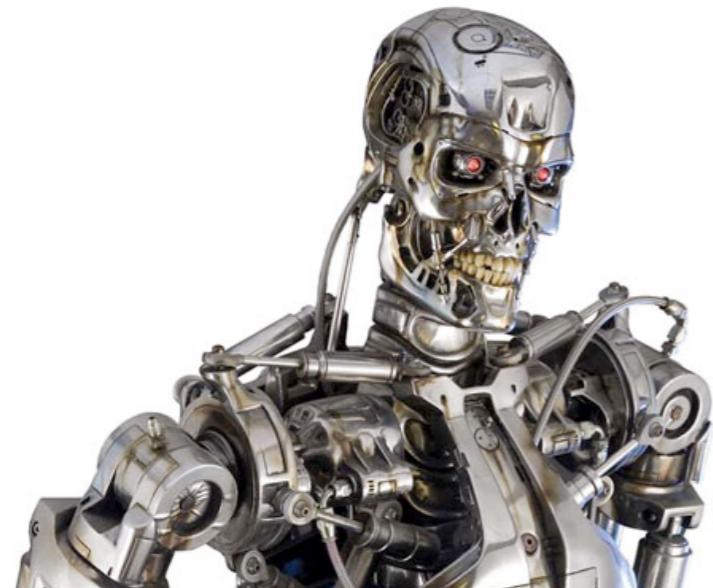


```
Robot bigOne = new Terminator();  
Robot smallOne = new R2D2();
```

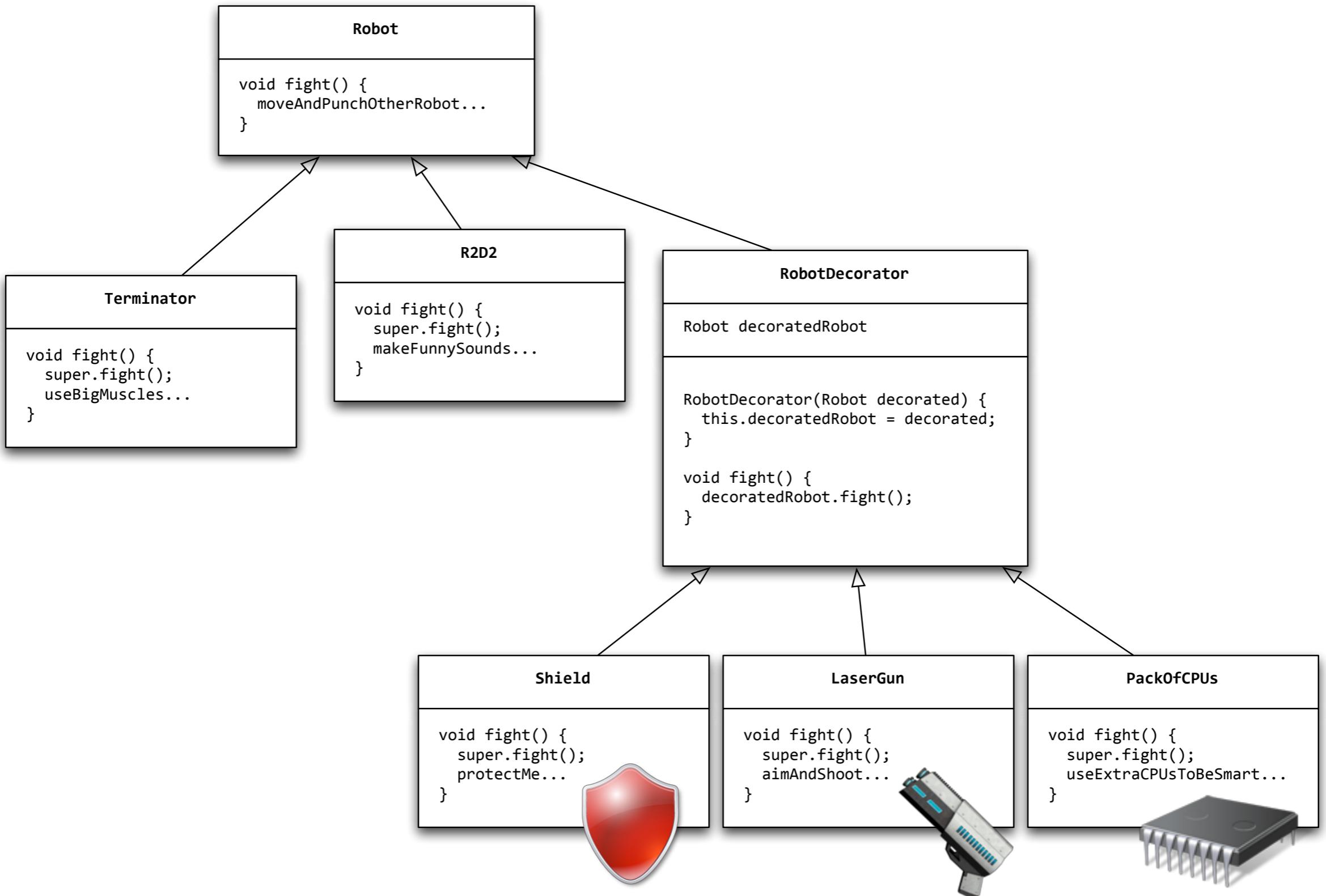
```
bigOne.fight();  
smallOne.fight();
```

--  
bigOne > useBigMuscles  
smallOne > makeFunnySounds

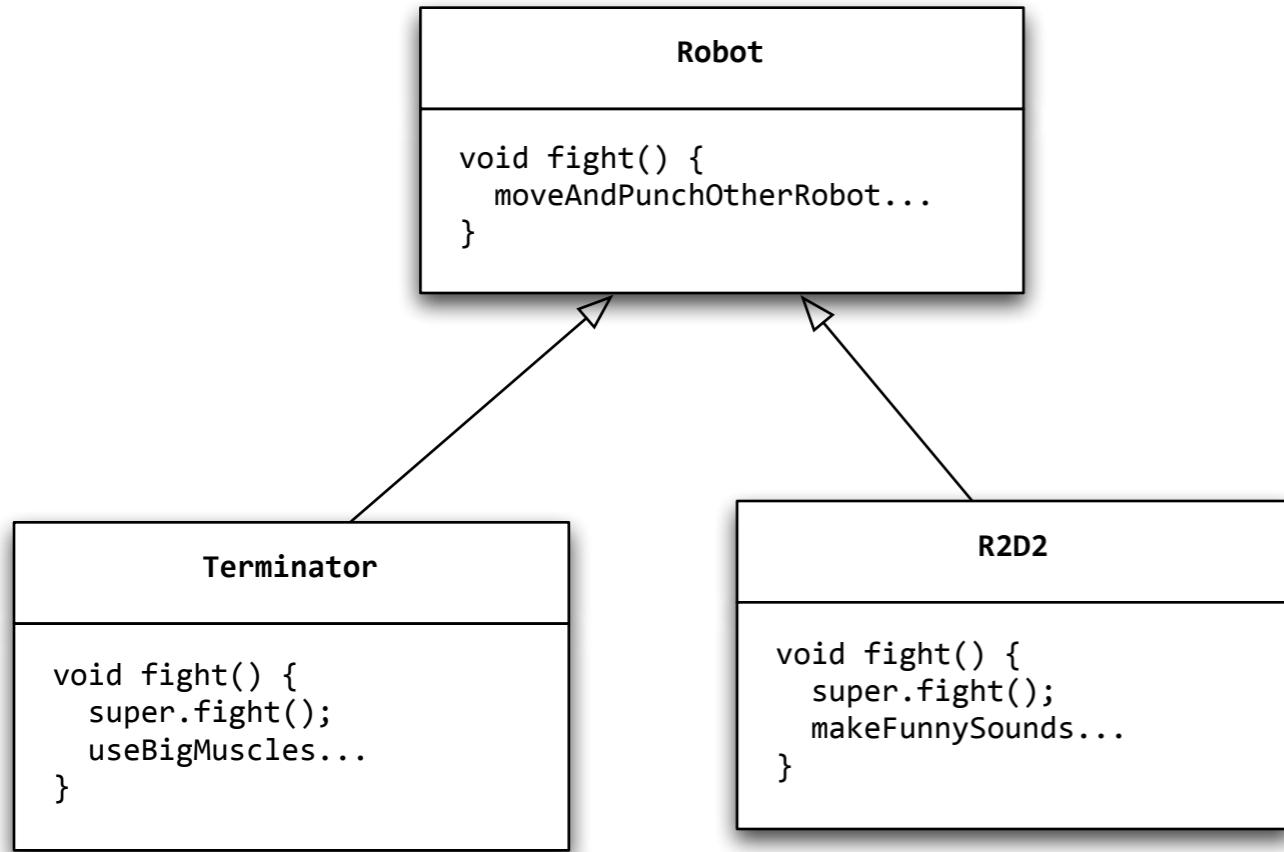
bigOne wins.



# Example : Decorators for Robots



# Example : Decorated Robots



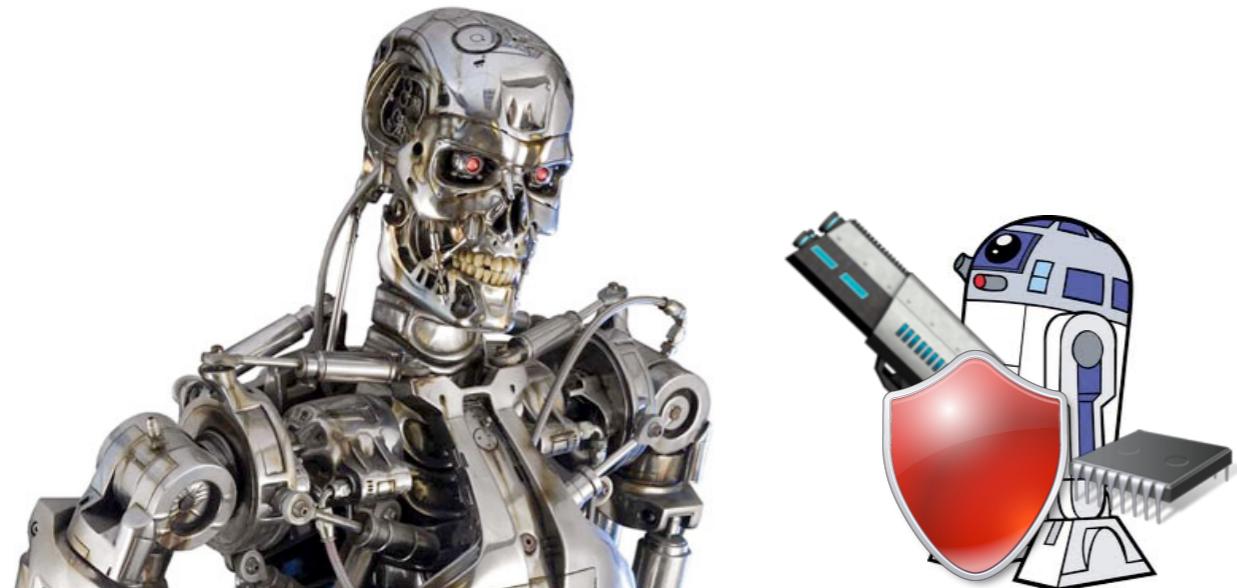
```
Robot bigOne = new Terminator();
Robot decoratedSmallOne =
    new Shield(
        new LaserGun(
            new PackOfCPU(
                new R2D2()
            )
        )
    );

```

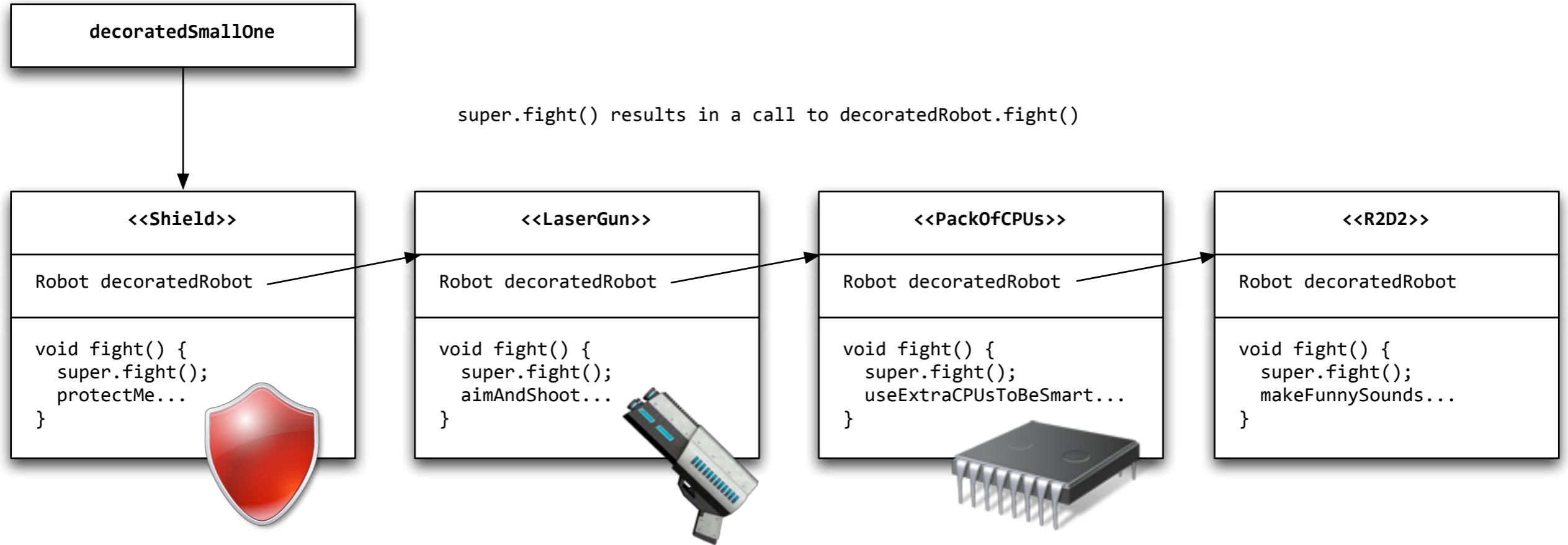
```
bigOne.fight();
decoratedSmallOne.fight();
```

--  
bigOne > useBigMuscles  
smallOne > makeFunnySounds,  
useExtraCPUsToBeSmart, aimAndShoot,  
protectMe

decoratedSmallOne wins.



# Invocation Chain



`decoratedSmallOne.fight()`

```
-> shield.fight();
-> laserGun.fight() + protectMe;
-> packOfCPUs.fight() + aimAndShoot + protectMe
-> R2D2.fight() + useExtraCPUsToBeSmart + aimAndShoot + protectMe
-> makeFunnySounds + useExtraCPUsToBeSmart + aimAndShoot +
protectMe.
```

# Example: **02-FileIOExample** (2)



# Performance and Buffering



Do you know what happens when you do a

```
int c = read();
```

?

It's a bit like when you are thirsty and feel like  
**drinking** something...



# Buffered IOs

***It takes you 56' to sip a beer***



20 min

5 min

10 min

20 min

1 min

# Buffered IOs

Thirsty again...

?

***It takes you 56' again to sip the next beer***



20 min

5 min

10 min

20 min

1 min

# Buffered IOs

Can we do better...

?

***It still takes you 56' to bring back a pack of beers...***



20 min

5 min

10 min

20 min

1 min

# Buffered IOs

Thirsty again...

?

***It now only takes 2 minutes to sip the next one!***



1 min

1 min

Coming back to

```
int c = read();
```

- If you don't use buffered IOs, calling `read()` will issue **one system call** to retrieve **one single byte**... which is not efficient.
- With buffered IOs, calling `read()` will **pre-fetch “several” bytes** and store it in a **temporary memory space** (i.e. in a **buffer**). “several” defines the **buffer size**.
- Subsequent calls to `read()` will be able to **fetch bytes directly from the buffer**, which is very fast.



What about

**write(c);**

?

It's the same thing! There is one gotcha:

Sometimes, you want to immediately send the content of the buffer to the output stream.

**os.flush();**

# Buffered IOs in Java

- Remember the **Decorator** Design Pattern?
- Using buffered IOs is **as simple as decorating any of your byte or character streams** (don't forget about flushing buffered output streams when required!).

```
InputStream slow;  
BufferedInputStream fast = new BufferedInputStream(slow);
```

```
OutputStream slow;  
BufferedOutputStream fast = new BufferedOutputStream(slow);
```

```
Reader slow;  
BufferedReader fast = new BufferedReader(slow);
```

```
Writer slow;  
BufferedWriter fast = new BufferedWriter(slow);
```

# Example: 01-BufferedIOPBenchmark

*What is the **real** impact of buffered IOs on performance?*

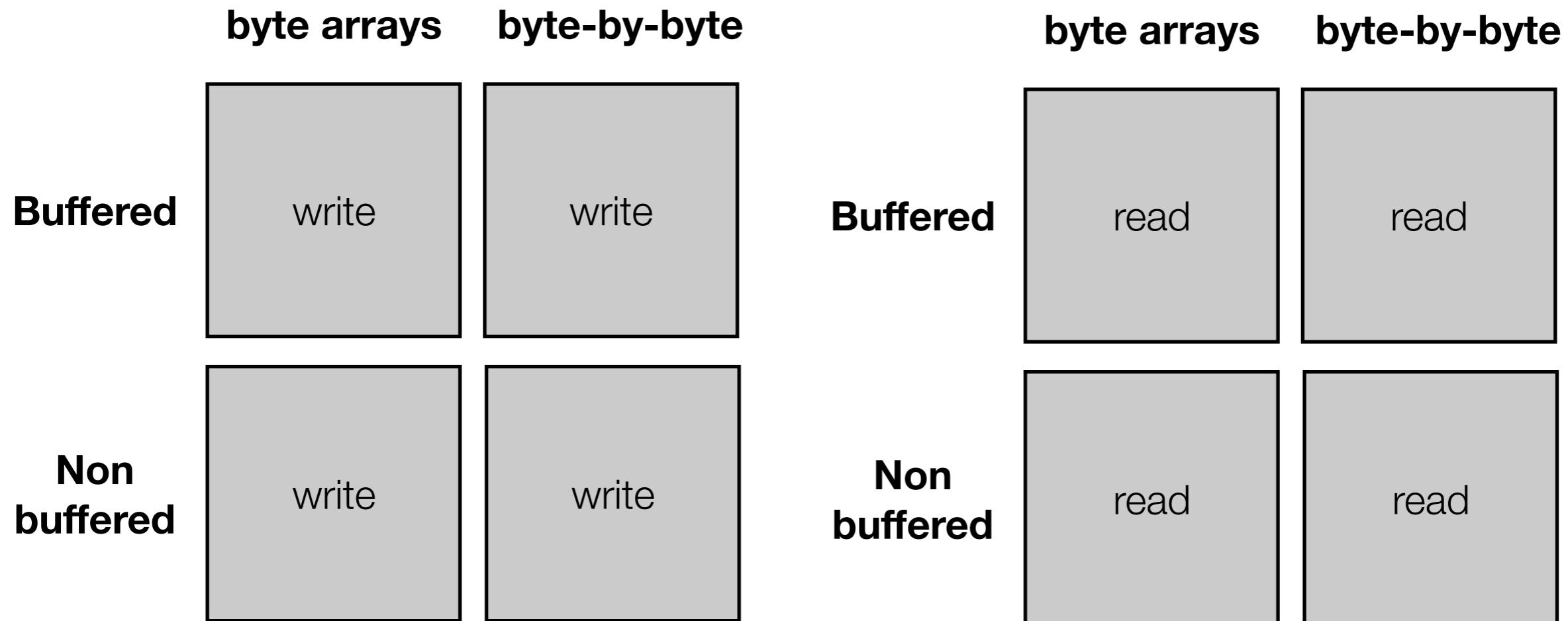


# BufferedIOBenchmark

- 
- **Step 1:** code walkthrough and live demo (10')
  - **Step 2:** how can we improve the code to be able to analyze results? (15')
  - **Step 3:** branching with git (15')

# Code walkthrough

- **Write** and **read** random data to/from **disk**.
- 4 **strategies** (with/without BufferedIOs, operations on byte arrays/single bytes)



# Code walkthrough

```
/**  
 * This enum is used to describe the 4 different strategies for doing the IOs  
 */  
public enum IOStrategy {  
    ByteByByteWithoutBufferedStream,  
    ByteByByteWithBufferedStream,  
    BlockByBlockWithoutBufferedStream,  
    BlockByBlockWithBufferedStream  
};  
  
// we will write and read test files at this location  
final static String FILENAME_PREFIX = "test-data";  
  
// we will write and read 10 MB files  
final static long NUMBER_OF_BYTES_TO_WRITE = 1024 * 1024 * 10;
```

# Code walkthrough

```
// this takes care of opening CONCRETE output streams (connected to files)
private void produceTestData(IOStrategy ioStrategy, long numberOfWorksToWrite, int blockSize);

// this takes care of producing a random stream of bytes, based on a strategy
private void produceDataToStream(OutputStream os, IOStrategy ioStrategy, long
numberOfWorksToWrite, int blockSize) throws IOException;

// this takes care of opening CONCRETE input streams
private void consumeTestData(IOStrategy ioStrategy, int blockSize);

// this takes care of consuming the stream of bytes, based on a strategy
private void consumeDataFromStream(InputStream is, IOStrategy ioStrategy, int blockSize)
throws IOException
```

# Timer

```
public class Timer {  
  
    private static long timestamp = 0;  
  
    public static void start() {  
        timestamp = System.currentTimeMillis();  
    }  
  
    public static long takeTime() {  
        if (timestamp == 0) {  
            timestamp = System.currentTimeMillis();  
        }  
        long ellapsedTime = System.currentTimeMillis() - timestamp;  
        timestamp = System.currentTimeMillis();  
        return ellapsedTime;  
    }  
}
```

# ***Printing the measures on the console is a first step, but...***

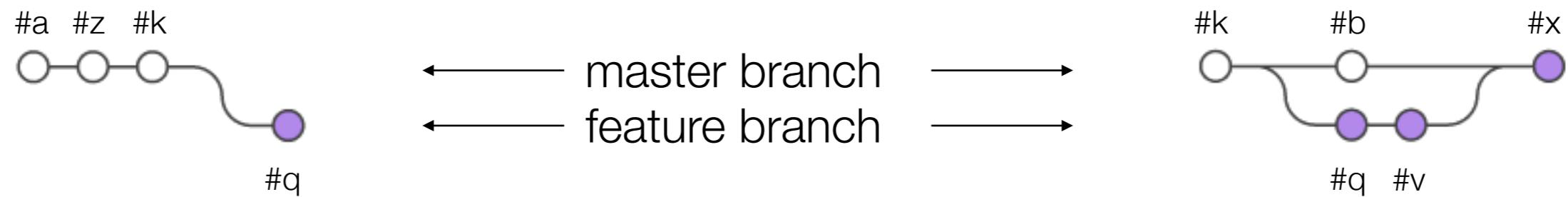
- *What is we have 10, 20 strategies?*
- *What if we have 5 parameters for each strategy?*
- *How can we analyze the data more efficiently?*
- *How can we archive the results?*
- *What is we want to analyze/chart in Excel?*

***Take 15' to think about these questions.  
What would you do to improve the code?***

# Git branches

- With git, branches are used to **do some work in isolation** from the rest of the team. Typically, you create a branch for:
  - **Every** bug fix
  - **Every** new feature
- Even if you are the **only person** working on the project, branches are useful because you can do **exploratory work** while keeping your “master” branch clean.
- Most teams have a “branching strategy”, where branches have a **short life time**. Typically, you create a branch, work on it for **a couple of hours** (maybe **a couple of days**). Then, you **decide if it is worth to merge the results** back onto your main project branch.

# Git branches



```
git checkout -b fb-my-new-feature
```

```
git merge master  
git checkout master  
git merge fb-my-new-feature
```

<https://www.atlassian.com/git/tutorials/comparing-workflows/feature-branch-workflow>

# Binary vs Character-Oriented IOs



# Classes in the `java.io` package (1)

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`FileOutputStream`

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`PipedOutputStream`

`FilterInputStream`

`FilterOutputStream`

`BufferedInputStream`

`BufferedOutputStream`

# Classes in the `java.io` package (2)

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CharArrayReader

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FilterReader

BufferedReader

writer

FileWriter

CharArrayWriter

StringWriter

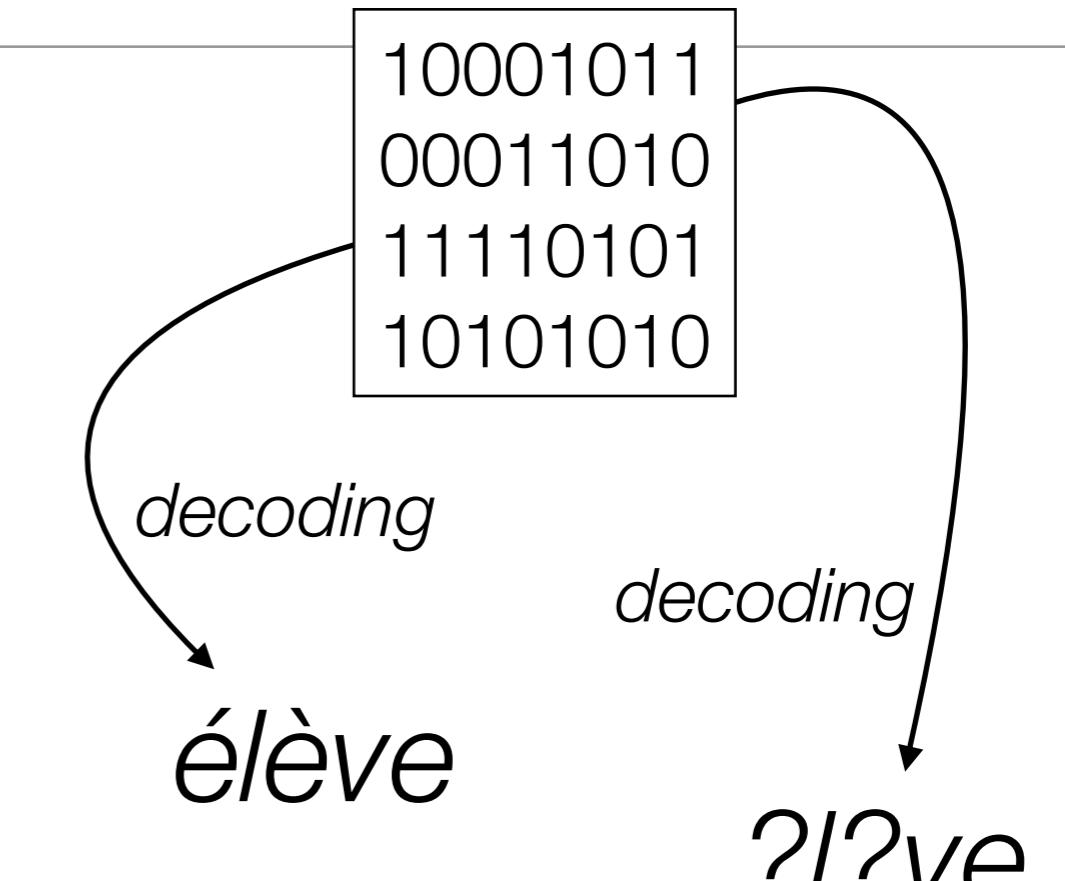
FilterWriter

PrintWriter

BufferedWriter

# Bytes vs. Characters

- There are different types of data sources. Some sources produce **binary data**. Other sources produce **textual data**.
- It's always a **series of 0's and 1's**. The real question is : “how do you interpret these bits”?
- When you deal with **textual data**, the interpretation is not always the same. It depends on the “**character encoding system**”?
- When you deal with IOs, you have to **use different classes** for processing binary, respectively textual data. **Otherwise, you will corrupt data!**



For binary data, use **inputStreams** and **outputStreams**.  
For text data, use **readers** and **writers**.

# Bytes vs. Characters

---

*“A byte is a sequence of 8 bits. Period.”*

1000001 → 1000001 → 1000001

*“A character is the **interpretation** of a sequence of n bits. Producer and consumer need to **agree** on how to do this interpretation.”*

✓ ‘A’ ↪ 1000001 ↪ ‘A’

✗ ‘A’ ↪ 1000001 ↩ ‘□’

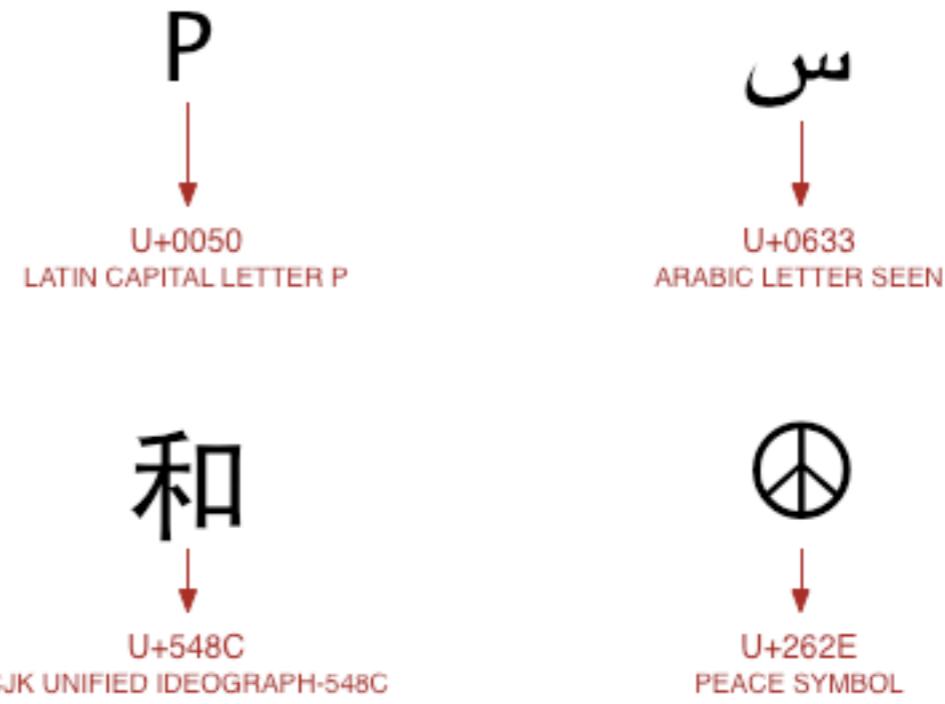
# Example : the ASCII encoding

' A ' 1000001 65  
64-32-16-08-04-02-01

USASCII code chart															
b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
Column →		Row ↓						0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	NUL	DLE	SP	0	@	P	'	p
0	0	0	0	1	1	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	0	2	2	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	0	3	3	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	4	ENQ	NAK	%	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	5	ENQ	SYN	B	5	E	U	e	u
0	1	1	0	6	ACK	SYN	6	BEL	ETB	6	F	V	f	v	
0	1	1	1	7	BEL	ETB	7	BS	CAN	7	G	W	g	w	
1	0	0	0	8	BS	CAN	8	HT	EM	8	H	X	h	x	
1	0	0	1	9	HT	EM	9	VT	ESC	9	I	Y	i	y	
1	0	1	0	10	LF	SUB	10	VT	ESC	*	J	Z	j	z	
1	0	1	1	11	FF	FS	11	FF	FS	:	K	[	k	{	
1	1	0	0	12	CR	GS	12	CR	GS	<	L	\	l	l	
1	1	0	1	13	SO	RS	13	SO	RS	=	M	]	m	}	
1	1	1	0	14	S1	US	14	SO	RS	>	N	^	n	~	
1	1	1	1	15	S1	US	15	S1	US	?	O	-	o	DEL	

# Example : Unicode & UTF-8 encoding

- **Unicode** is an industry standard for representing text in almost all world languages (e.g. japanese, hebrew, arabic, etc.).
- With Unicode, **every character is associated with a “code point”**, which is nothing else than a number. It is expressed as ‘U+’ followed by an **hexadecimal** value.
- For instance, ‘A’ has the code point **U+41** (41 is 65 in hexadecimal).
- The code points for **latin characters** have the same value as in the ASCII encoding.
- **UTF-8** is one of the encoding systems used to represent characters of the Unicode character set.
- **UTF-8 is a variable-length encoding system.** Some characters are encoded with 1 byte, others with 2 bytes, etc.



[http://wiki.secondlife.com/wiki/Unicode\\_In\\_5\\_Minutes](http://wiki.secondlife.com/wiki/Unicode_In_5_Minutes)

- Java uses the **unicode character encoding system**. This means that your program can manipulate characters in different languages and alphabets.
- Every **char** variable is defined by **2 bytes**, i.e. 16 bits. The two bytes
- Think about **what happens when you read data from a source**. You will see a series of 1's and 0's. You know that these bits represent characters, but how do you know how to interpret them? The answer will depend on the source! Or more precisely, **it will depend on the encoding system used by the source**.
- **Same problem when you produce data**. You have text data in memory (char and String variables). You want to understand and control how this data is transformed in a series of bits. This is important if you want that other parties are able to read what you have produced!

# Exploring the Unicode Charset

<http://www.fileformat.info/info/unicode/char/41/index.htm>

## Unicode Character 'LATIN CAPITAL LETTER A' (U+0041)



Browser Test Page  
Outline (as SVG file)  
Fonts that support U+0041

Unicode Data	
Name	LATIN CAPITAL LETTER A
Block	Basic Latin
Category	Letter, Uppercase [Lu]
Combine	0
BIDI	Left-to-Right [L]
Mirror	N
Index entries	Latin Uppercase Alphabet Uppercase Alphabet, Latin Capital Letters, Latin
Lower case	<a href="#">U+0061</a>
Version	Unicode 1.1.0 (June, 1993)

Encodings	
HTML Entity (decimal)	&#65;
HTML Entity (hex)	&#x41;
How to type in Microsoft Windows	Alt +41 Alt 065 Alt 65
UTF-8 (hex)	0x41 (41)
UTF-8 (binary)	01000001
UTF-16 (hex)	0x0041 (0041)
UTF-16 (decimal)	65
UTF-32 (hex)	0x00000041 (41)
UTF-32 (decimal)	65
C/C++/Java source code	"\u0041"
Python source code	u"\u0041"
More...	

# Example: 03-CharacterIODemo

*How do I avoid these  
damn **?I?ves** when I want  
to see **élèves**?*



# CharacterIDemo

- **Step 1:** code walkthrough and live demo (10')
- **Step 2:** self-study of the code and individual experiments

# Demo

When I encode '**ABC élève 広島**' (12 chars) with encoding US-ASCII, I generate 12 bytes.

01000001	65
01000010	66
01000011	67
00100000	32
00111111	63
01101100	108
00111111	63
01110110	118
01100101	101
00111111	63
00111111	63
00111111	63

If I decode the result with the default encoding for this JVM (UTF-8), I get: **ABC ?l?ve???**

If I decode the result with the same encoding (US-ASCII) for this JVM (UTF-8), I get: **ABC ?l?ve???**

# Demo

When I encode '**ABC élève 広島**' (12 chars) with encoding ISO-8859-15, I generate 12 bytes.

01000001	65
01000010	66
01000011	67
00100000	32
11101001	-23
01101100	108
11101000	-24
01110110	118
01100101	101
00111111	63
00111111	63
00111111	63

If I decode the result with the default encoding for this JVM (UTF-8), I get: **ABC lve???**

If I decode the result with the same encoding (ISO-8859-15) for this JVM (UTF-8), I get: **ABC élève???**

# Demo

When I encode '**ABC élève 広島**' (12 chars) with encoding UTF-8, I generate 20 bytes.

01000001	65
01000010	66
01000011	67
00100000	32
11000011	-61
10101001	-87
01101100	108
11000011	-61
10101000	-88
01110110	118
01100101	101
11100011	-29
10000000	-128
10000000	-128
11100101	-27
10111010	-70
10000011	-125
11100101	-27
10110011	-77
10110110	-74

If I decode the result with the default encoding for this JVM (UTF-8), I get: **ABC élève 広島**

If I decode the result with the same encoding (UTF-8) for this JVM (UTF-8), I get: **ABC élève 広島**

# Demo

When I encode '**ABC élève 広島**' (12 chars) with encoding UTF-16, I generate 26 bytes.

11111110	-2
11111111	-1
00000000	0
01000001	65
00000000	0
01000010	66
00000000	0
01000011	67
00000000	0
00100000	32
00000000	0
11101001	-23
00000000	0
01101100	108
00000000	0
11101000	-24
00000000	0
01110110	118
00000000	0
01100101	101
00110000	48
00000000	0
01011110	94
10000011	-125
01011100	92
11110110	-10

If I decode the result with the default encoding for this JVM (UTF-8), I get: **ABC lve0^**

If I decode the result with the same encoding (UTF-16) for this JVM (UTF-8), I get: **ABC élève 広島**

# Code walkthrough

```
// Lets create an output stream, which will send written bytes to a memory zone
ByteArrayOutputStream os = new ByteArrayOutputStream();
...
byte[] encodedMessage = os.toByteArray();
...
decodedMessage = new String(encodedMessage, encoding);
```

```
OutputStreamWriter writer = new OutputStreamWriter(os, encoding);
writer.write(message);
```

# Beware of the FileReader and FileWriter!

## Constructor Summary

### Constructors

#### Constructor and Description

`FileReader(File file)`

Creates a new FileReader, given the File to read from.

`FileReader(FileDescriptor fd)`

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

`FileReader(String fileName)`

Creates a new FileReader, given the name of the file to read from.

no way to specify an encoding!!!



## Constructor Summary

### Constructors

#### Constructor and Description

`InputStreamReader(InputStream in)`

Creates an InputStreamReader that uses the default charset.

`InputStreamReader(InputStream in, Charset cs)`

Creates an InputStreamReader that uses the given charset.

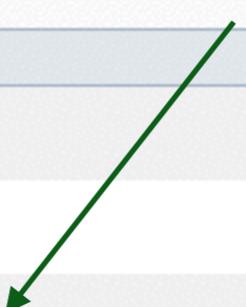
`InputStreamReader(InputStream in, CharsetDecoder dec)`

Creates an InputStreamReader that uses the given charset decoder.

`InputStreamReader(InputStream in, String charsetName)`

Creates an InputStreamReader that uses the named charset.

InputStreamReader to the rescue



```
Reader reader = new InputStreamReader(new FileInputStream(file), "UTF-8");  
is safer than  
Reader reader = new FileReader(file); // what is the "default" encoding???
```

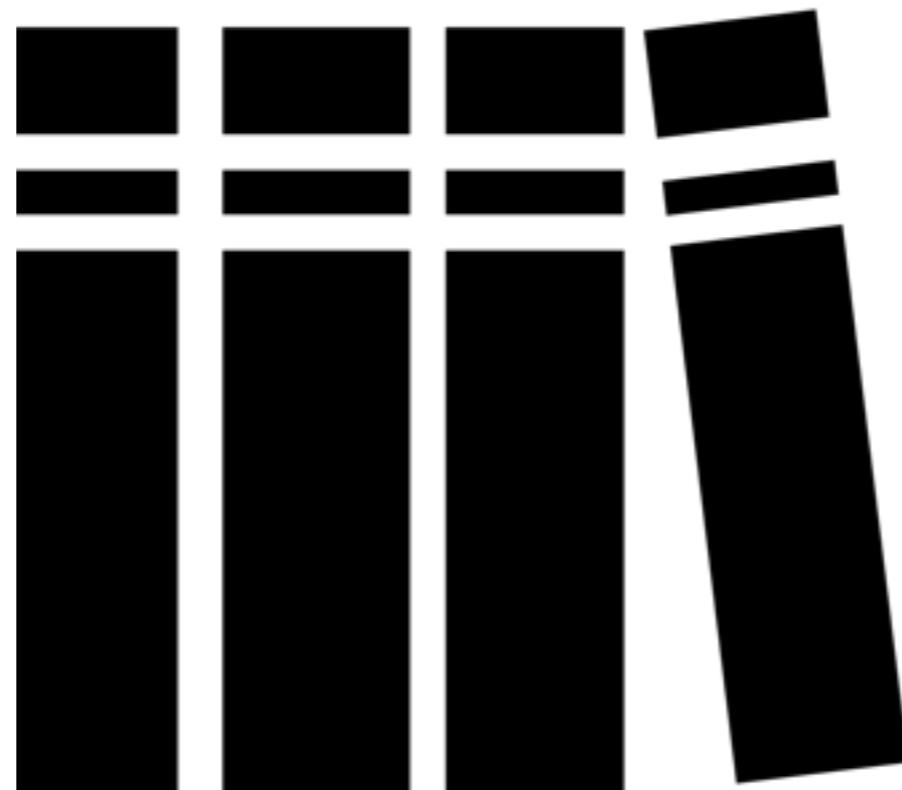
# Shit Happens...

## Dealing with IO Exceptions

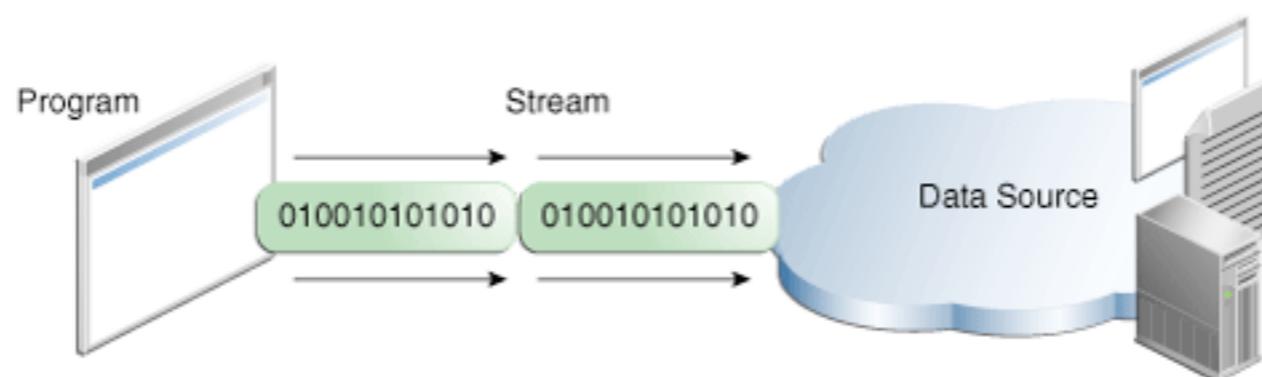
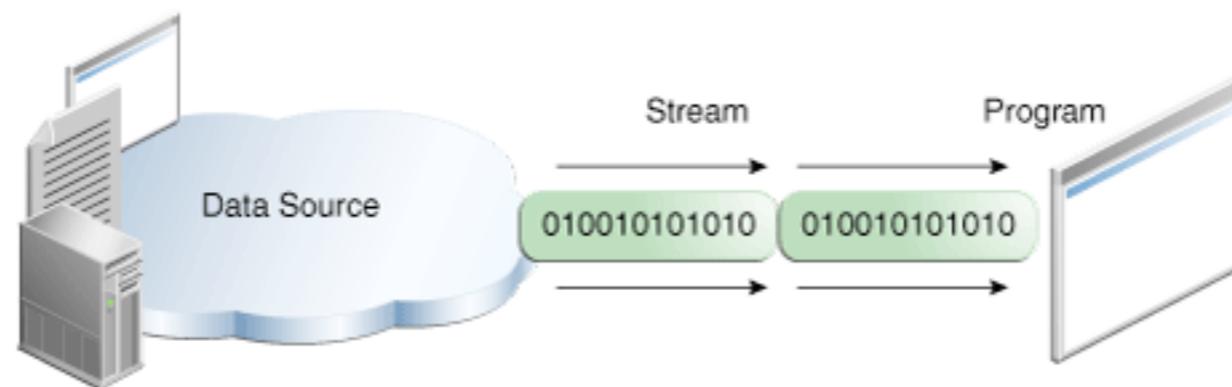


Exception Summary	
Exception	Description
CharConversionException	Base class for character conversion exceptions.
EOFException	Signals that an end of file or end of stream has been reached unexpectedly during input.
FileNotFoundException	Signals that an attempt to open the file denoted by a specified pathname has failed.
InterruptedIOException	Signals that an I/O operation has been interrupted.
InvalidClassException	Thrown when the <code>Serialization</code> runtime detects one of the following problems with a Class.
InvalidObjectException	Indicates that one or more deserialized objects failed validation tests.
IOException	Signals that an I/O exception of some sort has occurred.
NotActiveException	Thrown when serialization or deserialization is not active.
NotSerializableException	Thrown when an instance is required to have a <code>Serializable</code> interface.
ObjectStreamException	Superclass of all exceptions specific to Object Stream classes.
OptionalDataException	Exception indicating the failure of an object read operation due to unread primitive data, or the end of data belonging to a serialized object in the stream.
StreamCorruptedException	Thrown when control information that was read from an object stream violates internal consistency checks.
SyncFailedException	Signals that a sync operation has failed.
UnsupportedEncodingException	The Character Encoding is not supported.
UTFDataFormatException	Signals that a malformed string in <code>modified UTF-8</code> format has been read in a data input stream or by any class that implements the data input interface.
WriteAbortedException	Signals that one of the <code>ObjectStreamExceptions</code> was thrown during a write operation.

# References

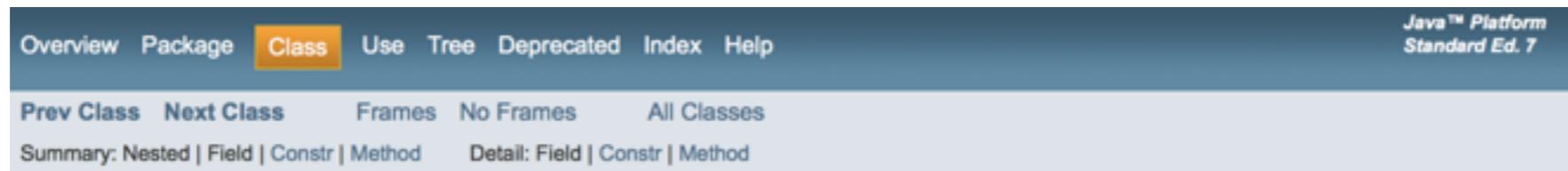


# The IO Trail in the Java Tutorial



<http://docs.oracle.com/javase/tutorial/essential/io/index.html>

# The `java.io` API documentation



A screenshot of the Java API Documentation header. It features a dark blue header bar with white text. The top navigation includes links for Overview, Package, Class (which is highlighted in yellow), Use, Tree, Deprecated, Index, and Help. To the right, it says "Java™ Platform Standard Ed. 7". Below the header, there are links for Prev Class, Next Class, Frames, No Frames, and All Classes. At the bottom, there are links for Summary: Nested | Field | Constr | Method and Detail: Field | Constr | Method.

java.io

## Class InputStream

`java.lang.Object`  
  `java.io.InputStream`

### All Implemented Interfaces:

`Closeable, AutoCloseable`

### Direct Known Subclasses:

`AudioInputStream, ByteArrayInputStream, FileInputStream, FilterInputStream, InputStream, ObjectInputStream, PipedInputStream,`  
`SequenceInputStream, StringBufferInputStream`

---

```
public abstract class InputStream
extends Object
implements Closeable
```

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

Applications that need to define a subclass of `InputStream` must always provide a method that returns the next byte of input.

### Since:

JDK1.0

### See Also:

`BufferedInputStream, ByteArrayInputStream, DataInputStream, FilterInputStream, read(), OutputStream,`  
`PushbackInputStream`

# Books

