Object-Oriented Programming in 

Guillaume Muller

based on work from:

Ch. Gravier, F. Laforest, J. Subercaze

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While I'm talking :)

If you don't have another JDK/IDE:

- Download `OpenJDK 8+ (LTS) / HotSpot`
  https://adoptopenjdk.net/installation.html
- Download `Eclipse IDE 2020-06`
  https://www.eclipse.org/downloads/

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Disclaimer

This course is an **introdution**

- Does **NOT** cover **all** Java
- Goal: give you enough to understand future TD's intros
- Goes up to Java 8
- A more complete course (in French)
  http://jmdoudoux.developpez.com/cours/developpons/java/

- Thanks Christophe Gravier for the material!

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Outline

[1] Images from "Java Head First" book.

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Java: What & Why

- Created in May **1995**
- It's an **Object-Oriented** language
- Syntax is close to C/C++ [1], similar to C♯ [2]
- **2nd "most used"** language in August 2020

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Java: What & Why

Aug 2020	Aug 2019	Change	Programming Language	Ratings	Change
1	2	↑	C	16.98%	+1.83%
2	1	↓	Java	14.43%	-1.60%
3	3		Python	9.69%	-0.33%
4	4		C++	6.84%	+0.78%
5	5		C#	4.68%	+0.83%
6	6		Visual Basic	4.66%	+0.97%
7	7		JavaScript	2.87%	+0.62%
8	20	⇈	R	2.79%	+1.97%
9	8	↓	PHP	2.24%	+0.17%
10	10		SQL	1.46%	-0.17%
11	17	⇈	Go	1.43%	+0.45%
12	18	⇈	Swift	1.42%	+0.53%
13	19	⇈	Perl	1.11%	+0.25%
14	15	↑	Assembly language	1.04%	-0.07%
15	11	⇊	Ruby	1.03%	-0.28%
16	12	⇊	MATLAB	0.86%	-0.41%
17	16	↓	Classic Visual Basic	0.82%	-0.20%
18	13	⇊	Groovy	0.77%	-0.46%
19	9	⇊	Objective-C	0.76%	-0.93%
20	28	⇈	Rust	0.74%	+0.29%

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Java:What & Why

- In 2011:
  - **97% of machines** have a JVM in enterprises
  - **9 millions+ Java developers** in the world
  - **3 billions+ mobile devices** run Java (Android...)
- In 2020:
  - 3rd in **Job Postings**
  - 3rd in **Average Salary**

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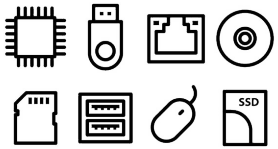
Characteristics

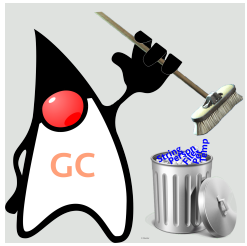
- Both **Compiled** (to bytecode) & **Interpreted** (on the JVM)
- **Hardware independent** (⇒ truly portable)



- **Strongly Typed**

- **Object Oriented**
- Java manages the memory

  (**NO** explicit **pointers** \o/, Garbage Collector)



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Distributions

There are several **distributions** of Java

- Sun/Oracle vs. OpenJDK vs. Eclipse vs. GNU...
- **JRE**: Java Runtime Environment
  - **Execution** environment only (JVM)
  - ⇒ for **end users**!
- **JDK**: Java Development Kit
  - Tools & APIs to **develop** in Java
  - ⇒ for **devs**!
- **J2EE**: Java Enterprise Edition
  - JDK + tools & APIs for **web development**

Note: Installing a JDK also installs a JRE!

Versions

- **Since 2017**: 1 new version every 6 months
  - New Features vs. LTS system
  - Today (2020): latest = Java 14
  - Big changes in Java 8 (Collections, Stream, **Lambdas**)
  - Java is **backward compatible**

- Check installed version (Command Prompt)

```
$ java -version
openjdk version "11.0.8" 2020-07-14
```

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Don't get it wrong

Java IS **NOT** JavaScript

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Specificities

The Java platform has some **specificities**:

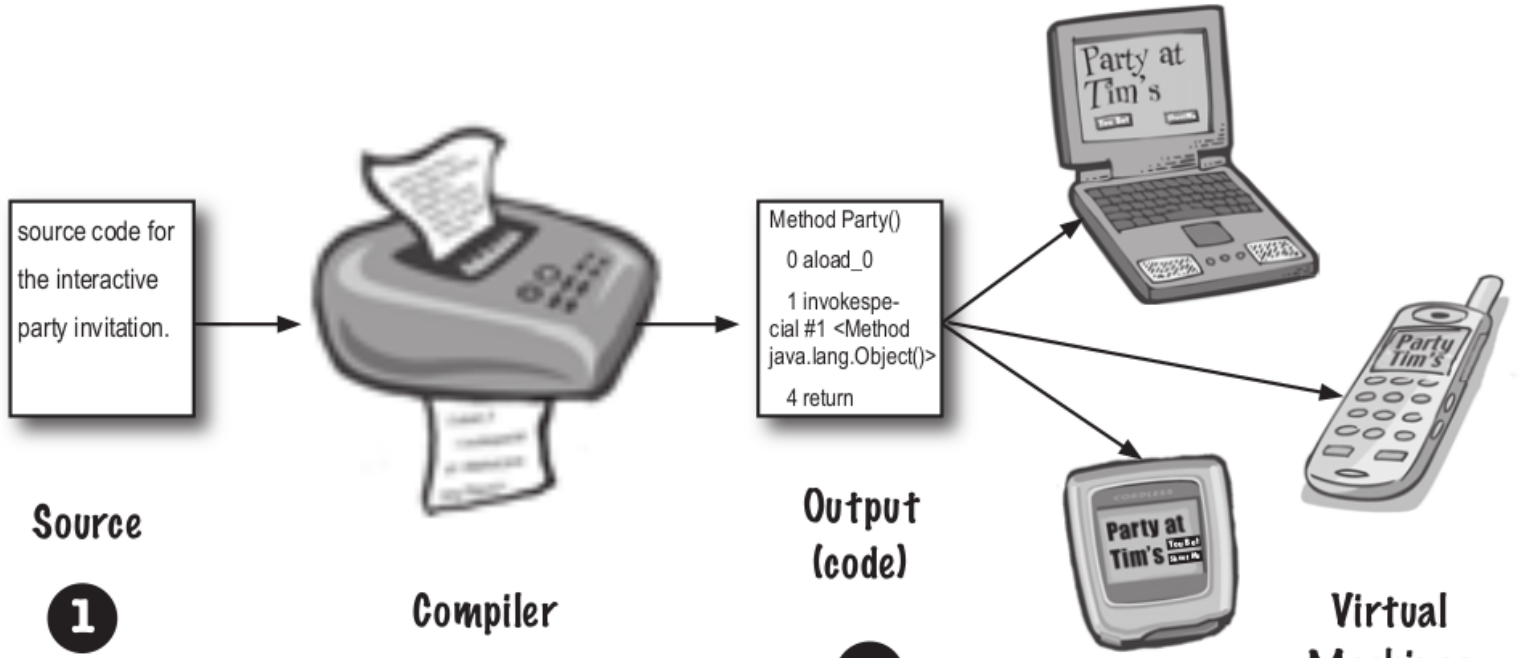
- A **single** (public) class per `java` source file
- **Compiles** source code into bytecode (hardware independent)
- This **bytecode** is executed (**interpreted**) on the **JVM** [2]
- **No** header files, **no** linking
- **Packages** allow to organize code (**Classes**)
- `jar` (Java **AR**chive): format to distribute an "executable"
- **CLASSPATH** indicates where to find classes

[2] Java Virtual Machine

Outline

[3] Images from "Java Head First" book.

Compilation Chain – User's View



Source

1

Create a source document. Use an established protocol (in this case, the Java language).

Compiler

2

Run your document through a source code compiler. The compiler checks for errors and won't let you compile until it's satisfied that everything will run correctly.

Output (code)

3

The compiler creates a new document, coded into Java ***bytecode***. Any device capable of running Java will be able to interpret/translate this file into something it can run. The compiled bytecode is platform-independent.

Virtual Machines

4

Your friends don't have a physical Java Machine, but they all have a ***virtual*** Java machine (implemented in software) running inside their electronic gadgets. The virtual machine reads and *runs* the bytecode.

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Compilation Chain – Developer's View

```
import java.awt.*;
import java.awt.event.*;
class Party {
  public void buildInvite() {
    Frame f = new Frame();
    Label l = new Label("Party at Tim's");
    Button b = new Button("You bet");
    Button c = new Button("Shoot me");
    Panel p = new Panel();
    p.add(l);
  } // more code here...
}
```

Source

1

Type your source code.

Save as: ***Party.java***

```
File Edit Window Help Plead
% javac Party.java
```

Compiler

2

Compile the ***Party.java*** file by running `javac` (the compiler application). If you don't have errors, you'll get a second document named ***Party.class***

The compiler-generated Party.class file is made up of *bytecodes*.

```
Method Party()
  0 aload_0
  1 invokespecial #1 <Method java.lang.Object()>
  4 return
Method void buildInvite()
  0 new #2 <Class java.awt.Frame>
  3 dup
  4 invokespecial #3 <Method java.awt.Frame()>
```

Output (code)

3

Compiled code: ***Party.class***

```
File Edit Window Help Swear
% java Party
```

Virtual Machines

4

Run the program by starting the Java Virtual Machine (JVM) with the ***Party.class*** file. The JVM translates the *bytecode* into something the underlying platform understands, and runs your program.

Source code & bytecode

- Source code in `MyClass.java` file[4]
- File name = (public) class name
- Compile with: `javac <file>.java` (**java** compiler)
- Results in `.class` file (bytecode)
- Execute with: `javac <file>`[5] (JVM)

[4] One single (public) class per file

[5] NOTE: there is no extension here!

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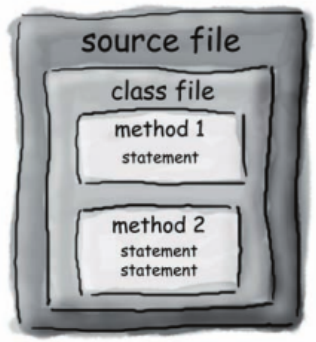
Source File



Put a class in a source file.

Put methods in a class.

Put statements in a method.

What goes in a source file?

A source code file (with the *.java* extension) holds one ***class*** definition. The class represents a *piece* of your program, although a very tiny application might need just a single class. The class must go within a pair of curly braces.

```
public class Dog {



}
```
class

What goes in a class?

A class has one or more ***methods***. In the Dog class, the ***bark*** method will hold instructions for how the Dog should bark. Your methods must be declared *inside* a class (in other words, within the curly braces of the class).

```
public class Dog {
   void bark() {


   }
}
```
method

What goes in a method?

Within the curly braces of a method, write your instructions for how that method should be performed. Method *code* is basically a set of statements, and for now you can think of a method kind of like a function or procedure.

```
public class Dog {
   void bark() {
     statement1;
     statement2;
   }
}
```
statements

Compilation Chain – First Run


```
public class MyFirstApp {

   public static void main (String[] args) {
     System.out.println("I Rule!");
     System.out.println("The World");
   }

}
```

1 Save

`MyFirstApp.java`

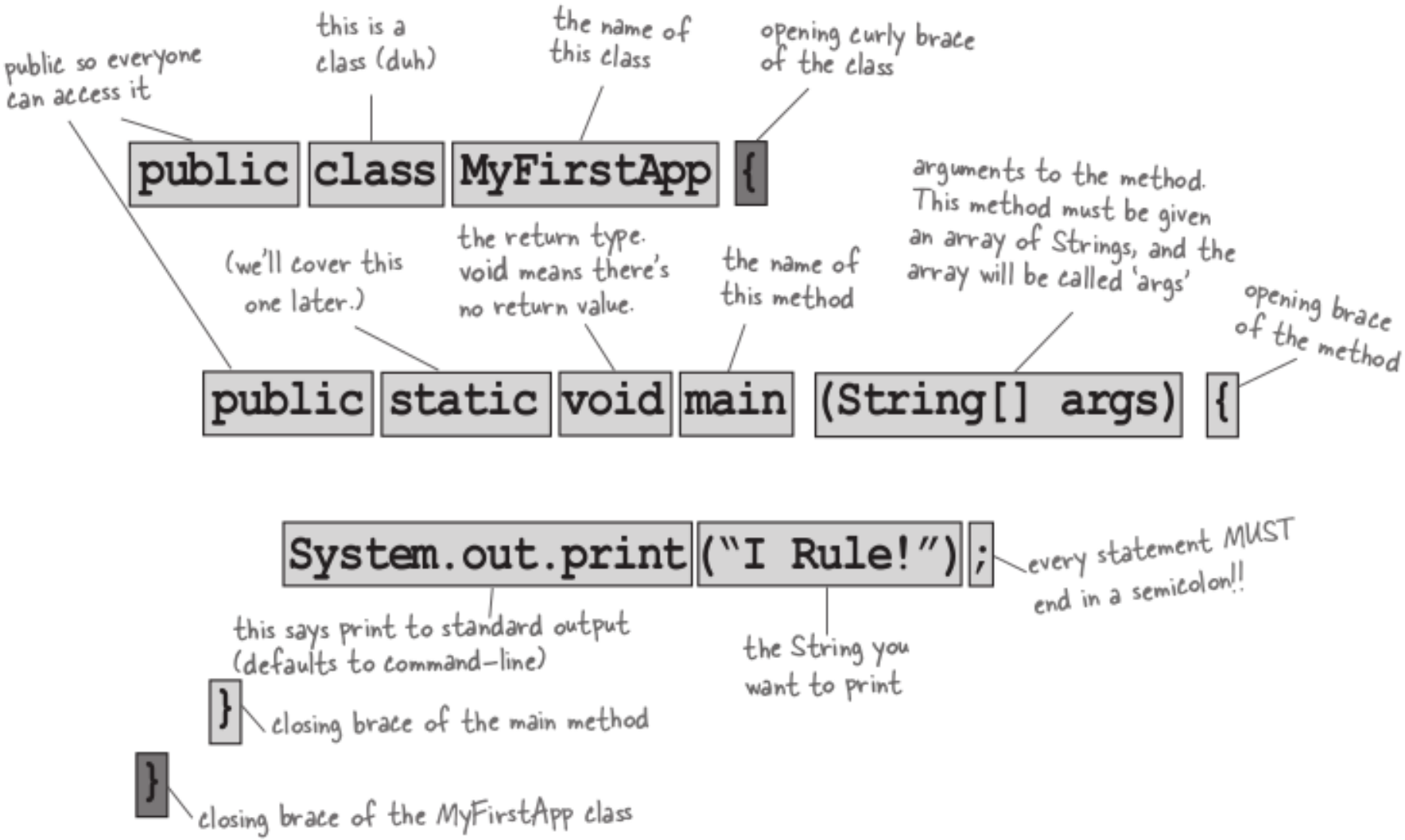
2 Compile

```
javac MyFirstApp.java
```

3 Run

```
File Edit Window Help Scream
%java MyFirstApp
I Rule!
The World
```

My First Class



Outline

[6] Images from "Java Head First" book.

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Java Keywords

- **Comments**: `/* comnent */`, `/** Java Doc */`, `// single line`
- (Basic) **Types**:
  `void`, `boolean`, `char`, `byte`, `short`, `int`, `float`, `long`, `double`, `[]`
  `String`, `List`, `Set`, `Map`...
- **Control Structures**:
  `for`, `while/do`, `break/continue`
  `if/else`, `switch/case`
- **Methods**: `return`, `super`
- **Packages**: `package`, `import`
- **Objects**:
  `interface/class`, `abstract`, `implements`, `extends`
  `new`, `this`
  `static`, `final`
- **Visibility**: `private`, `public`, `protected`
- **Exceptions**:
  `throw/throws`, `try/catch/finally`

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Outline

[7] Images from "Java Head First" book.

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Naming Conventions

- **Packages**: lowercase + dots

```
com.sun.eng
```

- **Classes / Interfaces**: (upper) CamelCase

```
class ImageSprite;
interface RasterDelegate;
```

- **Methods**: dromedaryCase == (lower) camelCase

```
run();
runFast();
```

- **Variables / Attributes**: dromedaryCase

```
int             i;
char            c;
float           myWidth;
```

- **Constants**: ALL CAPS + snake_case

```
static final int MIN_WIDTH = 4;
```

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Outline

[8] Images from "Java Head First" book.

Pointers and parameters

Listing 1: MyCode.cpp

```
1       Pair origin;
2       Pair *p, *q, *r;
3       origin.x = 0;
4       p = new Pair;
5       p -> y = 5;
6       q = p;
7       r = \& origin;
```

Listing 2: MyCode.java

```
1       Pair origin = new Pair();
2       Pair p, q, r;
3       origin.x = 0;
4       p = new Pair();
5       p.y = 5;
6       q = p;
7       // not possible
```

⚠ Objects in Collections **can be modified**!!!
(behind the hood, the Collection contains references)!!!

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No delete?

- The `new` keyword creates instances

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- There is **no** `delete` in Java!!!

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- **Java manages the memory itself**
- The « **Garbage Collector** » does the job *It's a module of the JVM that removes Objects from memory when they are not use (referenced) anymore*

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- **Pros? Cons?**

No delete?

- The `new` keyword creates instances
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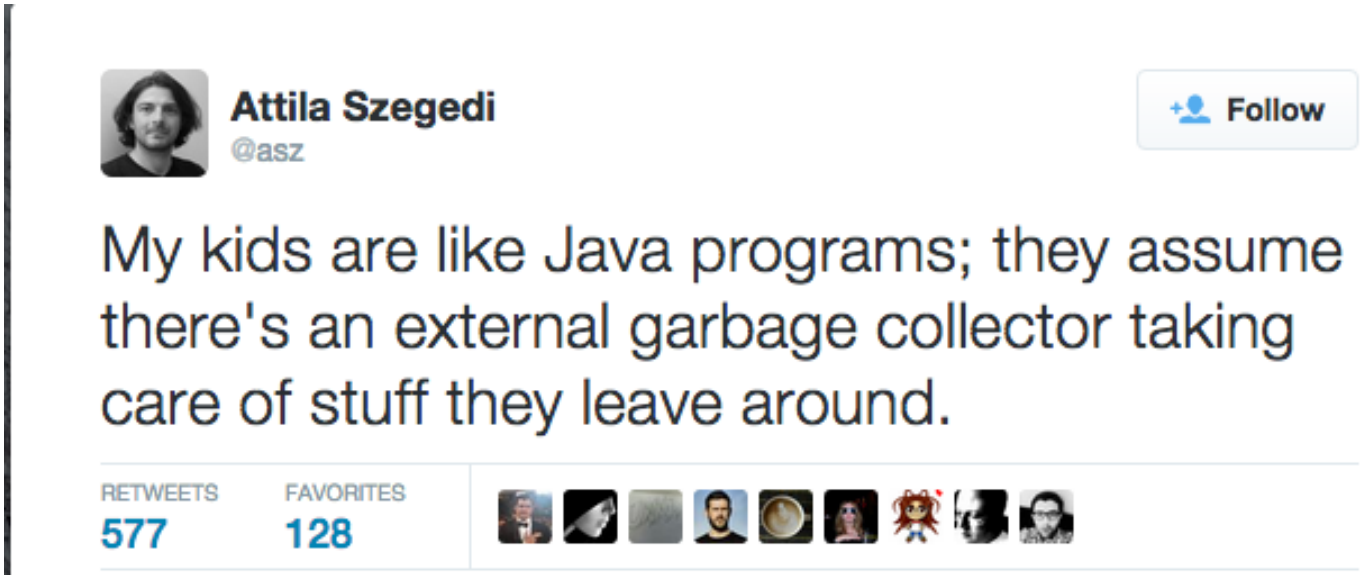
- **Pros? Cons?**



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Outline

[9] Images from "Java Head First" book.

Example

Listing 3: MyClass.java

```
1  public class MyClass {
2    public static void main(String[] args) {
3      System.out.println("Hello World!");
4    }
5  }
```

- To compile (creates bytecode into `hello.class`):
  `javac MyClass.java`
- To excute (no extension! it the class name!):
  `java MyClass`
- Result:
  `|| Hello World!`

Packages

Listing 4: HelloWorld.java

```
1  package fr.tse.java;    // Declare Package (name == directory where stored!!)
2  import java.util.List; // Refers to another class in another Pacakge
3
4  public class HelloWorld {
5    public static void main(String[] args) {
6      List myList = ...;
7    }
8  }
```

- Source code is organised in « packages »
- Strings separated by points (.)
- Similar to file path: **it is indeed!**
  File: `fr/tse/java/HelloWorld.java`
- To compile:
  `javac fr/tse/java/MyClass.java`
- To excute (FQN):
  `java fr.tse.java.MyClass`

Packages included in Java platform

- `java.lang`: Basic classes *imported automatically*
  `String`, `Character`, `Integer`...
- `java.io`: Input/Output
  `File`...
- `java.util`: useful structures & methods
  `Collections`, `List`, `Set`, `Random`...
- `java.math`: math operations `cos()`, `sin()`...
- ...
- Extensive list in the official doc:
  http://docs.oracle.com/javase/8/docs/api/

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Example of importing java.util.ArrayList

Listing 5: MyArrayList.java

```
1  package fr.tse.java;
2
3  import java.util.ArrayList;
4
5  public class MyArrayList {
6    public static void main(String[] args) {
7      System.out.println("Bonjour");
8      ArrayList<String> v = new ArrayList<String>();
9    }
10 }
```

- Description of Java's ArrayList class: http://docs.oracle.com/javase/8/docs/api/java/util/ArrayList.html

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Outline

[10] Images from "Java Head First" book.

Java ARchive (JAR files)

- Assemble all the `.class` files into an executable[11]

```
jar -cf MyClass.jar ./fr
```

[11] A Java ARchive (JAR) file, with extension `.jar`

Java ARchive (JAR files)

- Assemble all the `.class` files into an executable[11]
  `jar -cf MyClass.jar ./fr`
- Execute this `jar` file
  `java -jar MyClass.jar`

[11] A Java ARchive (JAR) file, with extension `.jar`

Java ARchive (JAR files)

- Assemble all the `.class` files into an executable[11]
  `jar -cf MyClass.jar ./fr`
- Execute this `jar` file
  `java -jar MyClass.jar`
- Requires the name of the main Class (entry point: `main()`):
  - Config file: `./META-INF/MANIFEST.MF`:
    `Main-Class: fr.tse.java.MyClass`
  - Add this file to the `jar`:
    `jar -cmvf MyClass.jar ./fr`

[11] A Java ARchive (JAR) file, with extension `.jar`

Outline

[12] Images from "Java Head First" book.

Classpath

- Context:
  - My code is in a `jar` file
  - It `imports` library classes from other `jar` files
- Problem: How do I tell the JVM where to look for `imported` classes?
- Solution: The **CLASSPATH**, is a list of all the pathes where to find these librairies (both Java's and our own's)

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Classpath

- **CLASSPATH** = list of pathes to external code
- It is generally stored in an Environment Variable
- Each element can be:
  - A directory (with `.class` in its sub-directories)
  - A `.jar`
  - A `.zip` file (mostly used internally by JVM)
- Separator: “:” (Unices: Linux/MacOS) or “;” (Windows)

Example of a CLASSPATH:

```
.:/home/prog/lib/:/usr/lib/java/log4j-1.2.11.jar:../lib-ext/junit.jar
```

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Classpath – Example

`.:/home/prog/lib/:/usr/lib/java/log4j-1.2.11.jar:../lib-ext/junit.jar`
is composed of:

- All `.class` in current directory (`.` & subdirs)
- All `.class` in `/home/prog/lib/` (& subdirs)
- Classes from archive `log4j-1.2.11.jar` found in *absolute* path `/usr/lib/java/`
- Classes form archive `junit.jar` found in *relative* path `../lib-ext/`

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How to provide the **classpath** compile/run-time?

- Option `-classpath` du compilateur
  - `javac -classpath ./:/home/prog/lib/ MyClass.java`
- Option `-cp` of the JVM
  - `java -cp ./:/home/prog/lib/ MyClass`
  - `java -cp ./:/home/prog/lib/ fr.tse.java.MyClass`

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Outline

[13] Images from "Java Head First" book.

Sump Up – Running Java Manually

Let's do a live coding demo with Text Editor+Command Line!!!

- Open a text editor
- Create a `HelloWorld.java` file + Type a `HelloWorld` class
- Compile with `javac`
- Run with `java`

- Create a `fr/tse/java` dir hierarchy
- Move the class in this directory
- Try to run the class ⇒ does not work
- Add the `package` directive ⇒ it works!!

- Create a `jar` file
- Try to execute it with `java -jar` ⇒ does not work
- Correct it to add `./META-INF/MANIFEST.MF` file

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Sump Up – Eclipse

Let's do a 2nd live coding demo, with Eclipse IDE!!!

- Start Eclipse
- Select workspace (& accept forever?)
- Create a **Java/Maven Project**
- Observe the Project herarchy is automatically created
- Create a Package ⇒ the dirs are created automatically
- Create a Class ⇒ file/class names correspond!
- Use autocompletion to create `main`
- Use autocompletion to enter `sysout`

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Outline

[14] Images from "Java Head First" book.

References

- **Eclipse Key Bindings CheatSheet**
  https://mootse.telecom-st-etienne.fr/pluginfile.php/9061/mod_resource/content/1/EclipseShortcutCheatSheet.pdf
- **A few useful CheatSheets**
  https://dzone.com/refcardz/getting-started-eclipse
  https://dzone.com/refcardz/core-java
  https://dzone.com/refcardz/getting-started-java-gui
  https://www.jrebel.com/search/results?keys=cheat%20sheet
- **Tutorials sites**
  https://www.baeldung.com/
  https://www.tutorialspoint.com/java/index.htm
- **News sites**
  https://dzone.com/
  https://jrebel.com/resources/
  https://www.infoq.com/
- **Complete course**
  http://jmdoudoux.developpez.com/cours/developpons/java/
- **Glossary**
  http://mindprod.com/jgloss/jcheat.html
- **Books**
  - UK NoStarch, OReilly, Manning, Packt
  - FR Eyrolles, Dunod
- **Programming cleanly**
  https://www.worldcat.org/title/java-by-comparison-become-a-java-craftsman-in-70-examples/oclc/1035454599&referer=brief_results
  https://github.com/GMTSE/ProjetsJavaMaterial/blob/master/JavaByComparisonSumUp.md

Outline

[15] Images from "Java Head First" book.

Sump Up

- Java follows **OOP paradigm**
- Java is **widely used**
- Code in `.java` files (filename = Class name)
- Code organized in **packages** (many provided in Java platform)
- Compile
  `javac MyClass.java`
- Execute
  `java MyClass`
- We will learn **Java 8** features
- We will use **Eclipse** to write code
- We will use **Maven** to compile/manage deps

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Outline

[16] Images from "Java Head First" book.

Maven

- Goal: Manage compilation chain & dependencies

Maven

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- Uses conventions

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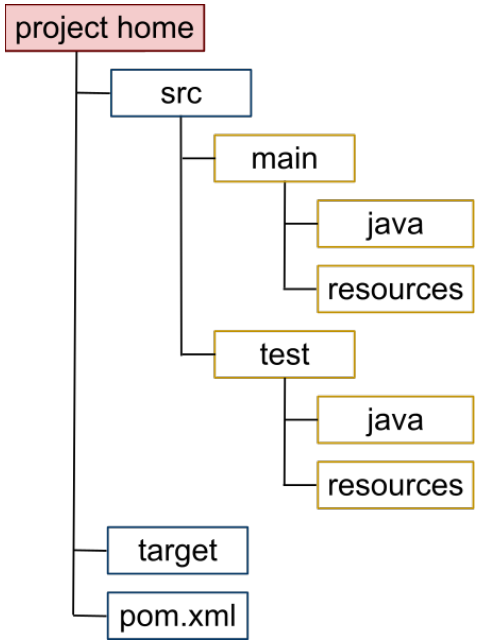
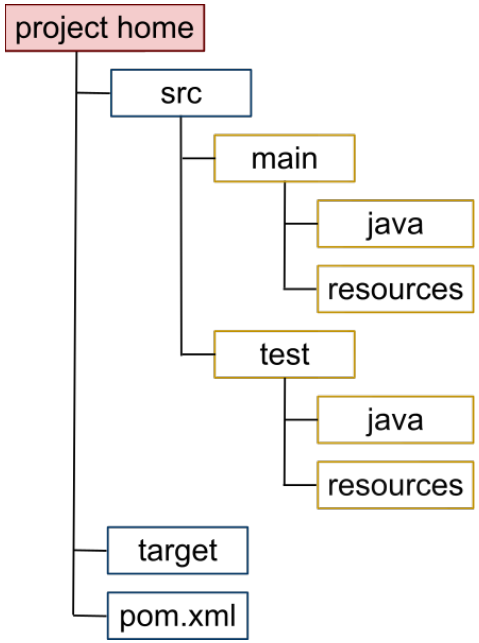
Maven

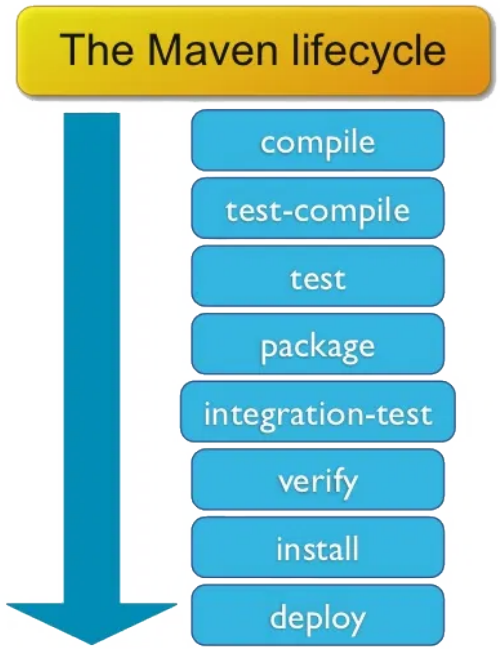
- Goal: Manage compilation chain & dependencies
- Uses conventions
  - Project architecture



Maven

- Goal: Manage compilation chain & dependencies
- Uses conventions
  - Project architecture
  - Pre-configured rules: `clean`, `compile`...





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Maven

- Goal: Manage compilation chain & dependencies
- Uses conventions
- Configuration via `pom.xml` file

Maven

- Goal: Manage compilation chain & dependencies
- Uses conventions
- Configuration via `pom.xml` file
- Example usage:
  `mvn clean compile`

Maven

- Goal: Manage compilation chain & dependencies
- Uses conventions
- Configuration via `pom.xml` file
- Example usage:
  `mvn clean compile`
- We will let Eclipse do (most of) that for us!!

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Maven – Example `pom.xml` file

```
1   <project>
2   <!-- model version is always 4.0.0 for Maven 2.x POMs -->
3   <modelVersion>4.0.0</modelVersion>
4   <!-- project coordinates, i.e. a group of values which uniquely identify this project -->
5   <groupId>com.mycompany.app</groupId>
6   <artifactId>my-app</artifactId>
7   <version>1.0</version>
8   <!-- library dependencies -->
9   <dependencies>
10  <dependency>
11  <!-- coordinates of the required library -->
12  <groupId>junit</groupId>
13  <artifactId>junit</artifactId>
14  <version>3.8.1</version>
15  <!-- this dependency is only used for running and compiling tests -->
16  <scope>test</scope>
17  </dependency>
18  </dependencies>
19  </project>
```

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