Welcome!

You need the following software installed on your computer:

- **Java** Development Kit (OpenJDK 21)
https://adoptium.net/

- **IntelliJ IDEA** (Community Edition)
https://www.jetbrains.com/idea/download/

(-possibly **Git** command line tool)
https://git-scm.com/downloads

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Introduction to the Java programming language

Compicampus - IT Courses for Students

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Last update: 2024-03-10

Goals

- Get a '**feeling**' for the language
- Get to know basic **tools** so that you could continue at home
- Learn basic Java **language constructs**
- Be able to **change**/improve existing programs

My opinion on Java use

Well-suited for:

- General data processing
- Simulations
- Games
- Android Apps
- Servers of all kind
- Desktop applications
- ...

Less well suited for:

- Statistics (*use R*)
- Linear algebra (*use Matlab or Octave*)
- Mathematics (*use Maple, Mathematica, Maxima or other CAS*)
- Machine Learning (*use Python*)
- Quick'n'dirty string processing (*use Python, Bash, ~~Ruby~~, ~~Perl~~, JS*)
- Data Visualization
- ...

Download material

- **Slides (PDF):**

  https://java.retorte.ch
  (Please take tiny survey later *during the course!)*

Verify that required software is installed

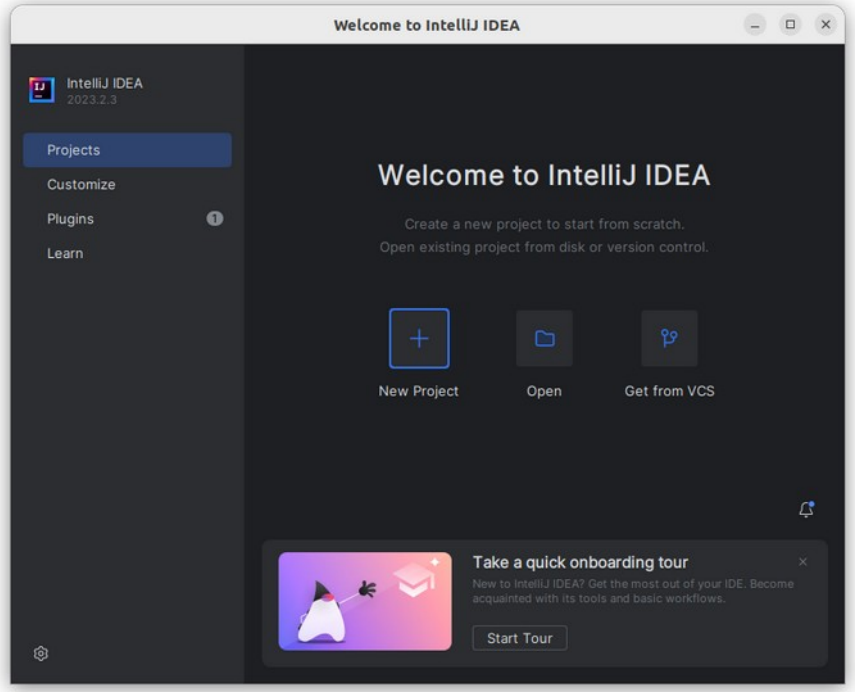
Java:

Open a terminal and enter '`java -version`':

```
$ java -version
openjdk version "21" 2023-09-19 LTS
[...]
```

IntelliJ IDEA Community Edition:

Software should start and look like this:



Acquire source code

We need the example source code on our own computer. As example we use a `*projects*` folder where we place the source code:

projects/java-intro

or

projects/java-intro-master
(if you download it manually)

E.g:

Linux: */home/USERNAME/*projects*/java-intro*

Windows: *C:\Users\USERNAME*projects*\java-intro*

Mac OS: */Users/USERNAME/*projects*/java-intro*

Acquire source code cont'd

With Git installed:

- Open a Terminal: Press *Windows Key* and start typing 'Terminal'. Click on the emerging icon labeled 'Terminal'.
- Execute the following commands (press *Enter* after every line):

```
mkdir -p projects      #(might already exist)
cd projects
git clone https://github.com/nwaldispuehl/java-intro.git
```

Note: If you decided to not install Git, see next slide for manual source code acquisition.

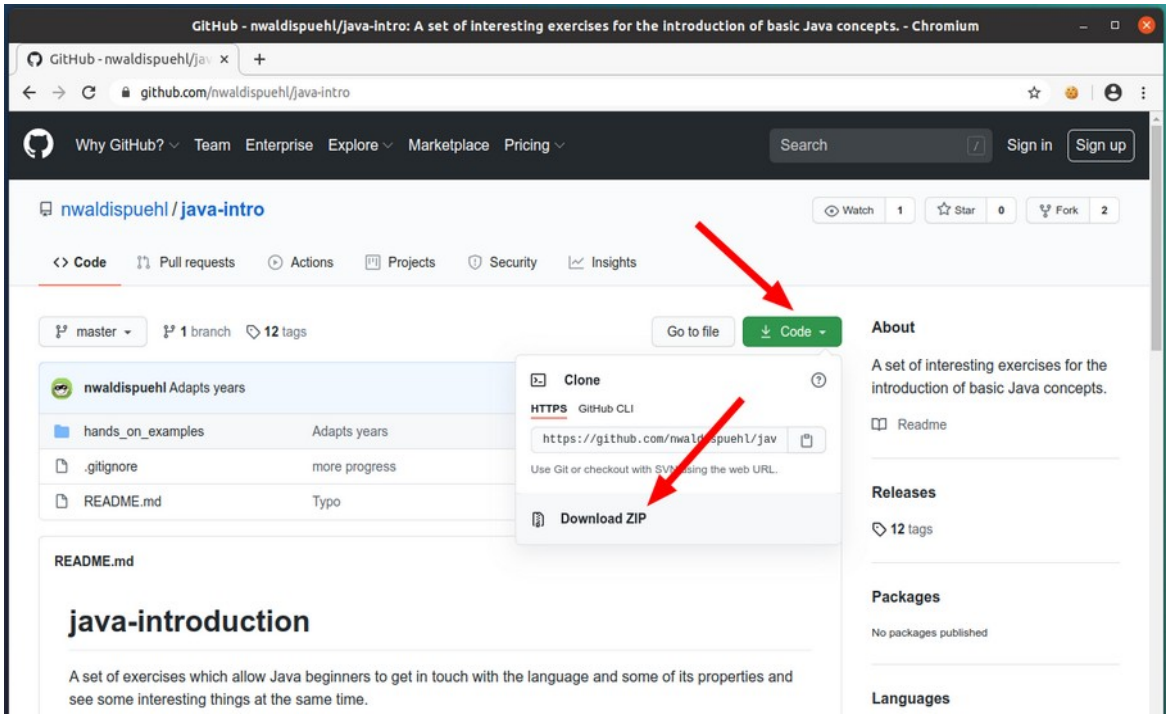
Acquire source code cont'd...

Manually:

- Surf to the repository with a web browser:

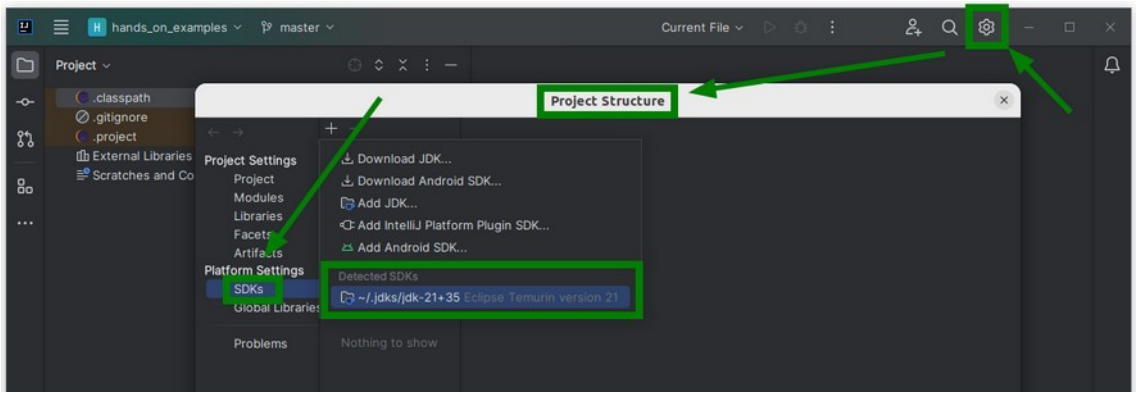
https://github.com/nwaldispuehl/java-intro

- Download the Zip archive of the code and extract it into your *projects* directory.



Open project in IntelliJ IDEA IDE*

- Start **IDEA**
- On the welcome screen: '**Open**'.
- Select '*projects*/**java-intro/hands-on-examples**' directory, → '**Ok**'
- Select **'Trust project'**
- *The project is being opened*
- ⚙ → Project Structure... → SDKs → + → *Select your JDK*
  (or explicitly add it via 'Add JDK…'. It might already be selected.)
- Project → Set SDK
- Open 'Project View'

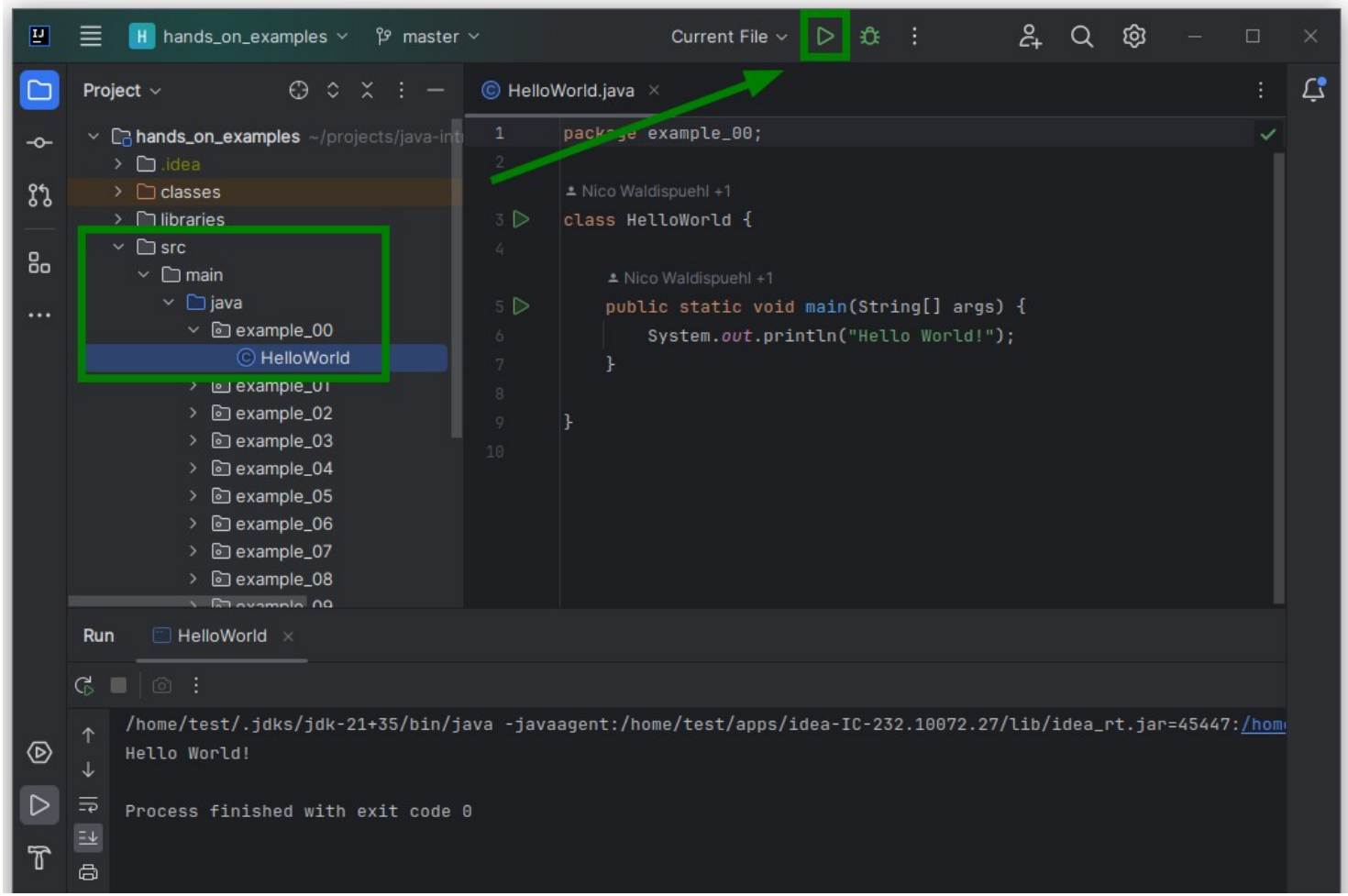


Hands-On

- Expand the package '**example_00**'
- Open the file '**HelloWorld.java**' *(e.g. with double-click)*

Task

Run the program.



Hands-On

Now prepare your environments.

Goal: Every student has run the `Hello World` program.

What does a Java program look like?

```
public class HelloWorld {
    public static void main(String[] args) {
            System.out.println("Hello World");
    }
}
```

For comparison the same program in Python:

```
print "Hello World"
```

→ Java is more *verbose*, and thus more *explicit*.

It is a '**statically typed**' programming language.

Read more here: http://docs.oracle.com/javase/tutorial/getStarted/cupojava/

Play around a bit with the sample program

Use this print statement to try out some easy operations:

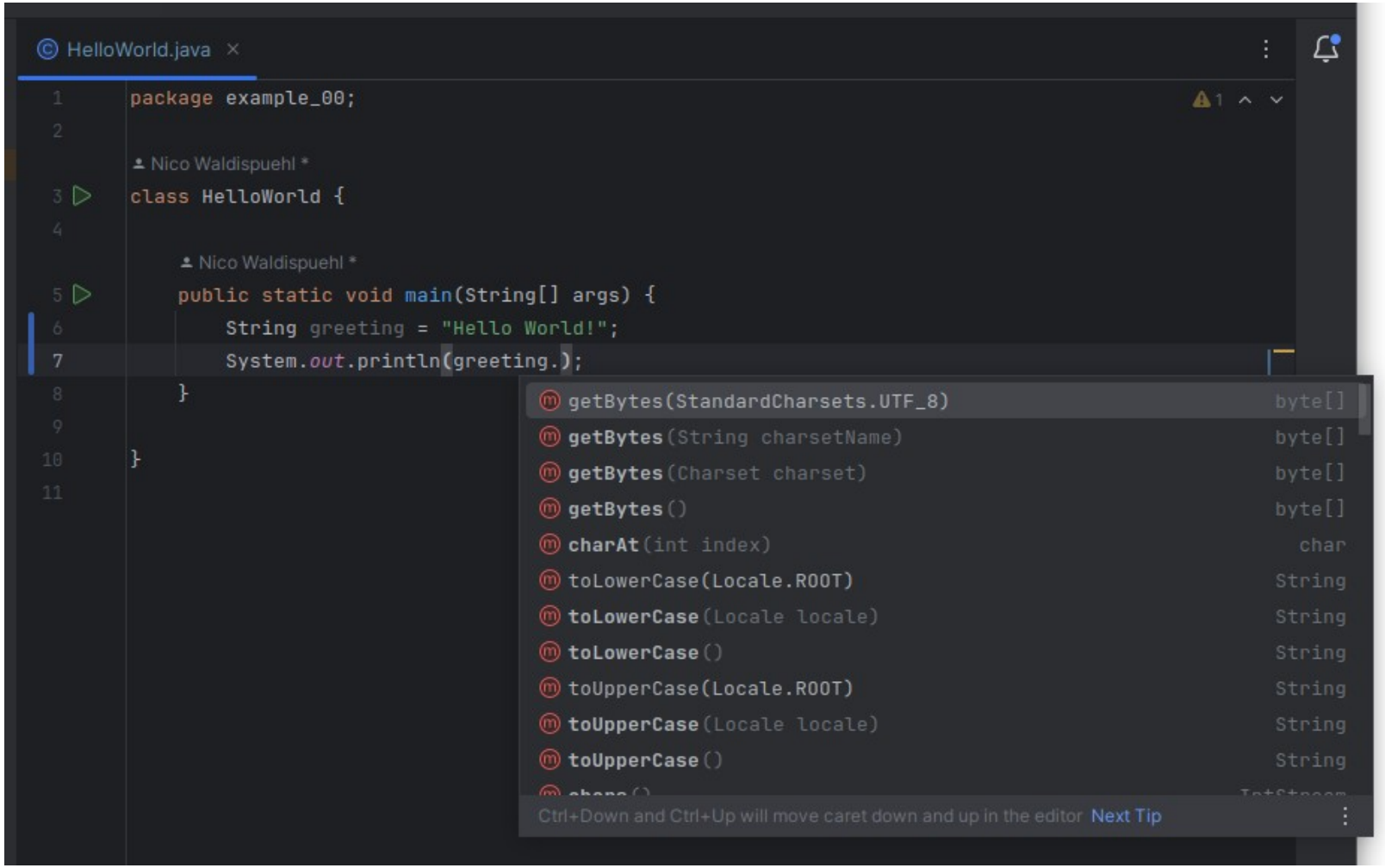
```
System.out.println( x );
```

Replace the '*x*' with these and check the output:

- **Arithmetic operations** ('calculations'):
  - Trivial ones: *1 + 1*, *500 / 0.001*, *3 * 3*
  - Extreme values: *1e300 * 1e200*, *2000000000 * 4*
- **Text manipulations**:
  - Concatenation: "*Hell*" + "*o*"
  - Method calls: "*Hello*".*toLowerCase()*
  - Chained method calls: "*Hello*".*toLowerCase()*.*toUpperCase()*

How to take advantage of the IDE

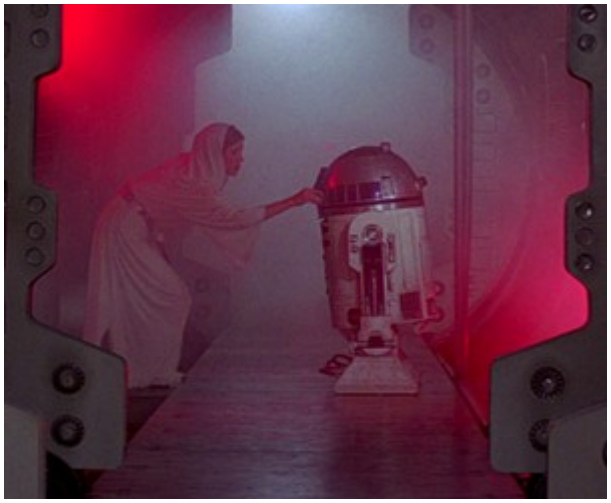
The keystroke **Ctrl+Space** brings up a list of possible and recommended methods/calls for the current cursor position.



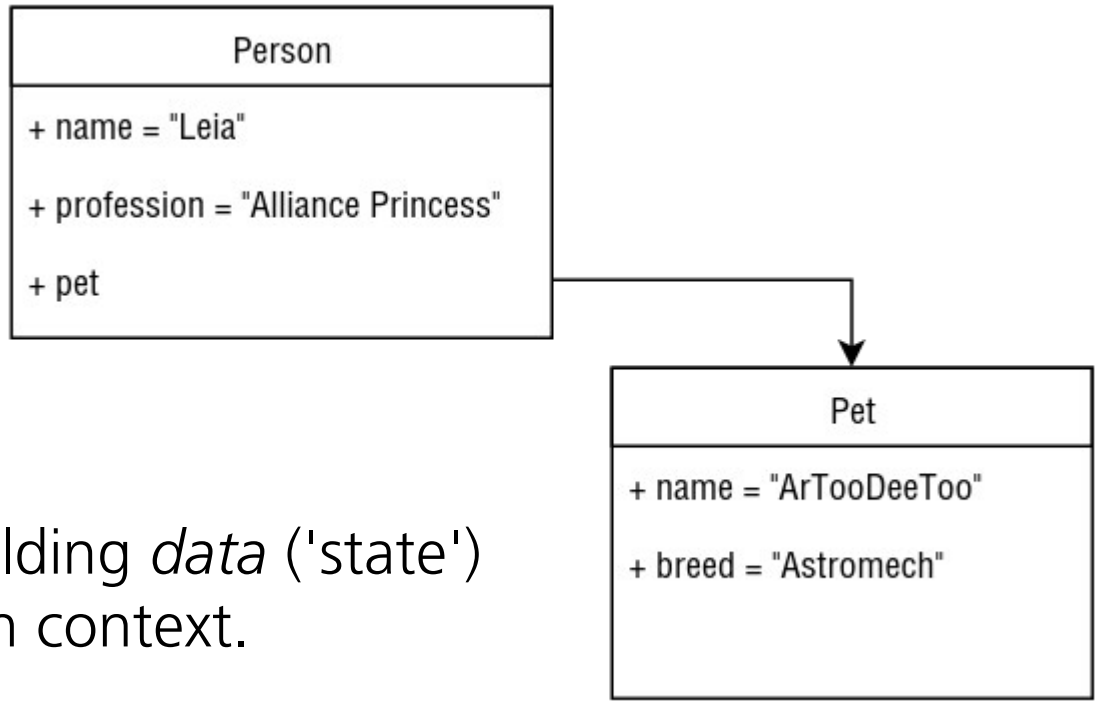
Java property: Object-orientation

In Java *everything is an object*; every real world 'thing' (we need in the software somehow) is modelled as 'object'.

– We tend to have less problems to think/talk about it this way.



VS

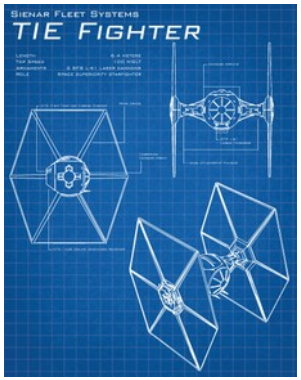


– An object is a 'container' holding *data* ('state') and *functionality* of a certain context.

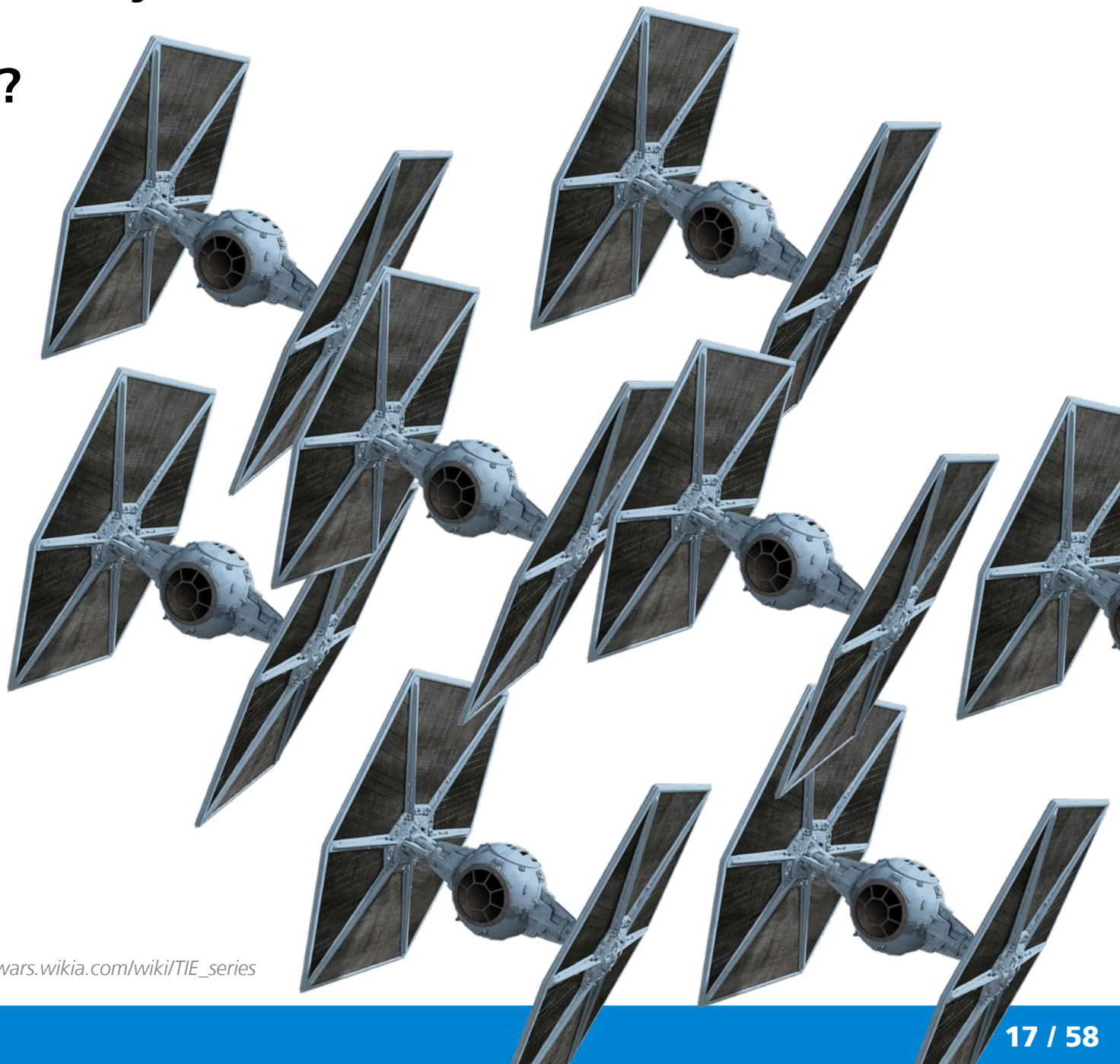
Sources: *http://starwars.wikia.com/wiki/R2-D2?file=Futureoftherebellion.png*

Java property: Object-orientation

– **Class vs Object?**



VS



Sources: *http://www.patrickkingart.com/, http://starwars.wikia.com/wiki/TIE_series*

Create an object, assign a variable

A Java object is instantiated with the use of the '***new***' keyword.

```
new String("Hello");
```

Create some objects and assign them to respective variables:
(Note: We need to declare the type before the name.)

```
// These are equivalent:
String greeting = new String("Hello");
String greeting = "Hello";

// These are equivalent:
Double piApproximation = new Double(3.1415926);
Double piApproximation = 3.1415926;

File textFile = new File("myTextfile.txt");
```

Types, Assignments, Operators

- **Types**
  - **Primitive types:**
    Integers: int
    int a = 5;

    Double prec. float: double
    double b = 3.5;

    Boolean value: boolean
    boolean isRight = true;
  - **Classes (Object types):**
    There are millions!! :)
    String myText = "Hello";
    Person bob = new Person();

- **Assignments: =**

  int aNumber = 5;
  Person alice = new Person();

- **Operators**
  Calculate: +, -, *, /, %
  x + y, z % 2

  Compare: ==, <, <=, >, >=, !=
  x == y, 0 < z

  Condition: &&, ||
  0 < x && x <= 10

  Negation: !

Note: Variable name must not be a keyword:
http://docs.oracle.com/javase/tutorial/java/nutsandbolts/_keywords.html

Read more here: http://docs.oracle.com/javase/tutorial/java/nutsandbolts/index.html

Primitive types vs object types

Primitive types

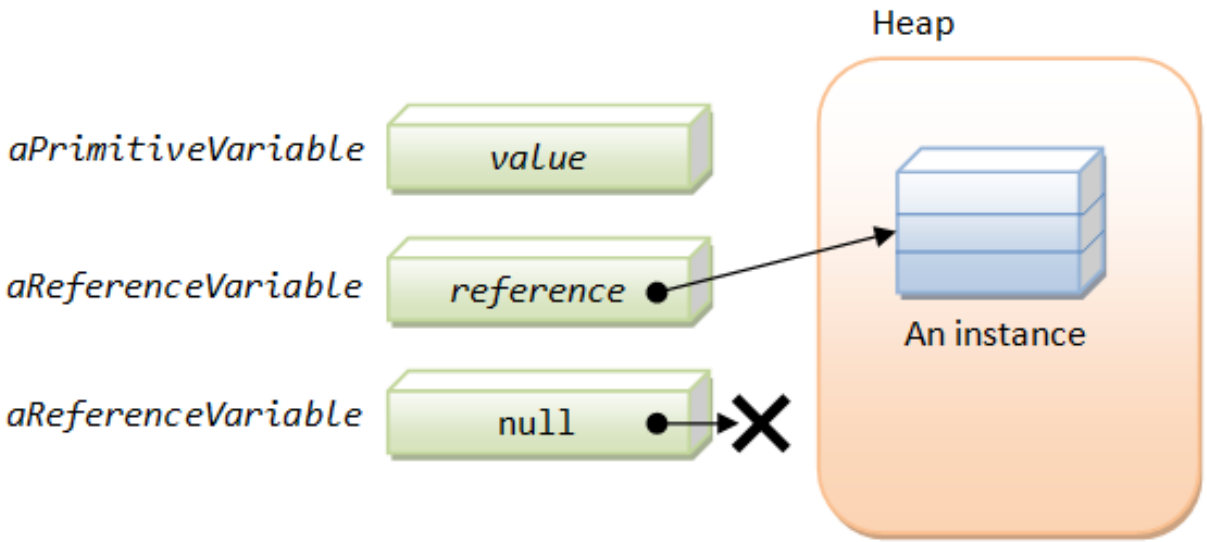
```
int age = 24;
```

- Fit in a single 'memory cell' in the stack.
- Thus restricted in size (e.g 32bit for *int*)

Object types

```
Integer age = new Integer(24);

Person alice = new Person();
```

- Only a reference to the object is kept in the stack.



Sources: *http://www3.ntu.edu.sg/home/ehchua/programming/java/j3c_oopwrappingup.html#zz-7.1*

Control flow

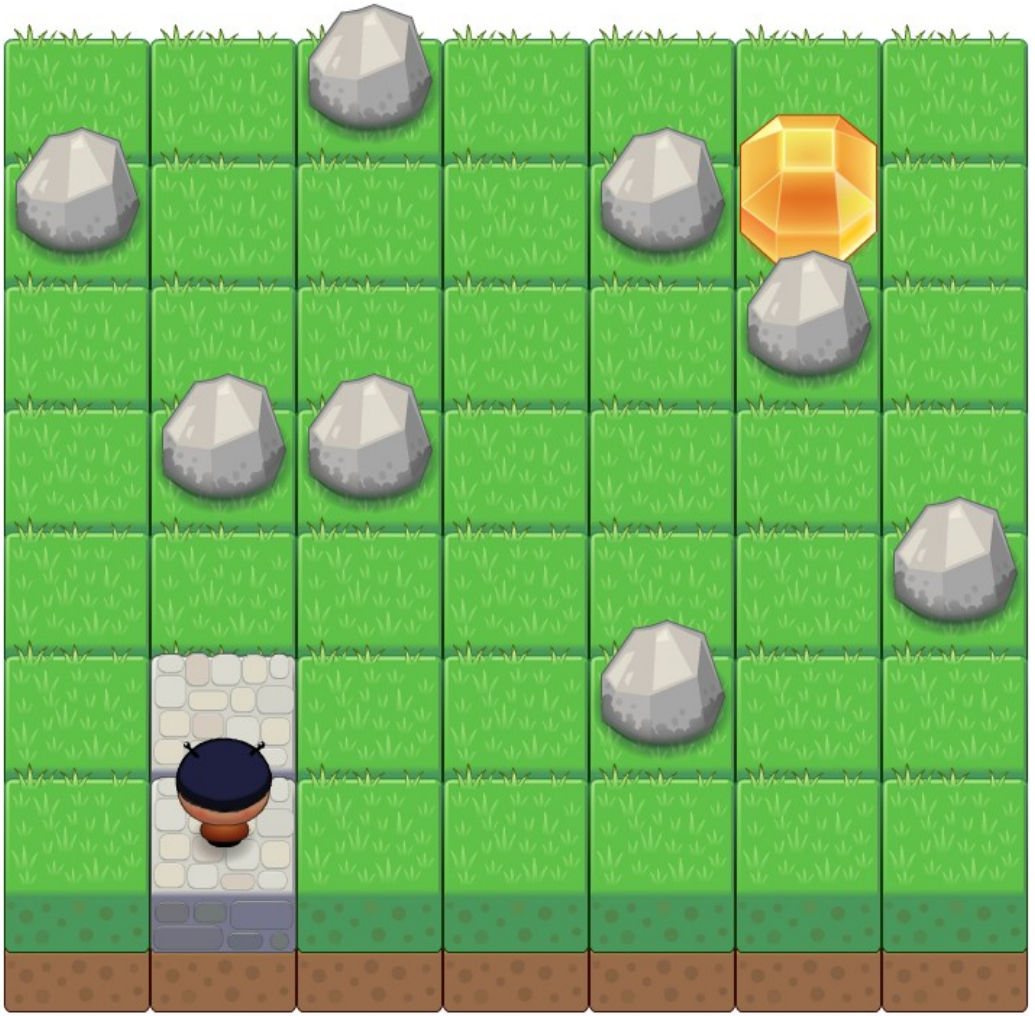
- **Branching**
  - ***if – then* clause**
    if (boolean condition) { ... }
    if (3 < x) { ... }
  - ***if – then – else* clause**
    if (cond.) { ... } else { ... }
    if (x == 0) { ... } else { ... }
  - **may be combined:**
    if (cond.) { ... }
    else if (cond.) { ... }
    else { ... }

    *) where ... denotes an arbitrary expression.

- **Loops**
  - ***for* loop**
    for (init; term ; incr) { ... }
    for (int i = 0; i < 10; i++) { ... }
  - ***while* loop**
    while (boolean condition) { . }
    int x = 0;
    while (x < 10) {
    *   x = x + 1;*
    }
  - **Object iteration** (e.g. String)
    List<String> stringList = ...
    for (String s : stringList) { ... }

Read more here: http://docs.oracle.com/javase/tutorial/java/nutsandbolts/flow.html

Game: Treasure Hunt



Sources: *http://www.lostgarden.com/2007/05/dancs-miraculously-flexible-game.html (graphic tiles)*

Hands-On

- Expand the package '**example_01**'
- Open the file '**TreasureHunt.java**'

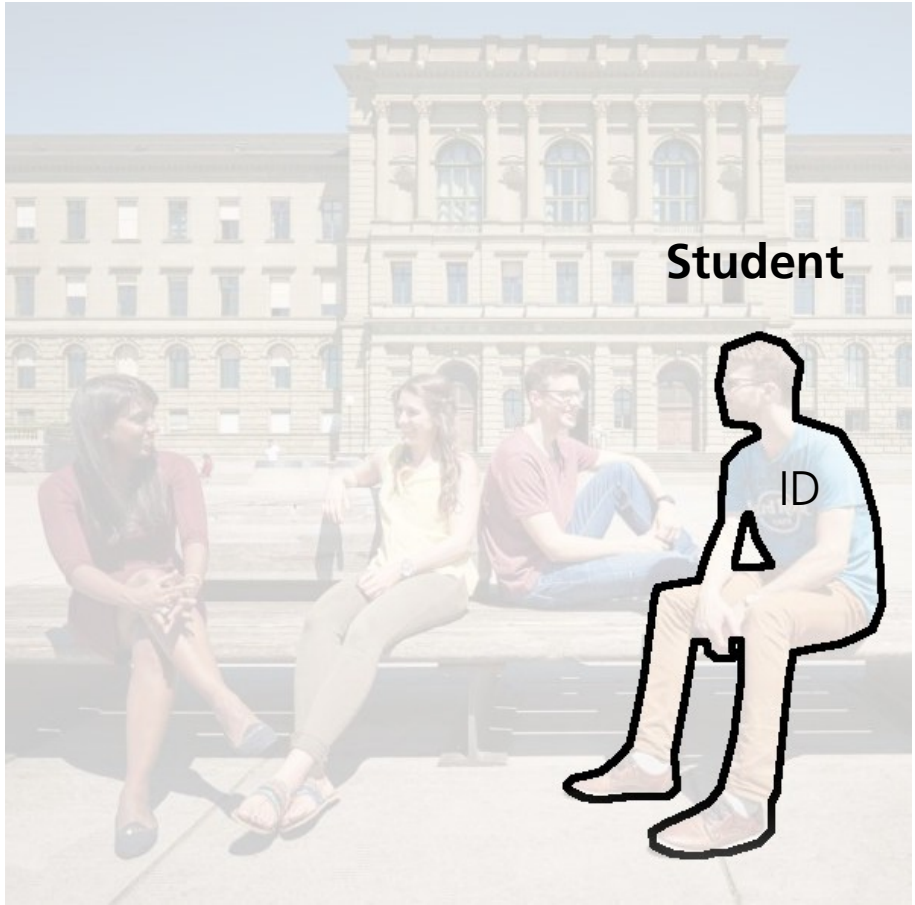
Tasks

- Run the program and observe.
- Open the file '**Avatar.java**'
- Enhance the method '**move()**' in the class '**Avatar**' with directions so that the character in the game catches the treasure.

Own program: Student Exam Manager

- Writing software = apply abstraction to the real world
  → Keep only the relevant parts.
- First, create data **model**, then **functionality**.

→



Anatomy of a Java program

Person.java

```java
public class Person {

  private String name;
  private int yearOfBirth;

  public Person(String name, int yearOfBirth) {
    this.name = name;
    this.yearOfBirth = yearOfBirth;
  }

  public int getAgeIn(int year) {
    return year - yearOfBirth;
  }
}
```

Constructor

Method

Access modifier
Keyword
Type
Class variable
Local variable

Parts of Program.java

```java
Person ronald = new Person("Ronald", 2001);
int ronaldsAge = ronald.getAgeIn(2024);
System.out.println("Age: " + ronaldsAge);
```

Hands-On

- Expand the package '**example_02**'
- Open the files '**Person.java**' and '**Program.java**'

Tasks

- Run the program.
- Enhance the class '**Person**' with a new *method* '**getName**'.

Java property: Object-orientation

- **Everything is an object in Java. OO means: Information hiding, asking someone to do something**


```
if (list.length == 0) {
    print "empty";
}
```

```
if (list.isEmpty()) {
    System.out.println("empty");
}
```

Read more here: http://en.wikipedia.org/wiki/Object-oriented_programming

Sources: *http://aliceandbobcurate.files.wordpress.com/2012/02/ask.jpg*

Hands-On

- Expand the package '**example_03**'
- Open the files '**Person.java**' and '**Program.java**'

Tasks

- Run the program.
- Enhance the method '**compareAgeWith**' of the class '**Person**' in a way that it returns the proper answer.
- Does the answer remain correct if you change names and birth years of the person instances?

Some more Java facts

- Current standalone Java version: **Version 8 Update 401**
  (New versioning scheme: two versions per year; currently: 21)
- **JRE** (Java Runtime Environment) aka **'Java'** *(<50 MB)*
  This needs to be installed to *run* Java programs.
  http://www.java.com/
- **JDK** (Java Development Kit) *(>120MB)*
  This needs to be installed to *write* Java programs.

- Mostly used: **java** (application launcher), and **javac** (Java compiler).

Read more here: http://www.oracle.com/technetwork/java/index.html

How to be able to program Java at home?

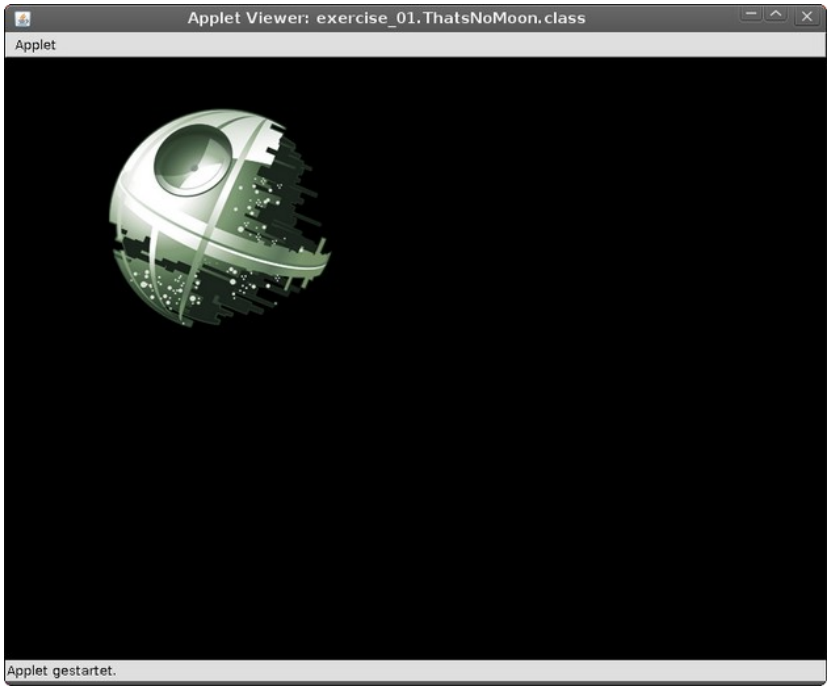
- **To *run* the programs: Install the JDK**
  https://adoptium.net/
  or google for "jdk download"
- **To *edit* the programs: Install an IDE**

  E.g. IntelliJ IDEA: https://www.jetbrains.com/idea/

  There are others:

  - *Eclipse (https://www.eclipse.org/)*
  - *Netbeans (https://netbeans.org/)*

Hands-On



- Expand the package '**example_04**'
- Open the file '**ThatsNoMoon.java**'

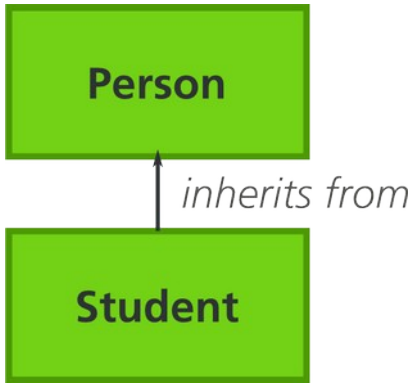
Tasks

- Run the program.
- Enhance the method '**updateValues**' of the class '**ThatsNoMoon**' in a way that the moon moves.
- Make the moon **change direction** when it hits a border.
- Introduce **gravity**: Let the speed change over time.

  Are you getting the moon **bouncing**?
  (Maybe you need dampening so it does not bounce too much?)

Inheritance

A powerful feature of object-orientation is inheritance. By **extending** another object, we inherit its properties.



Consequence: *A student is a person.*

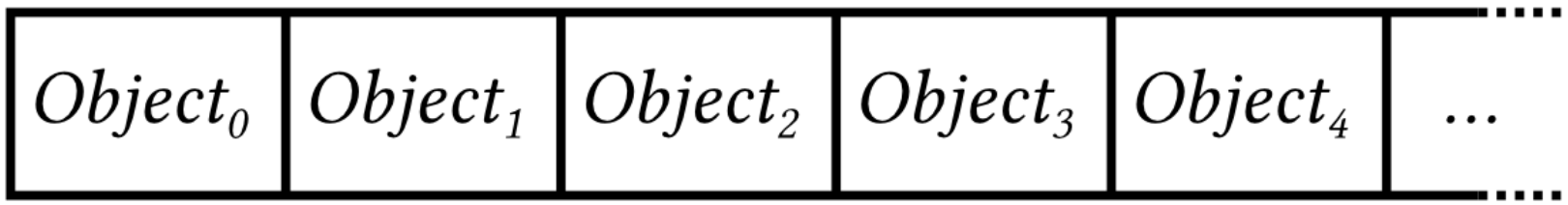
```
public class Student extends Person {
    private String studentNumber;

    public Student(String sNr, String name, int yearOfBirth) {
        super(name, yearOfBirth);
        this.studentNumber = sNr;
    }

    public String getStudentNumber() {
        return studentNumber;
    }
}
```

Keyword

Note: Every class implicitly extends the class **Object**.

Read more here: http://en.wikipedia.org/wiki/Inheritance_(object-oriented_programming)

Basic data structures: List



Basic data structures: List cont'd

- **List**
  ArrayList is a popular implementation:

```
ArrayList<String> myList = new ArrayList<>();

// Usual operations:
myList.add("some string");
String fifthElement = myList.get(4);

// Iterate over list:
for (String s : myList) {
   // Do something with s.
}
```

Read more here: https://docs.oracle.com/en/java/javase/11/docs/api/java.base/java/util/List.html

Hands-On

- Expand the package '**example_05**'
- Open the files '**Program.java**', and '**FinalExam.java**'.

Tasks

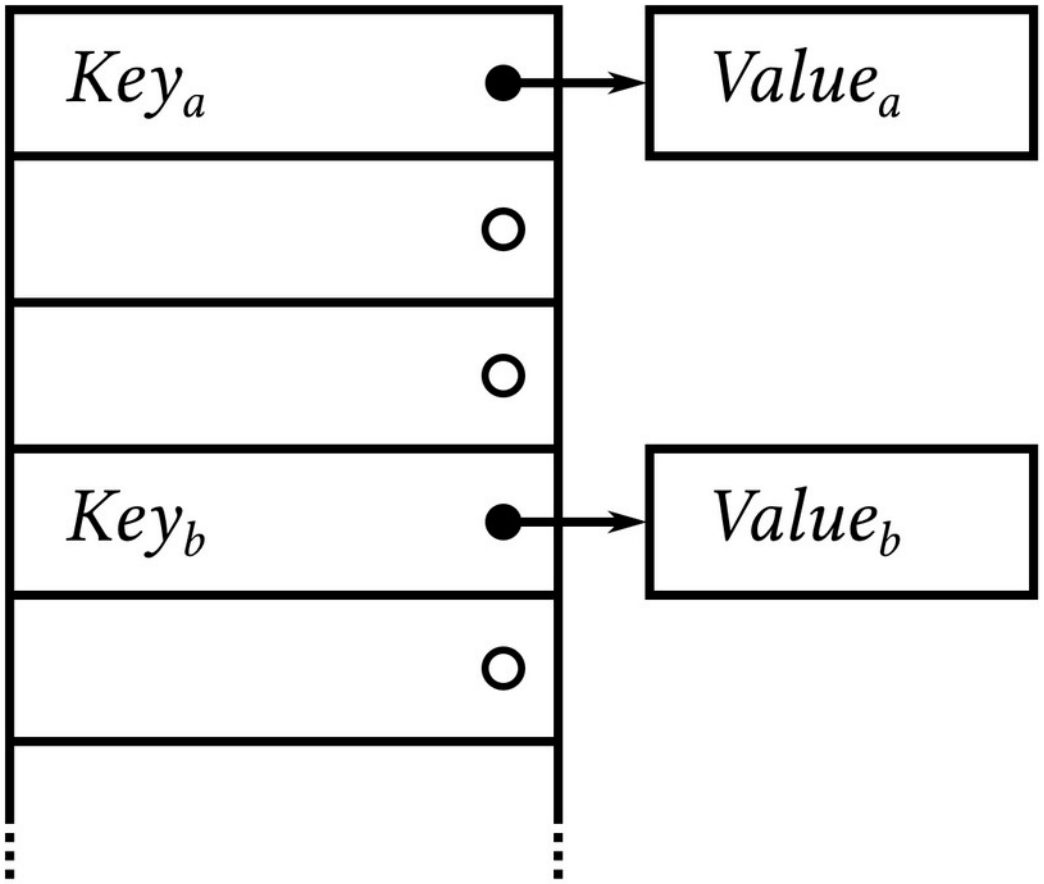
- Run the program.
- Complete the method '**printAcceptedApplicants**' in the class '**FinalExam**' in a way that a list of all eligible students is printed to the console.

End of the first part

See you tomorrow!

Basic data structures: Map

Other languages call it 'hash', or 'dictionary'.
(Works like a phone book.)



Basic data structures: Map cont'd

- **Map**
  HashMap is a popular implementation.

```
HashMap<String, Integer> myMap = new HashMap<>();

// Usual operations:
myMap.put("key", 123);
Integer value = myMap.get("key");

if (myMap.containsKey("key")) {
    // ...
}

// Iterate over map values (also possible for keys):
for (Integer value : myMap.values()) {
    // Do something with value.
}
```

Read more here: https://docs.oracle.com/en/java/javase/11/docs/api/java.base/java/util/Map.html

Hands-On

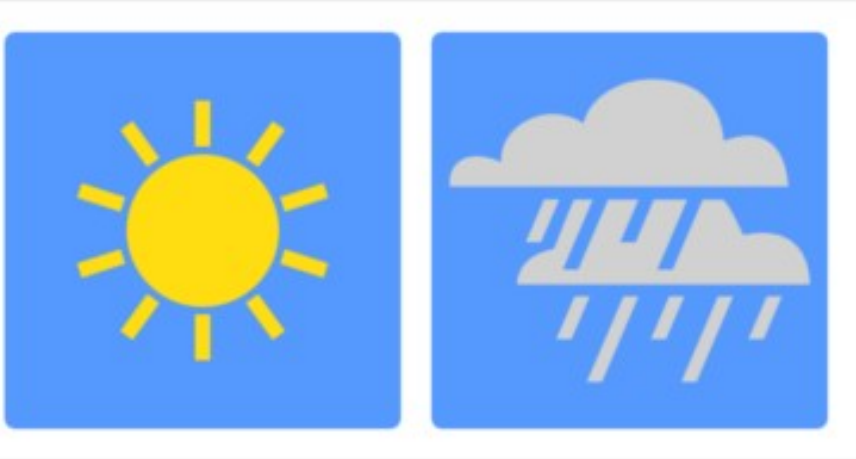
- Expand the package '**example_06**'
- Open the files '**Program.java**' and '**WordLengthFrequencyCounter.java**'.

Tasks

- Run the program.
- Implement the method '**calculateFrequencyTableFrom**' in the class '**WordLengthFrequencyCounter**' in a way that it stores a frequency table of the words length in the map '**frequencyTable**'.

Fetching information from the internet


```
    "coord": {
        "lon": 8.55,
        "lat": 47.37
    },
    "sys": {
        "message": 0.0037,
        "country": "CH",
        "sunrise": 1425966485,
        "sunset": 1426008237
    },
    "weather": [
        {
            "id": 803,
            "main": "Clouds",
            "description": "broken clouds",
            "icon": "04n"
        }
    ],
    "base": "cmc stations",
    "main": {
        "temp": 277.513,
        "temp_min": 277.513,
        "temp_max": 277.513,
        "pressure": 974.87,
        "sea level": 1041,
```

Hands-On

- Expand the package '**example_07**'
- Open the file '**Program.java**'.

Tasks

- Run the program.
- Export it as so called .jar (Java archive) file.
- Run it from command line.

How to export an executable Java program

- → 'Project Structure' → 'Artifacts' holds a definition.
- Menu: **Build → Build artifacts**....
- Select action: **Build**.
- The artifact is built in the PROJECT/out/artifacts directory.
- You can then start the program from the command line:

```
$ java -jar weather.jar Zurich
Temperature in 'Zurich': 13.18 °C
```

Class vs Interface?

Sources: *http://en.wikipedia.org/wiki/File:HITACHI_1_ZOLL_C.jpg, http://ios.wonderhowto.com/how-to/3-music-player-apps-put-your-iphones-built-music-app-shame-0140654/*

Class vs Interface?

```
interface MusicPlayer {
    void play();
}
```

The interface is implemented by:

```
class TapeRecorder implements MusicPlayer {
    void play() {
        // Start music tape playing.
    }
    // ...
}
```

```
class SmartPhone implements MusicPlayer {
    void play() {
        // Load mp3 from storage and play it.
    }
    // ...
}
```

Keyword

Class vs Interface?

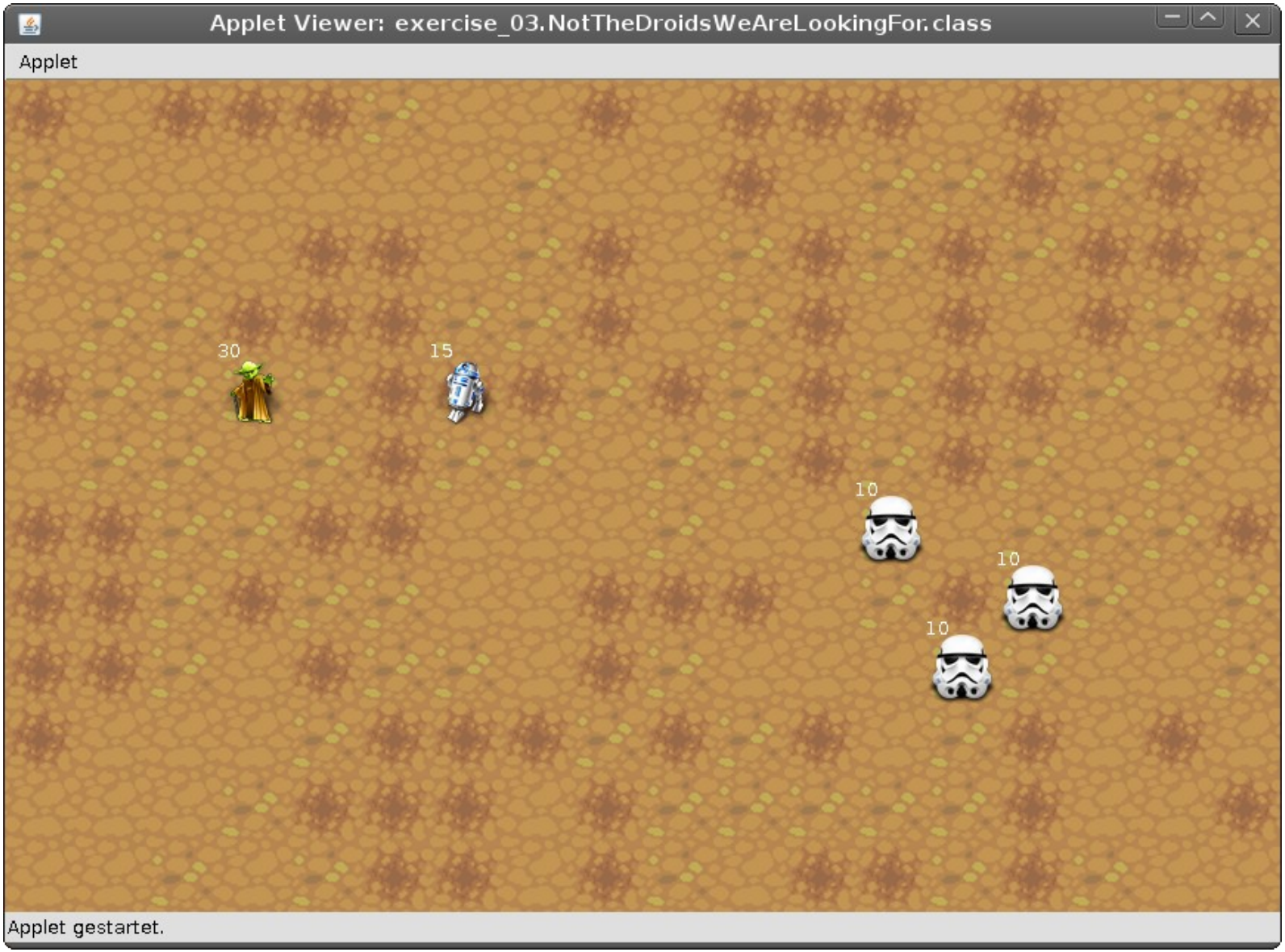
Why is that useful?

- Users may provide own implementations.
- Keep software as generic as possible.

```
class Club {
    private MusicPlayer musicPlayer;

    void setMusicSource(MusicPlayer musicPlayer) {
        this.musicPlayer = musicPlayer;
    }

    void startParty() {
        musicPlayer.play();
    }
}
```

Read more here: http://docs.oracle.com/javase/tutorial/java/concepts/interface.html

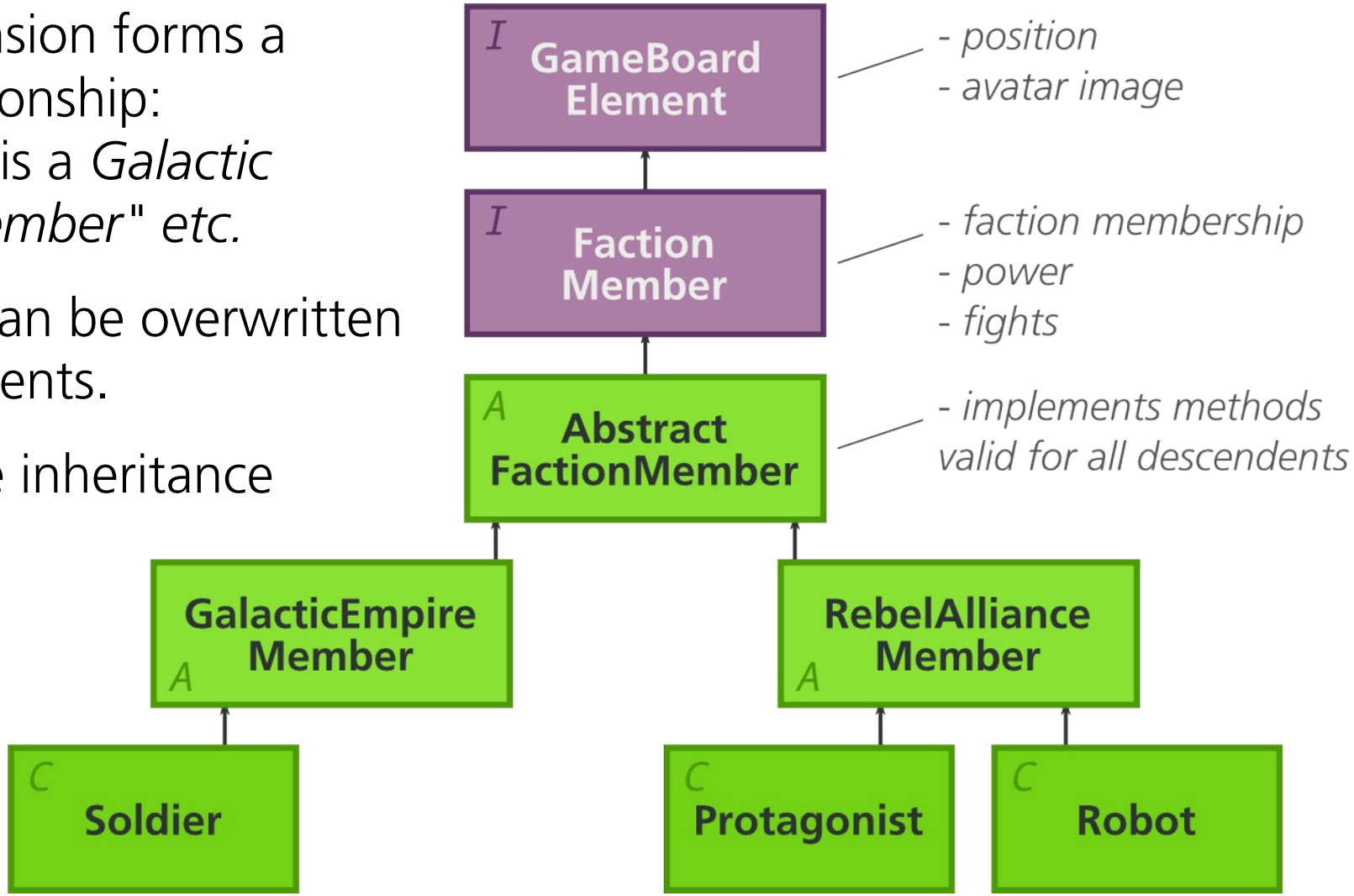
Game: Not the droids you're looking for



Sources: *http://www.iconarchive.com/show/star-wars-icons-by-artua.html, https://www.iconfinder.com/icons/15483/clone_droid_helmet_star_wars_storm_trooper_icon*

Game: Object structure

- By **extend**ing a class you inherit all properties from it.
- Such extension forms a '**is a**' relationship: "*A Soldier* is a *Galactic Empire Member*" *etc.*
- Methods can be overwritten in descendents.
- Only single inheritance

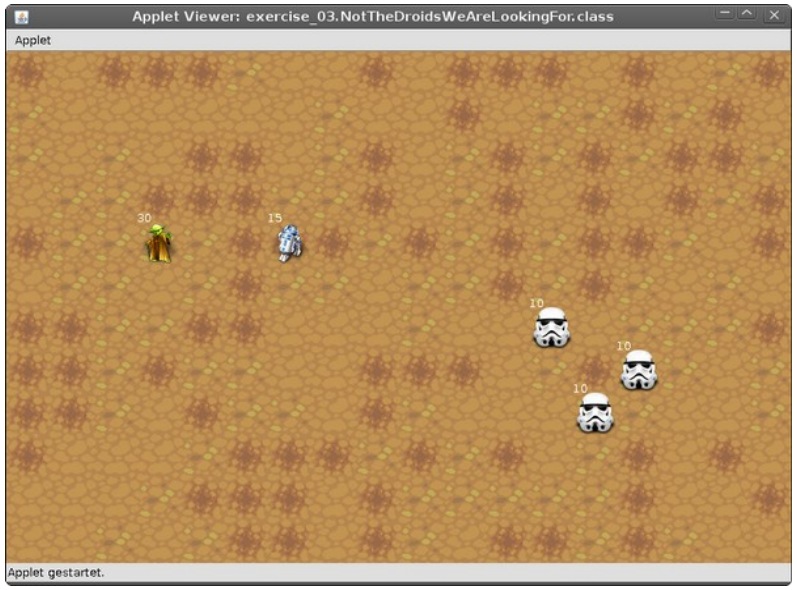


Check if object is of a certain type

The '**instanceof**' operator returns `true` if the argument is in the object hierarchy of the inspected object, `false` otherwise:

```
Soldier soldier = new Soldier(somePosition);
Robot robot = new Robot(anotherPosition);

if (soldier instanceof RebelAllianceMember) {
    // is not executed
}

if (robot instanceof RebelAllianceMember) {
    // is executed
}

if (robot instanceof GameBoardElement) {
    // is executed                                    Keyword
}
```

Hands-On



- Expand the package '**example_08**'.
- Open the file '**NotTheDroids...**'

Tasks

- Run the program.
- Let the game finish properly: Implement '**isGameFinished()**'.
- Add a new game board element '**Rock**' which is just an obstacle. *(Extend '**AbstractGameBoardElement**')*
- Add a new game board element '**Antagonist**' which should be a galactic empire member.
- Replace the random strategy of the empire members with a more elaborate strategy. (*E.g. move towards next enemy.)*

Android: 'Hello World' App

activity_main.xml

```
<RelativeLayout xmlns:android="http://schemas.android.com/.../android"
   xmlns:tools="http://schemas.android.com/tools"
   android:layout_width="match_parent"
   android:layout_height="match_parent" >

   <TextView
       android:layout_width="wrap_content"
       android:layout_height="wrap_content"

       android:text="Hello World!" />

</RelativeLayout>
```

MainActivity.java

```
public class MainActivity extends Activity {
    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main);
    }
}
```

Some interesting Links

- Get started with **Android** apps
  https://developer.android.com/training/basics/firstapp/
  http://developer.android.com/studio/
- 'Learn Java online' interactive **tutorial** (browser based)
  http://www.learnjavaonline.org/
- Questions and (mostly) **answers**
  http://stackoverflow.com/questions/tagged/java
- An ETHZ education project (in german) to learn Java: **Kara**
  http://swisseduc.ch/informatik/karatojava/kara/
- Popular computer **games** written in Java:
  - Minecraft: *https://minecraft.net/*
  - Mindustry: *https://mindustrygame.github.io*

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Thanks for your attention!

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Appendix

How one would compile the program by hand

Assuming we have the HelloWorld.java file from slide 4 at hand.

Compile with the Java compiler ('javac'):

```
javac HelloWorld.java
```

A class file 'HelloWorld.class' is created. We then call the java **interpreter** with the class name as argument:

```
java HelloWorld
```

*Note that we don't provide the file name, but the class name. Java searches automatically all class files in the so-called **class path** (the set of all paths java searches for classes) for this class.*

By default, the class path is the current path (and some known places).

How to download and use a library

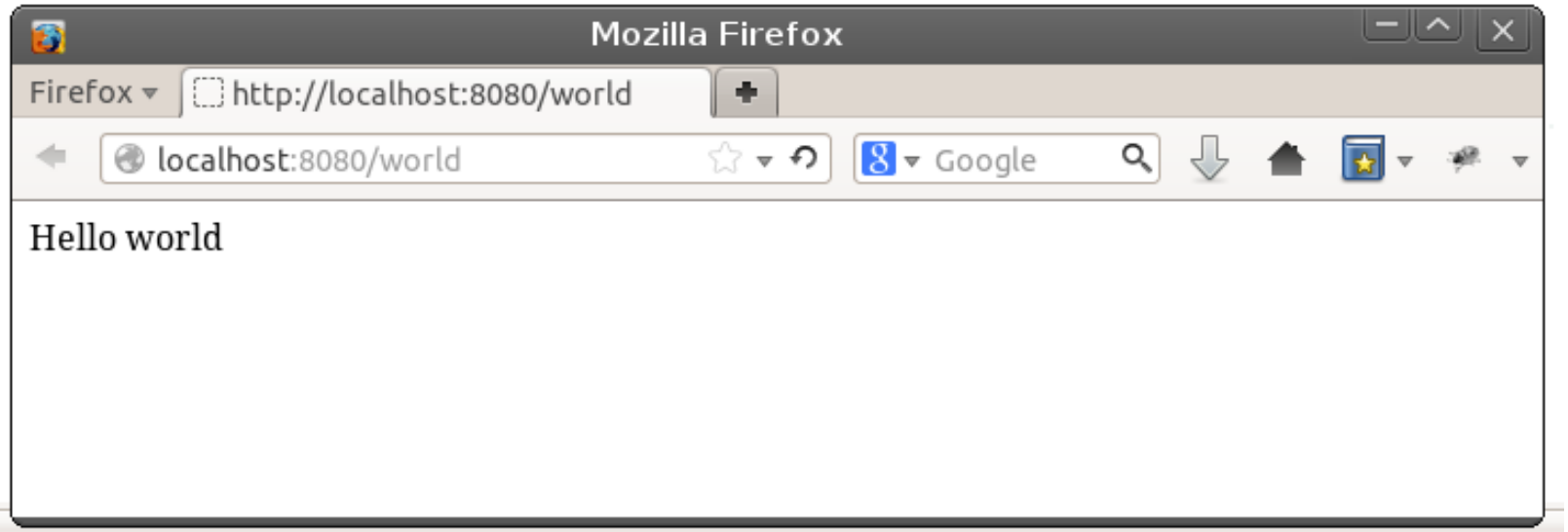
A library provides functionality not yet contained in the Java environment. It usually comes as .jar file.

- Create new directory (e.g. *libraries*) in your Eclipse project
- Download/obtain library (unzip if needed)
- Place .jar file(s) in new directory, refresh view in Eclipse
- Right-click on library file: '***Build path***' -> '***Add to build path...***'
- Library should then appear under 'Referenced libraries' and can be used in your classes.

My first web server

```
13      @Override
14      public String handle(String query) {

15
16          // Currently, this web server just returns 'Hello', when you use a brows
17          return "Hello " + query;
18
19
20
21
22
23
24
25
26
27
28
29
30
```



Problems @ Javadoc Declaration Search Console Debug Git Staging

HelloWorldWebserver [Java Application] /home/nw/apps/java/jdk1.7.0_51/bin/java (16.03.2014 14:56:05)

```
Webserver started on http://localhost:8080
Handling request from 127.0.0.1 for /world
```

Some interesting snippets

- Tipp: All classes provide a (more or less informative) string representation:

```
SomeClass someObject = new SomeClass();
someObject.toString();
```

- **Current date**

```
Date date = new Date();
```

- **Random number**

```
Random random = new Random();
random.nextInt();  // Provides an integer in [0, 2^31)
random.nextInt(n);    // Provides an integer in [0, n)
```

Hands-On

- Expand the package '**example_09**'
- Open the file '**HelloWorld...**'.

Tasks

- Run the program.
- Spice up the web servers output a bit:
  - Return the current time
  - Return a random number
  - ... ?
  - *Can you reach your neighbours webserver by the way? Ask him for his IP address.*
    On the terminal, it can be acquired as follows: `$ ip addr`