Object
(concept)

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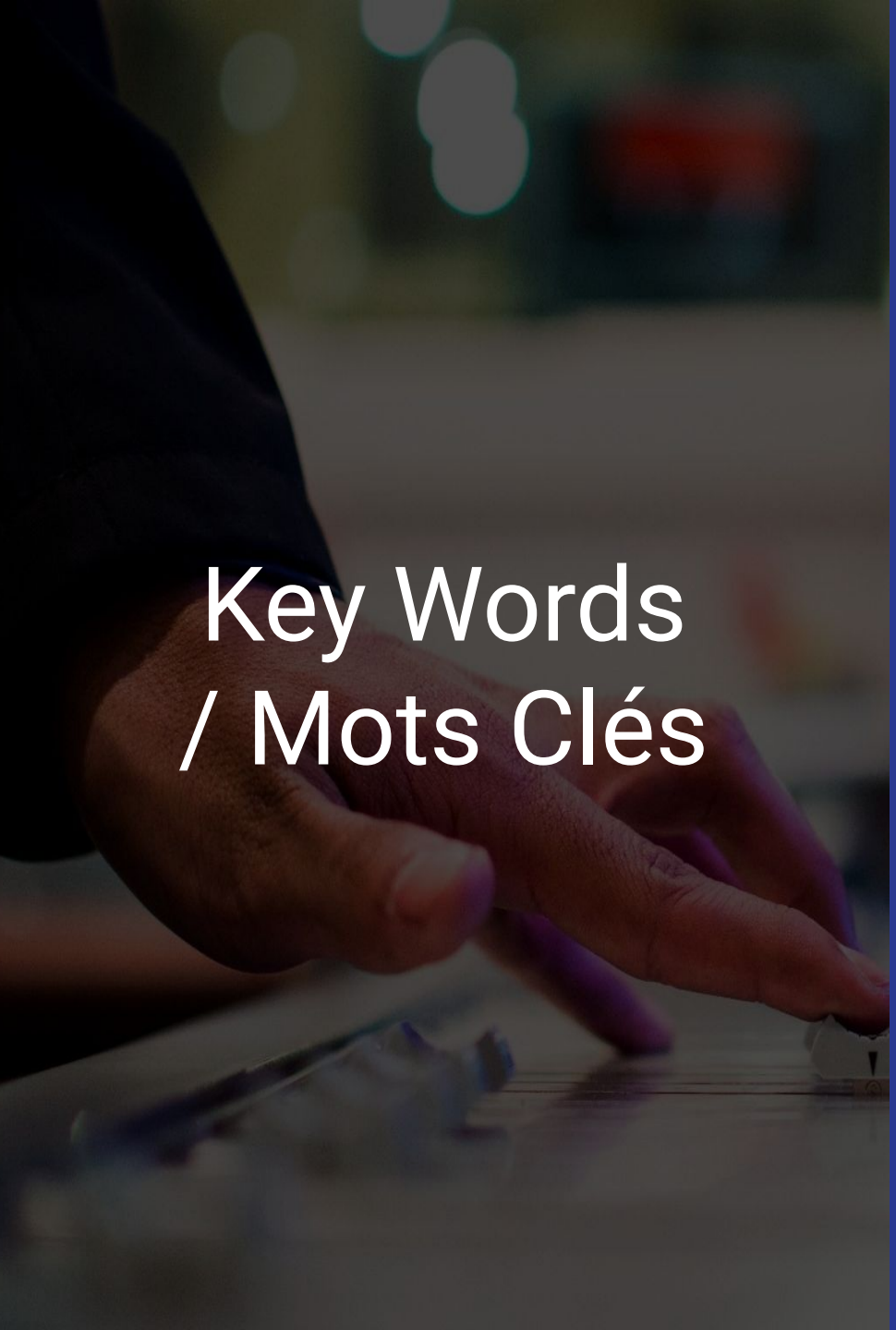
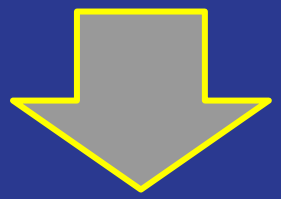
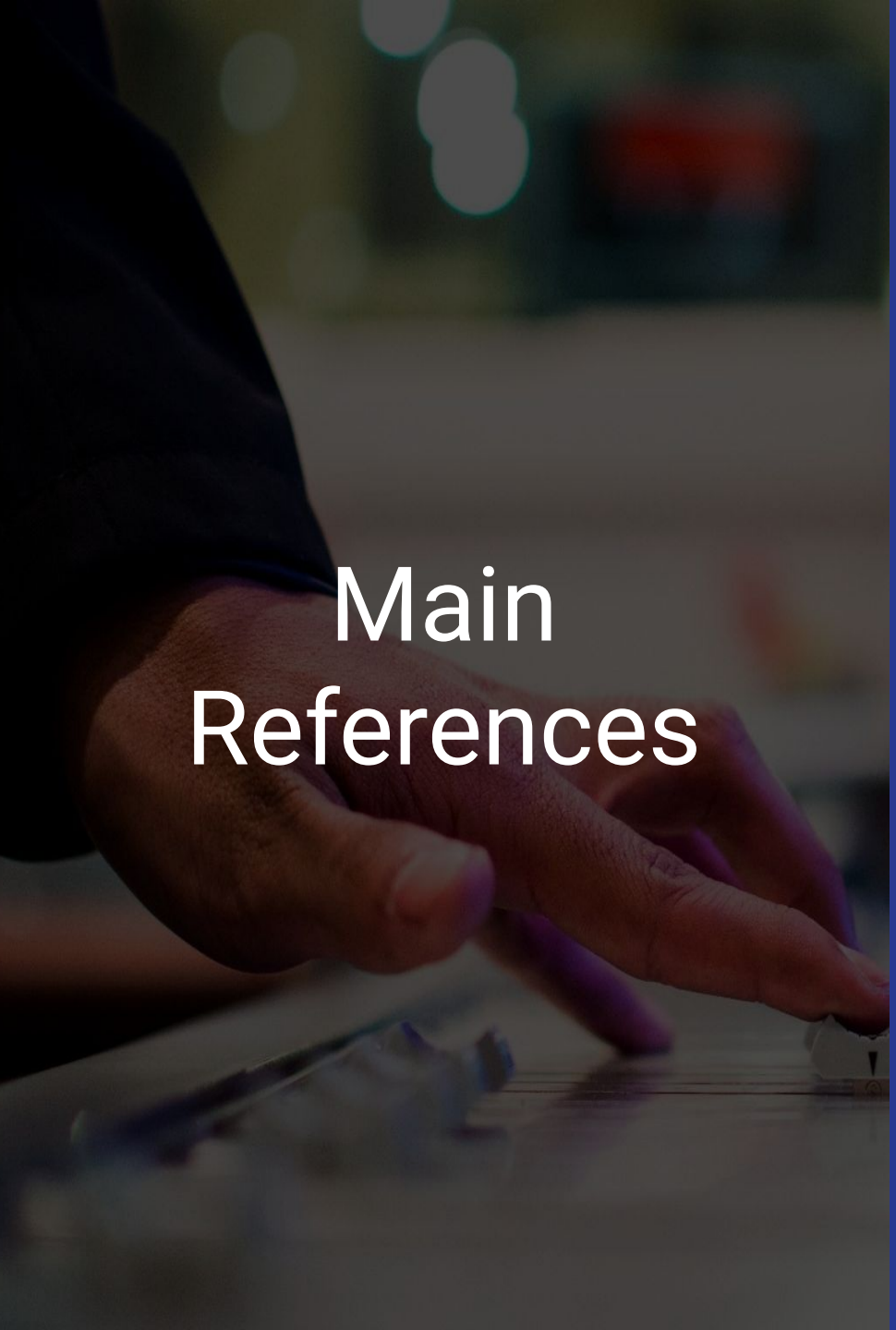


Key Words / Mots Clés

- Object Theory
- Object Oriented Programming
  - / Programmation Orientée Objet
  - JAVA (C++)
- Modeling Language
  - UML,
- Design Pattern
  - / Patron de conception



Simulation Project



Main References

- Courses of
  - Pr. Christine Force,
    - UML
  - Pr. David Hill,
    - Simulation & C++
  - Ferdinand Piette (ex-ISEN),
    - UML
- Books & Websites
  - Design Patterns - Gamma et al.,
  - http://www.volubis.fr/news/liens/courshtm/Java/objet.html,
  - https://openclassrooms.com/,
  - https://creately.com/blog/diagrams/uml-diagram-types-examples/,
  - https://www.ntu.edu.sg/home/ehchua/programming/cpp/cp3_OOP.html,
  - UML & Design Pattern from Eyrolles and DUNOD books.

Concepts Objets

8 sessions / séances

End of October 202i

Last session /Dernière séance

September the 1st 202i

1st session / séance

- Window [13.30 - 17.15] splitted into two parts of 1h45 :
  - **[13.30 - 15.30] ; 15 minutes break ; [15.45 - 17.15]**
- All in one:
  - Eng: Recitation, Lab & Lecture.
    - / TD, TP & CM.

To Write or not to Write ?

- *Slides* available during (e.g. exercises) or after each session
- Lab et recitation exercises corrections are given during the session.

- *Diapos* disponibles :
  - Pendant ou après chaque cours ;
- Les corrections (TD & TP) seront données en cours (hors *slides*).

English or French ?

- *Slides mainly in English*
- *Difficult words given in both languages like this:*
  - *English / French*

Evaluation

"paper test"

Exam

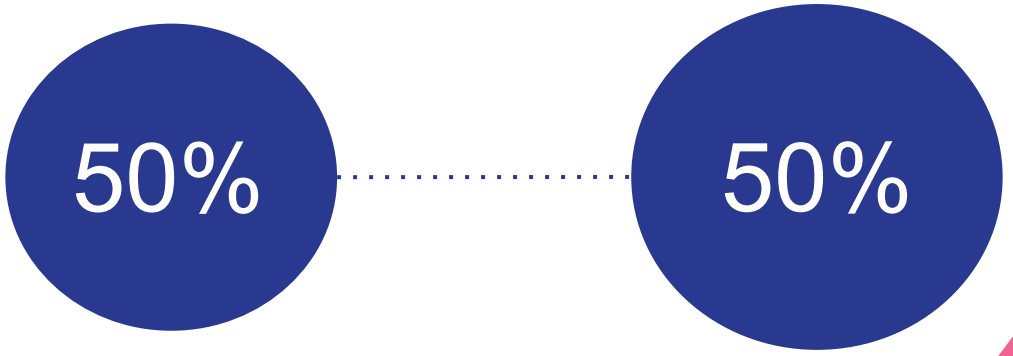
Simulation mini-Project
/ mini-Projet "Simulation"

JAVA Code (or **C++**) & short report.

Some time windows dedicated to it.

Group of 4, 5, 6 students.

We might start at the 5th session.



OUTLINE

1. Introduction
2. Fundamental Concepts
3. UML
4. Design Patterns

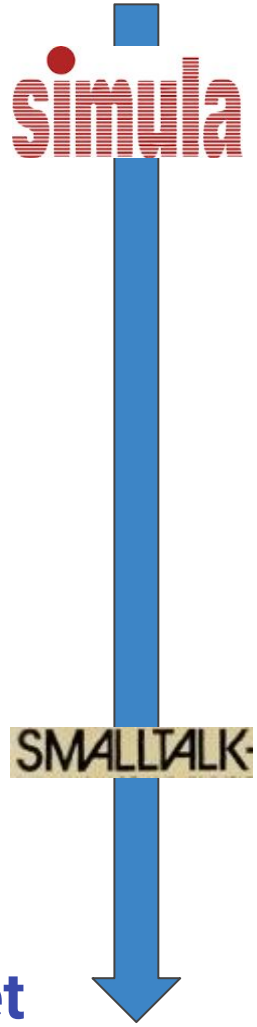
and some “breaks” about simulation.

1. Introduction

Once upon a time...the

Object Concept

SECRETS d'HISTOIRE



- 1967 : **SIMULA** language
  - First language using the "**Class**" concept,
  - **Discrete event simulation**,
    - / **simulation à événements discrets**,
  - Norwegian Computing Centre of Oslo,
  - 1st authors : Ole-Johan **Dahl** & Kristen **Nygaard** ;

- 1972 : **Smalltalk** language
  - First **object-oriented programming** language
    - / 1er langage de **programmation orientée objet**

Once upon a time...the

Object Concept

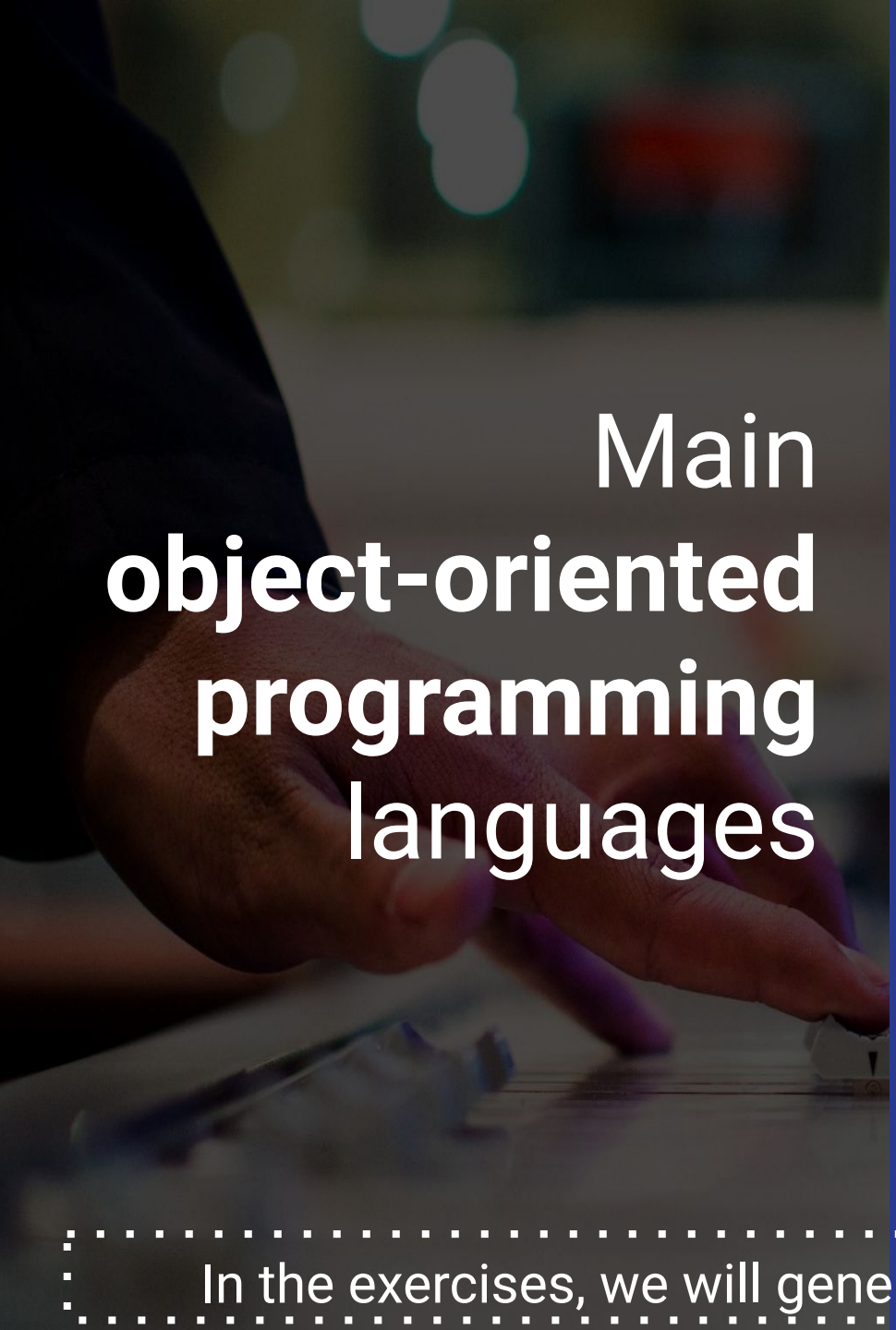
SECRETS d'HISTOIRE

- 1967 : **SIMULA**

```
Procedure report (message); Text message; Begin
   OutFix (Time, 2, 0); OutText (": " & message); OutImage;
End;
```

- 1972 : **Smalltalk**

```
exampleWithNumber: x
    | y |
    true & false not & (nil isNil) ifFalse: [self halt]
    y := self size + super size.
    #($a #a "a" 1 1.0)
        do: [ :each |
            Transcript show: (each class name);
                       show: ' '].
    ^x < y
```



Main **object-oriented programming** languages

The 2 languages you can use in this course

- C#
- **C++**
- PHP
- **JAVA**
- Delphi
- “Python”
  - (Some concepts only)
- Objective-C
- Precursors :
  - SIMULA-67,
  - SMALLTALK-80

In the exercises, we will generally correct the JAVA code.

First Concepts

One Object

- Data*(attributes)* / Données*(attributs)*
- Methods / Méthodes

- An object is an entity composed of **data** and code (**methods**) acting generally on this data.

- The data characterize the **state** of an object and the methods make it possible to pass **from one state to another**.

First Concepts

A Class / Une Classe

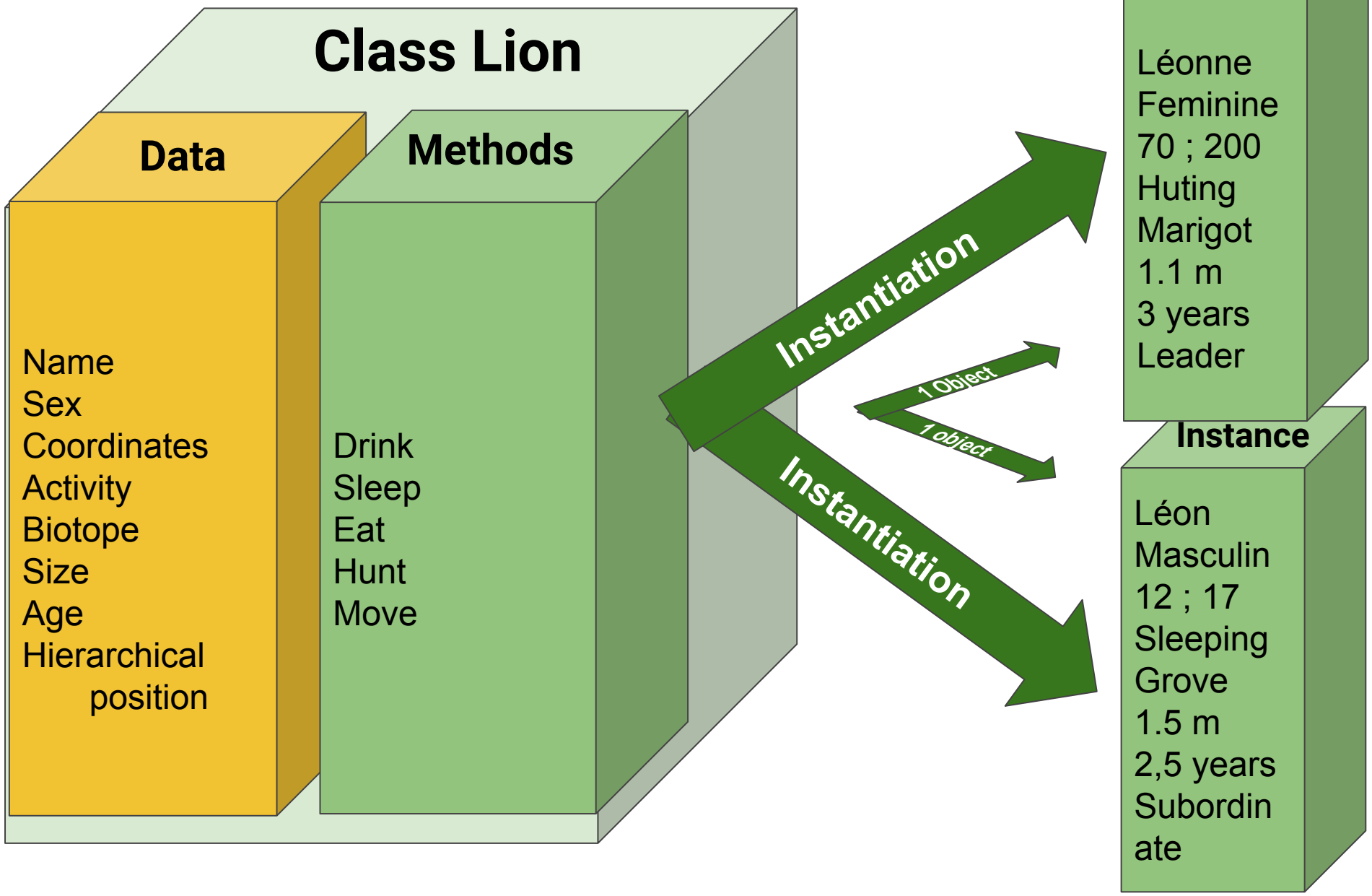
- **Model for creating an object**
  - / **Modèle** de **création d'objet**.
- **A class describes the structure of an object: data and actions on these data (methods)**
  - / Une classe décrit la structure d'un objet : les **données** et les actions possibles sur ces données (**méthodes**).

First Concepts

An Instance

- **Object** obtained from the **instantiation** process based on a class
  - **/ Objet** obtenu par **instanciation** à partir d'une **classe**.

Example


Class Lion
Data
Name
Sex
Coordinates
Activity
Biotope
Size
Age
Hierarchical position
Methods
Drink
Sleep
Eat
Hunt
Move
Instantiation
1 Object
1 object
Instantiation
Instance
Léonne
Feminine
70 ; 200
Huting
Marigot
1.1 m
3 years
Leader
Instance
Léon
Masculin
12 ; 17
Sleeping
Grove
1.5 m
2,5 years
Subordinate

First Concepts
Example and Questions

?

?

Among the 3 first concepts, “Who does what” in the kitchen?

First Concepts
Example and Questions

Muffin pan **Class**
/ **Classe** Moule à muffins

These 12 *muffin* objects are all instances of the Muffin Pan class.
/ Ces 12 **objets** *muffin* sont autant d'**instances** de la **classe** Moule à muffins.

Write by hand what this would give in Java (or C ++).
/ Ecrivez à la main ce que cela donnerait en Java (ou C++).

First Concepts
Example - Java

```
class MouleAMuffins{

   String nomGateau ;
    ...

}
```

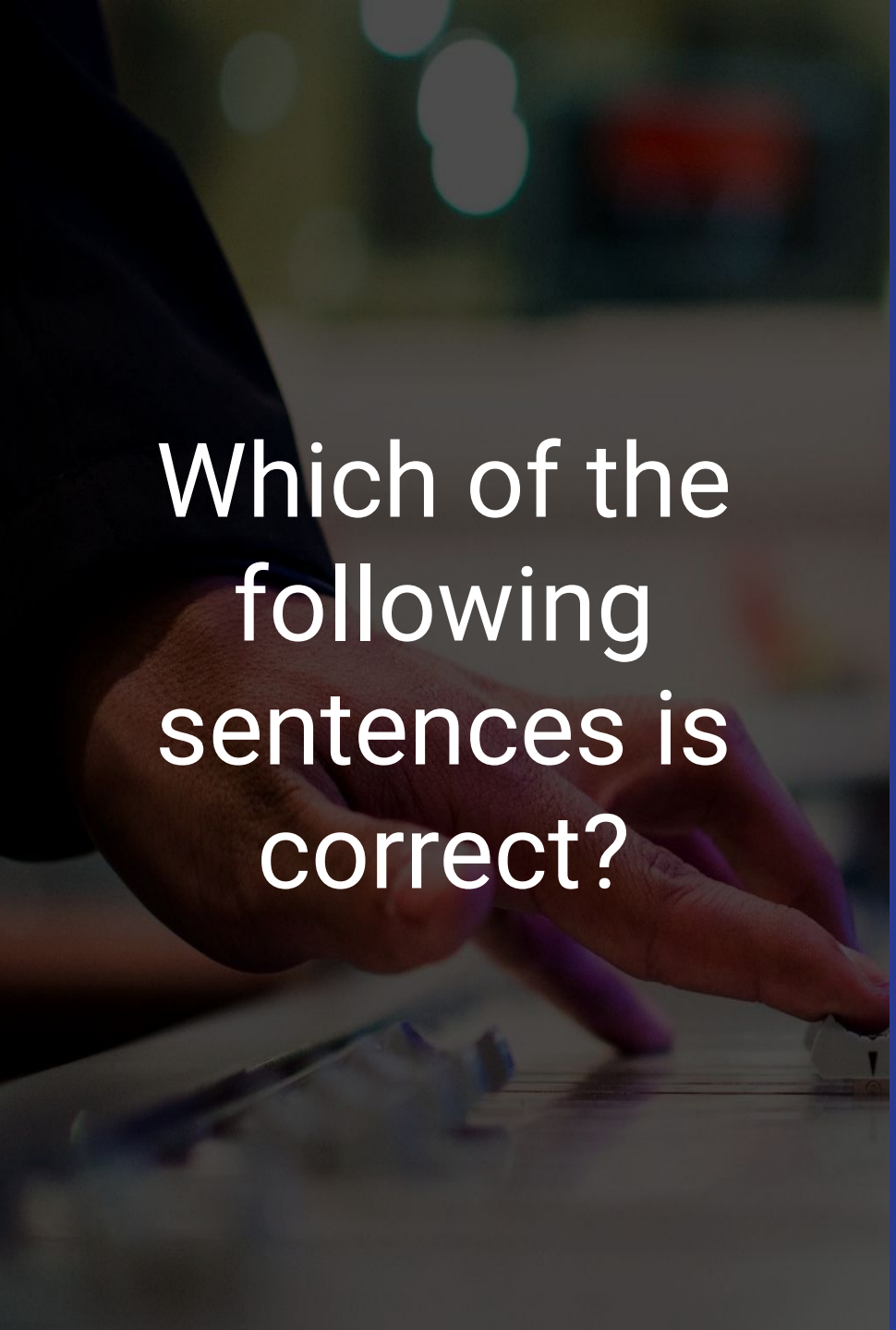
Class

```
MouleAMuffins muffinsChoco
      = new MouleAMuffins() ;
```

Instantiation / Instanciation

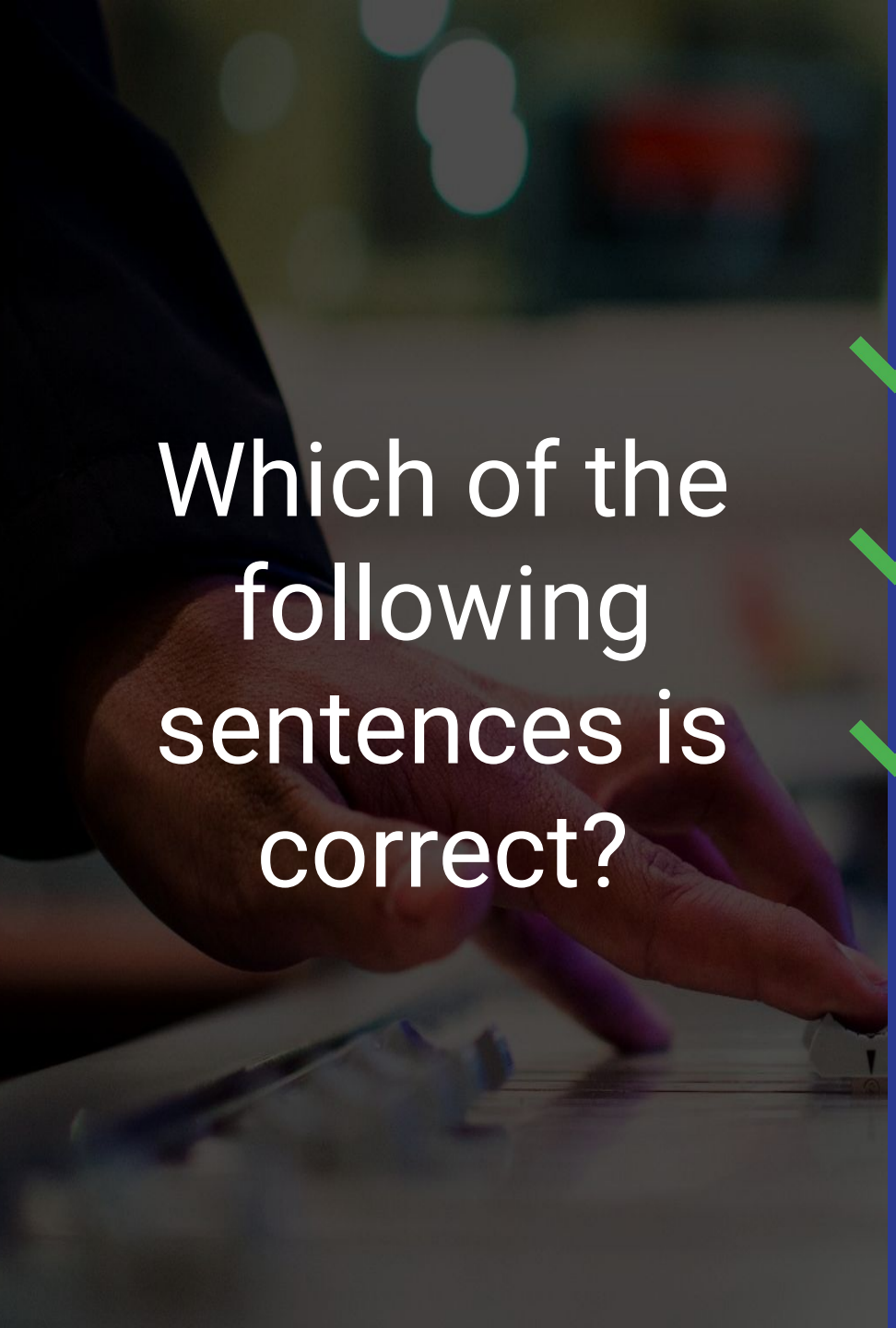
We get a muffinsChoco **object** which is an **instance** of the MouleAMuffins **class.**

/ On obtient un **objet** *muffinsChoco* qui est une **instance** de la **classe** *MouleAMuffins*.



Which of the following sentences is correct?

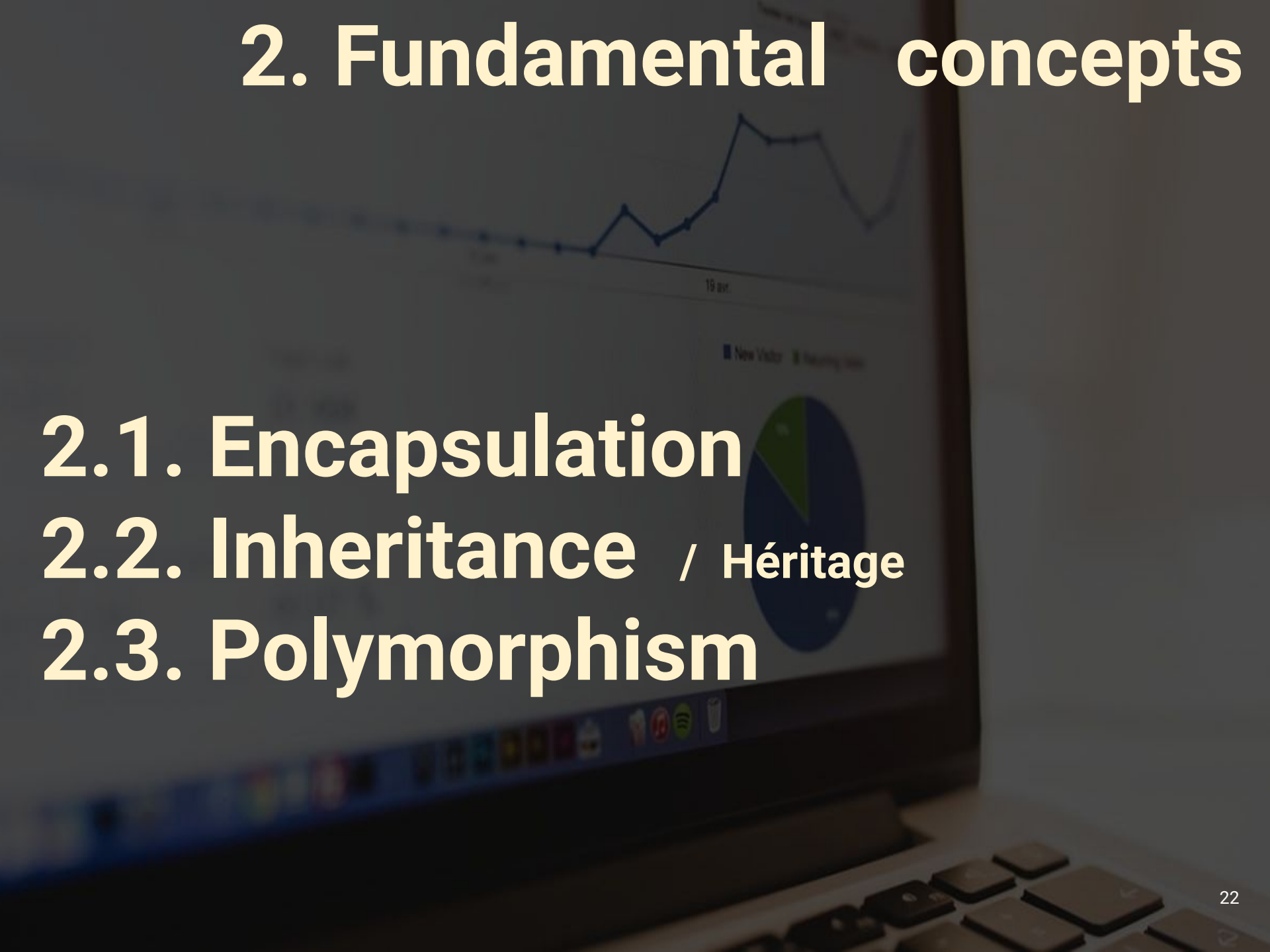
- **a** > An object is always an instance.
- b > An instance is always an object.
- **c** > An object and an instance are the same thing.



Which of the following sentences is correct?

- **a** > An object is always an instance.
- b > An instance is always an object.
- **c** > An object and an instance are the same thing.

2. Fundamental concepts

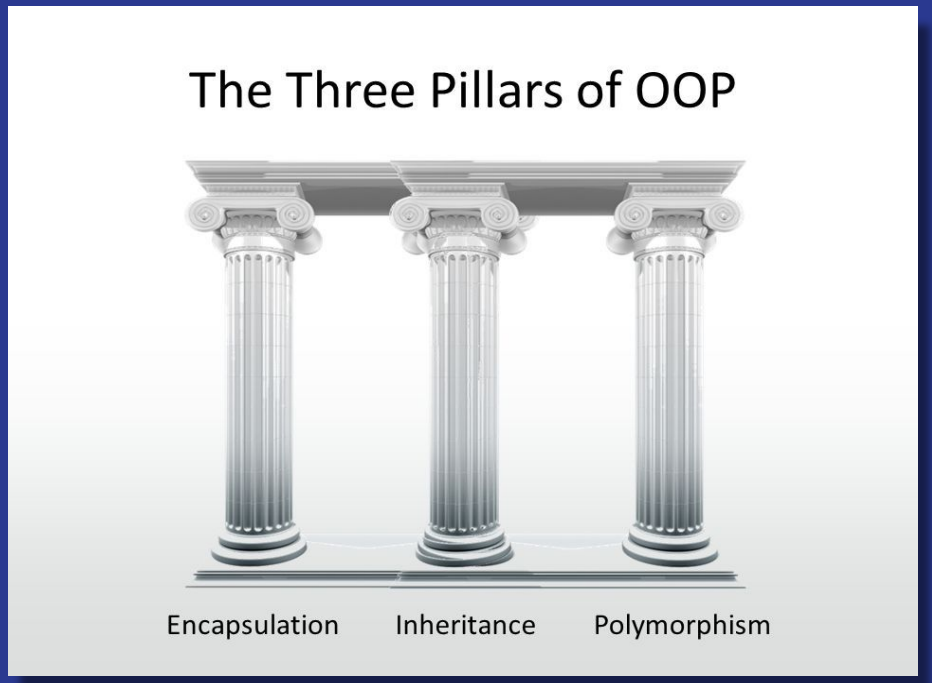


2.1. Encapsulation
2.2. Inheritance / Héritage
2.3. Polymorphism

Encapsulation...

meaning?

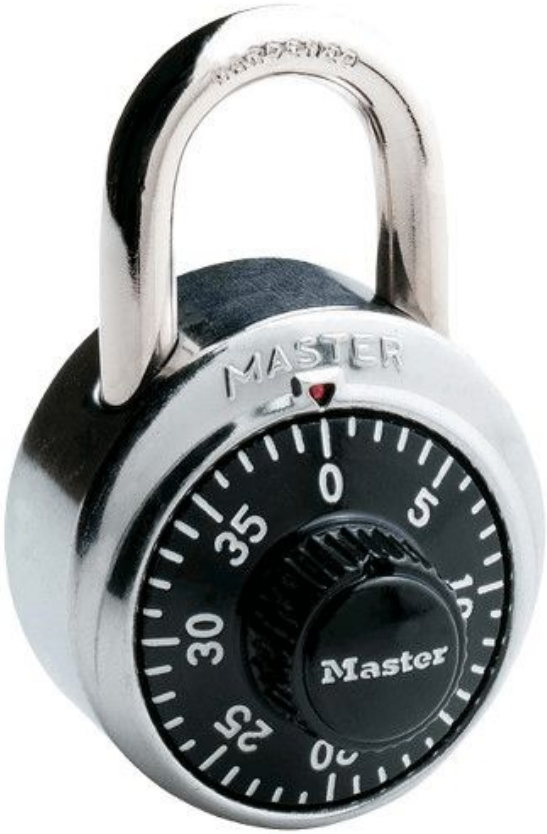
...and how it works in Java/C++?



(***OOP*** **: -eng-** ***Object-oriented programming***.)

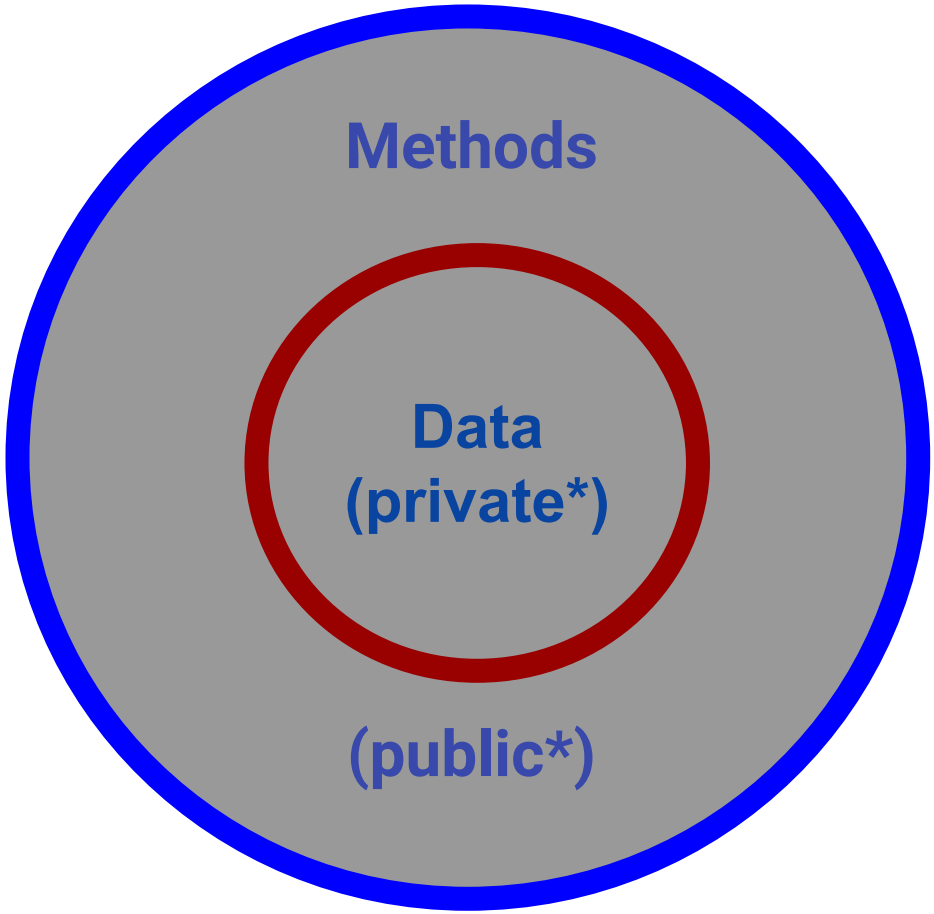
2.1.
1st Fundamental Concept

Encapsulation



(of the data)

1st Fundamental Concept
Encapsulation

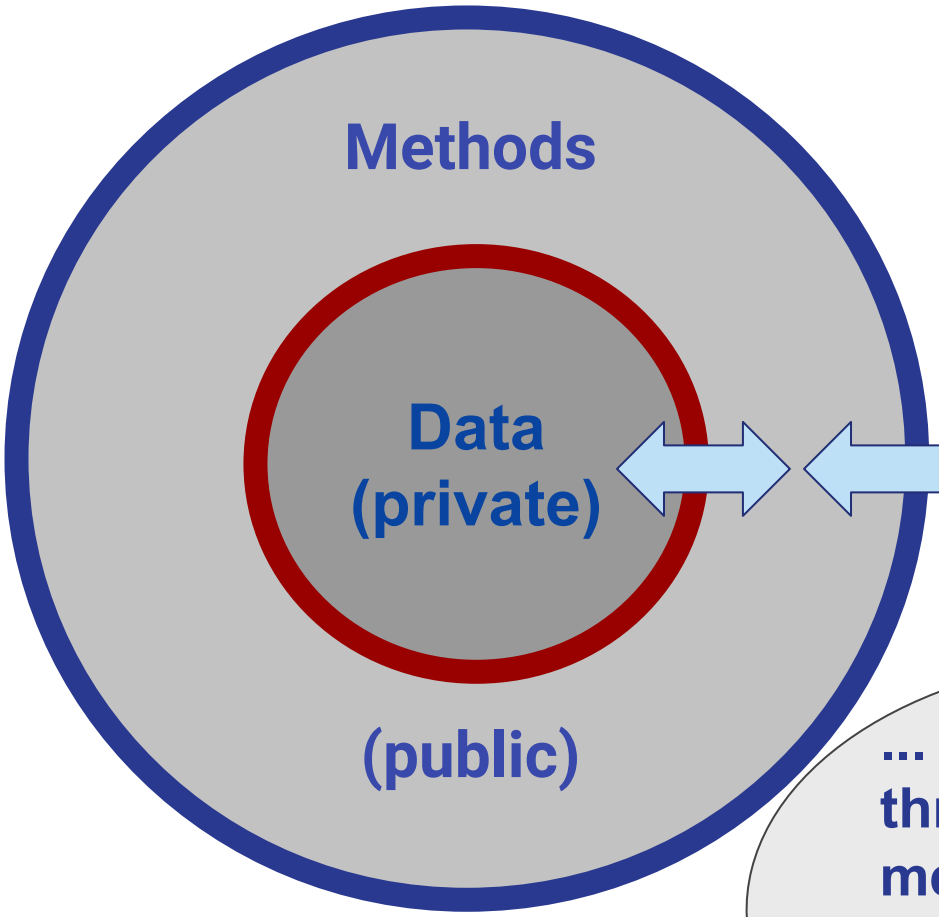


* from *the point of view* outside the object
/ du point de vue extérieur à l'objet

Remark: Some data and methods can be **static**: an attribute or a method can be linked to a class and not to an instance (e.g. an integer "numberDInstances").

Concept fondamental

Encapsulation



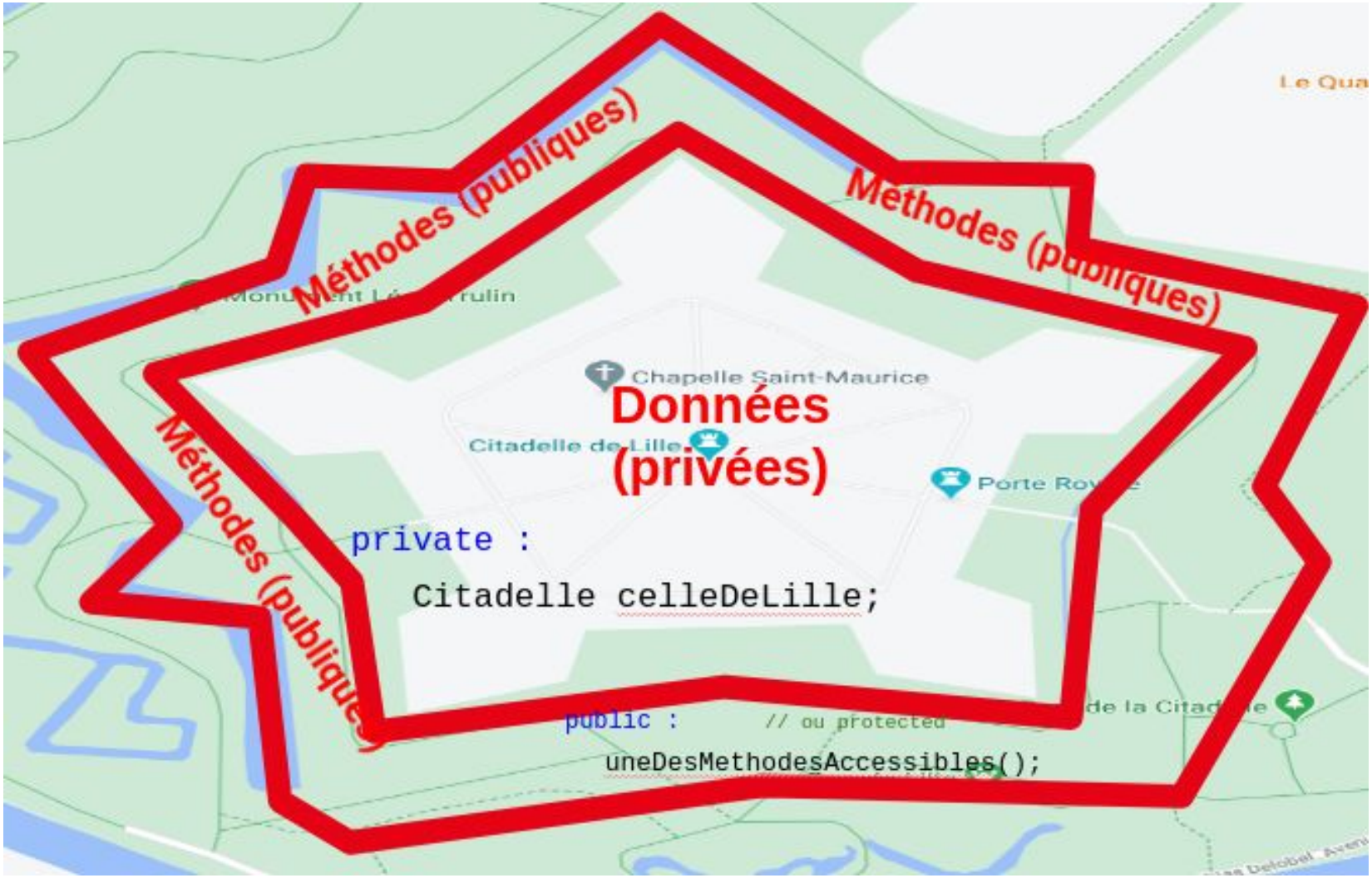
I want to modify private data ...

/ Je veux modifier une donnée privée...

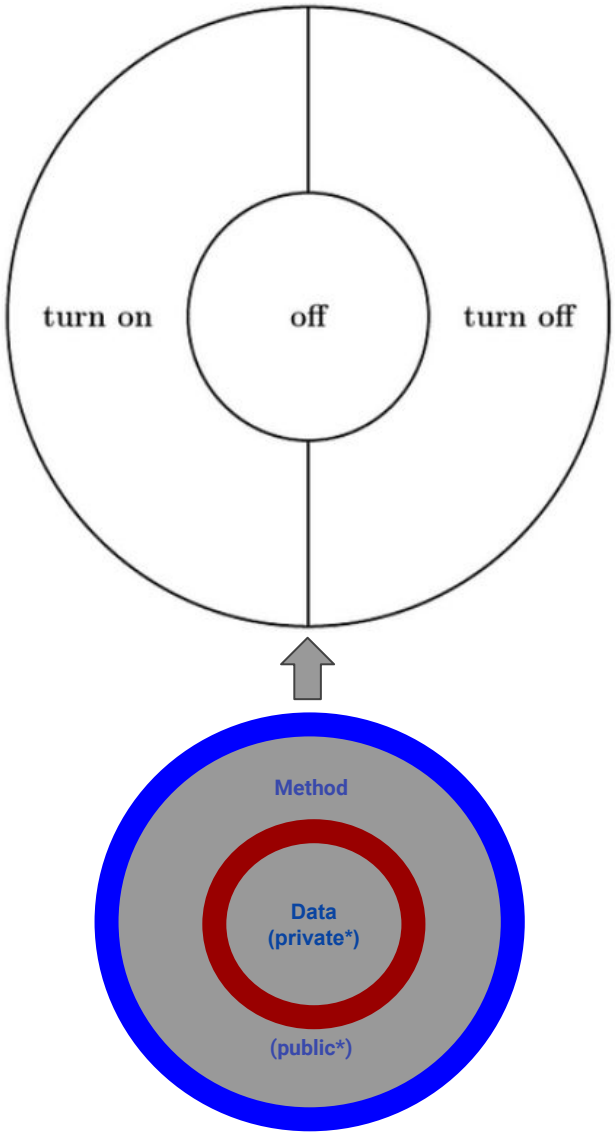
... then I go through a public method which has access to the private data of its own class.

/ ...alors je passe par une méthode publique qui a accès aux données privées de sa propre classe.

Main Goal: the security
(c++ example)

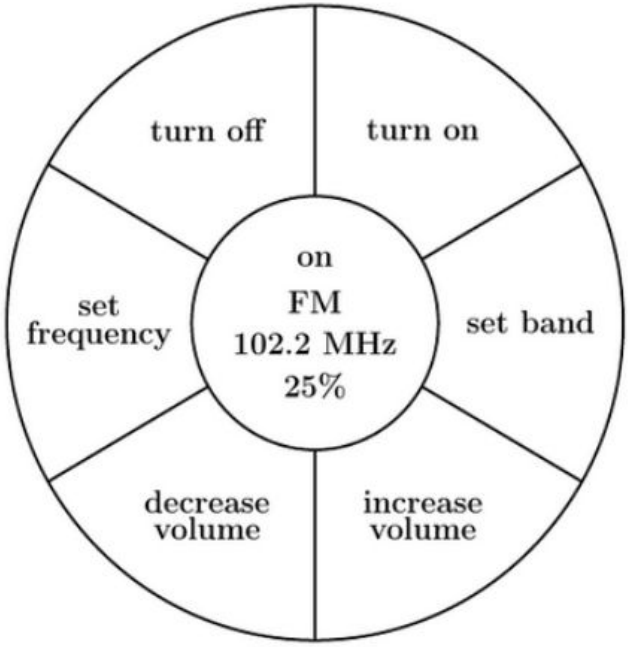


Encapsulation & Data Access
LAMP Example

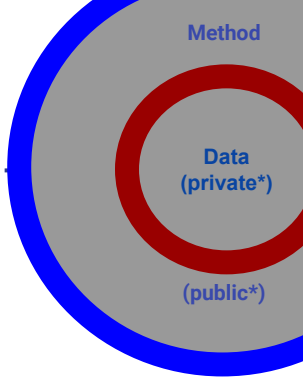


Source: http://www.ferdinandpiette.com/isen/concept_objet

Encapsulation & Data Access
Example: Radio Instance

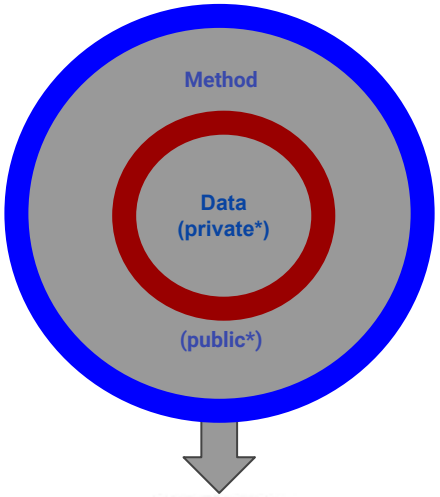


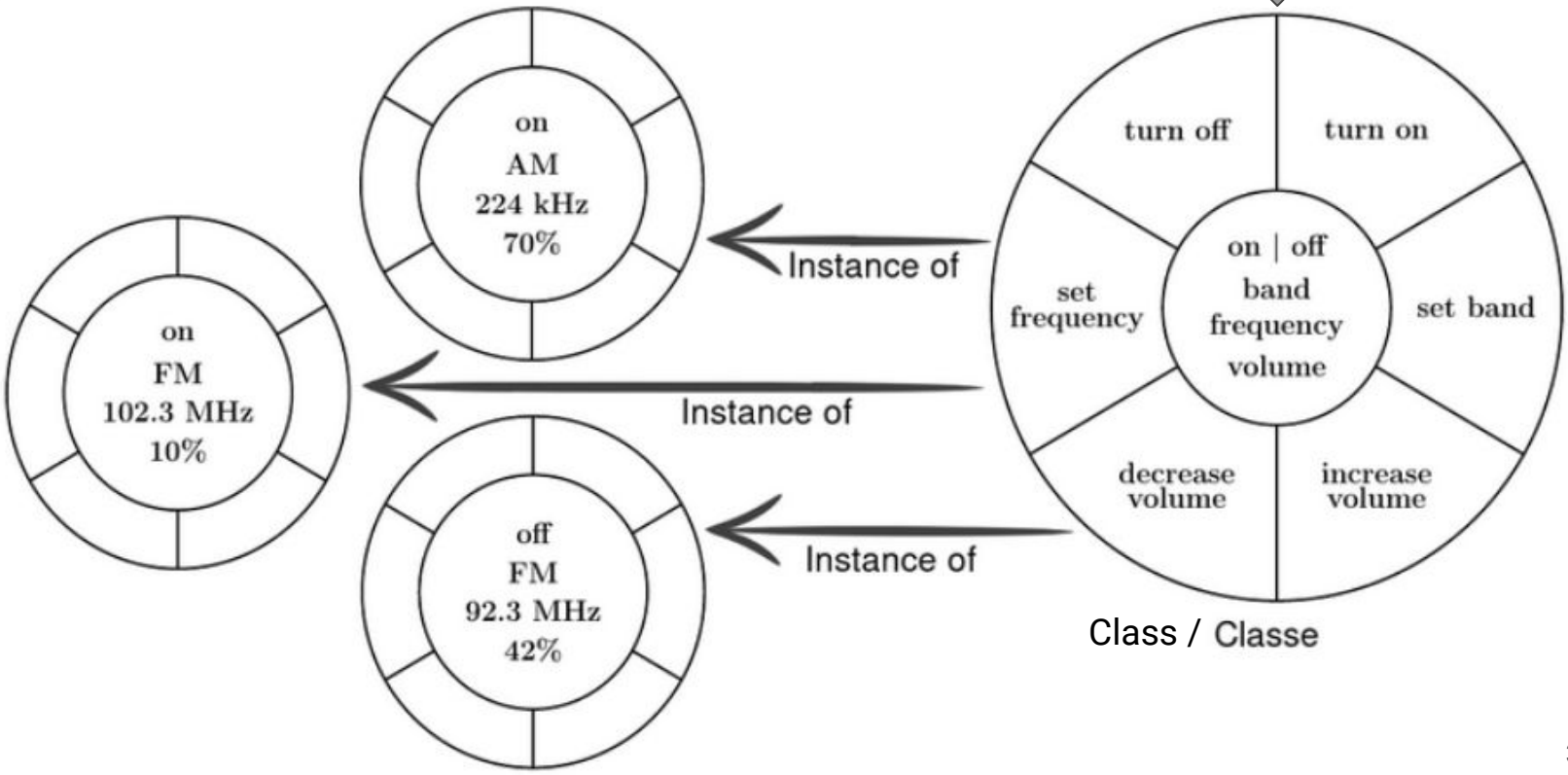
1 instance of Radio class



Source exemple : http://www.ferdinandpiette.com/isen/concept_objet

Example : Radio class & 3 instances / objects





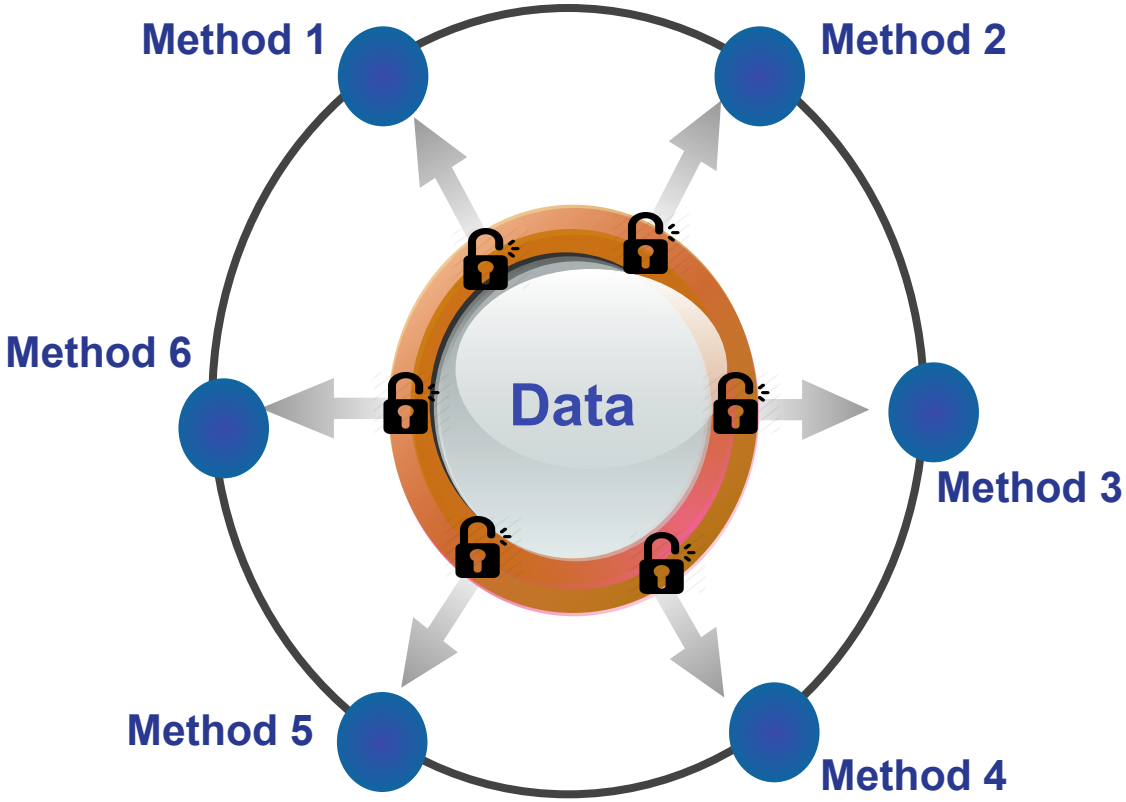
Source: http://www.ferdinandpiette.com/isen/concept_objet

Data Access...into the code

KeyWords: ***Getters*** *&* ***Setters*** *(/same in french)*

"**Getters**" = public methods of access to private data.

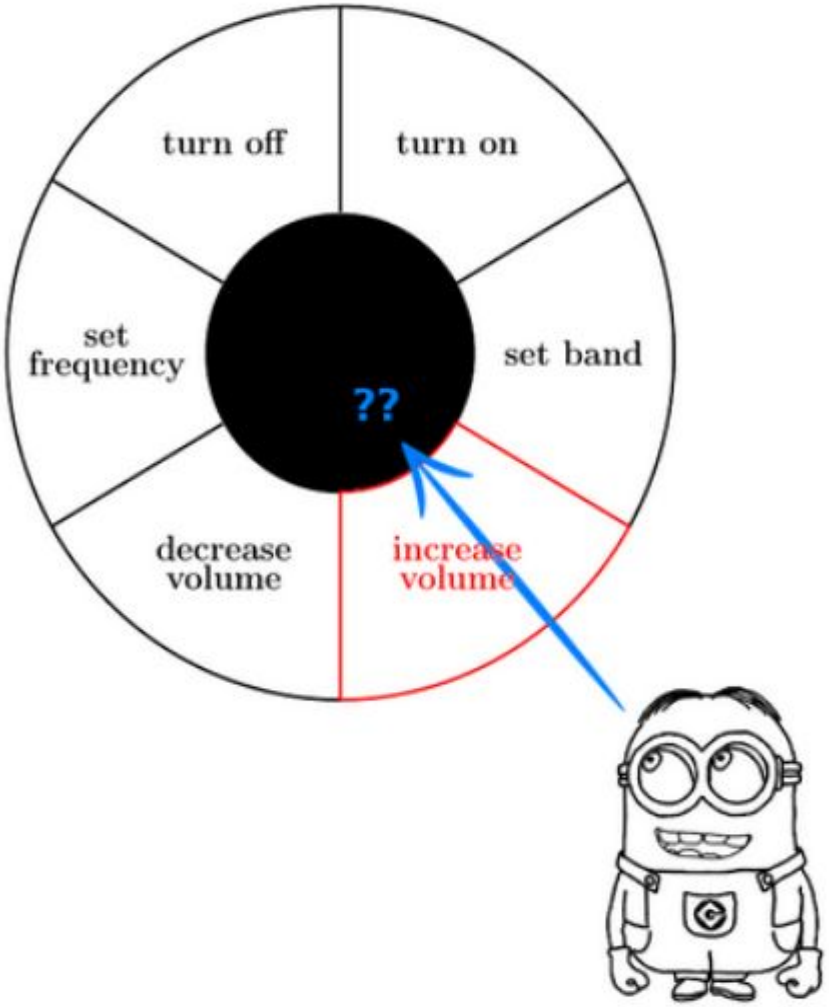
"**Setters**" = public methods of modifying data Private.



Encapsulation & Data Access
Data **visibility** / **Visibilité** des données

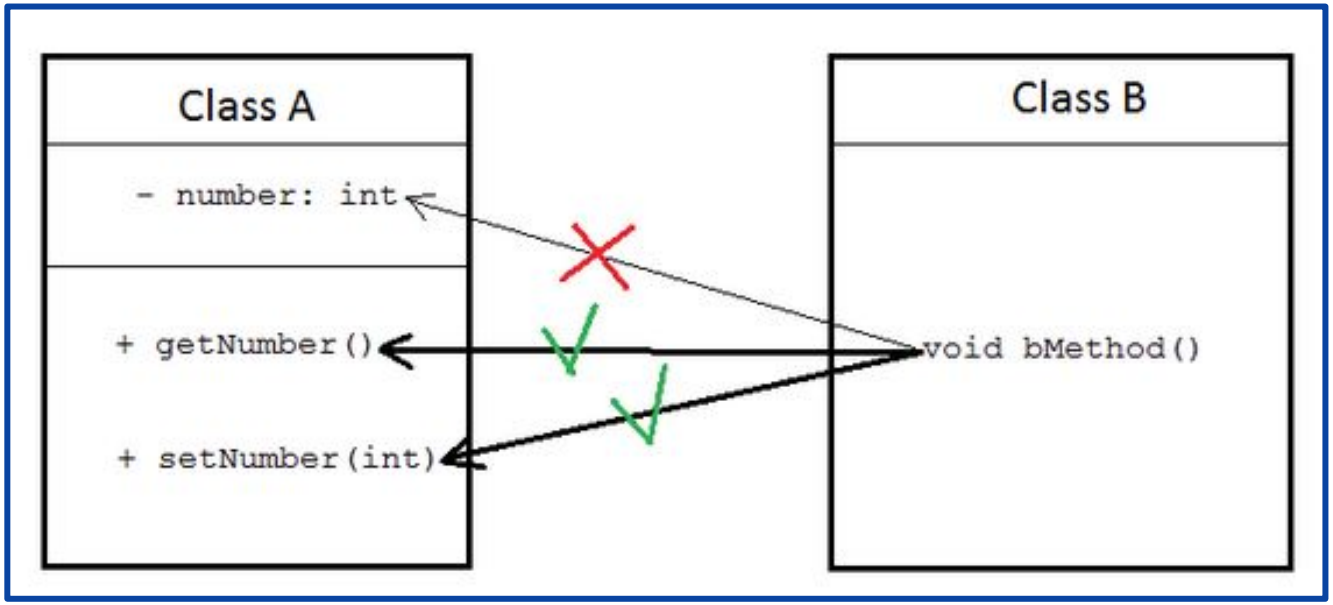
Take a point of view outside the object :

- **Data** are invisible because **Private**;
- **Methods** are the only way to interact with data because **Public**:
  - Access ("***getters***"),
  - Modification ("***setters***"),
  - Other actions on data.



Pic Source: http://www.ferdinandpiette.com/isen/concept_objet

Getters & Setters
- Example in JAVA -




```java
public int getNumber() {
    return this.number;
}
```

```java
public void setNumber(int num) {
    if (num < 10 || num > 100) {
        throw new IllegalArgumentException();
    }
    this.number = num;
}
```

Source : https://www.codejava.net/coding/java-getter-and-setter-tutorial-from-basics-to-best-practices

JAVA & *Muffins*

```
/* classe déclarée dans le fichier
   MouleAMuffins.java                    */
public class MouleAMuffins{

  Private String nomGateau ;
    ...

  Public String getNomGateau();
    ..

}
```

```
// e.g., code dans le Main
MouleAMuffins muffinsChoco
    = new MouleAMuffins() ;

String nomDuGateauInstancie
    = muffinsChoco.getNomGateau();
```

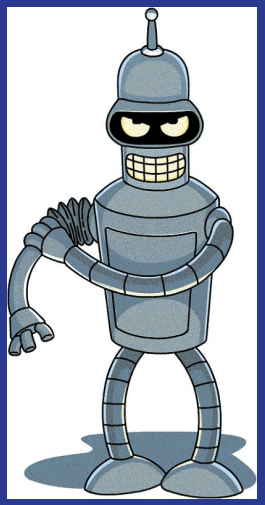
Public ==> Call of the Getter possible outside the methods of the MouleAMuffins class.

Practical work (labs)

/ Travaux Pratiques

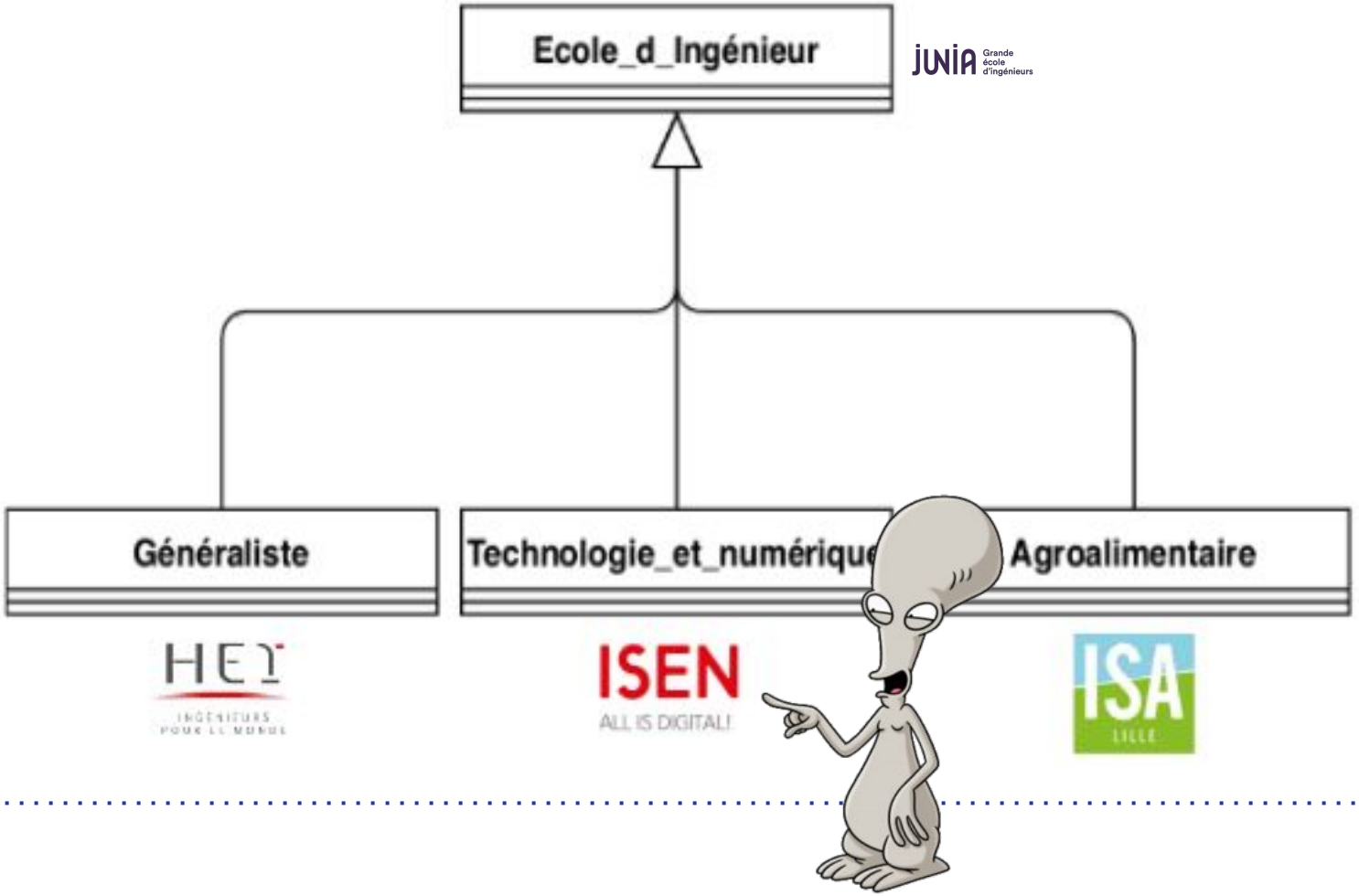
Practical Work 1

Back to the lecture / Retour au cours

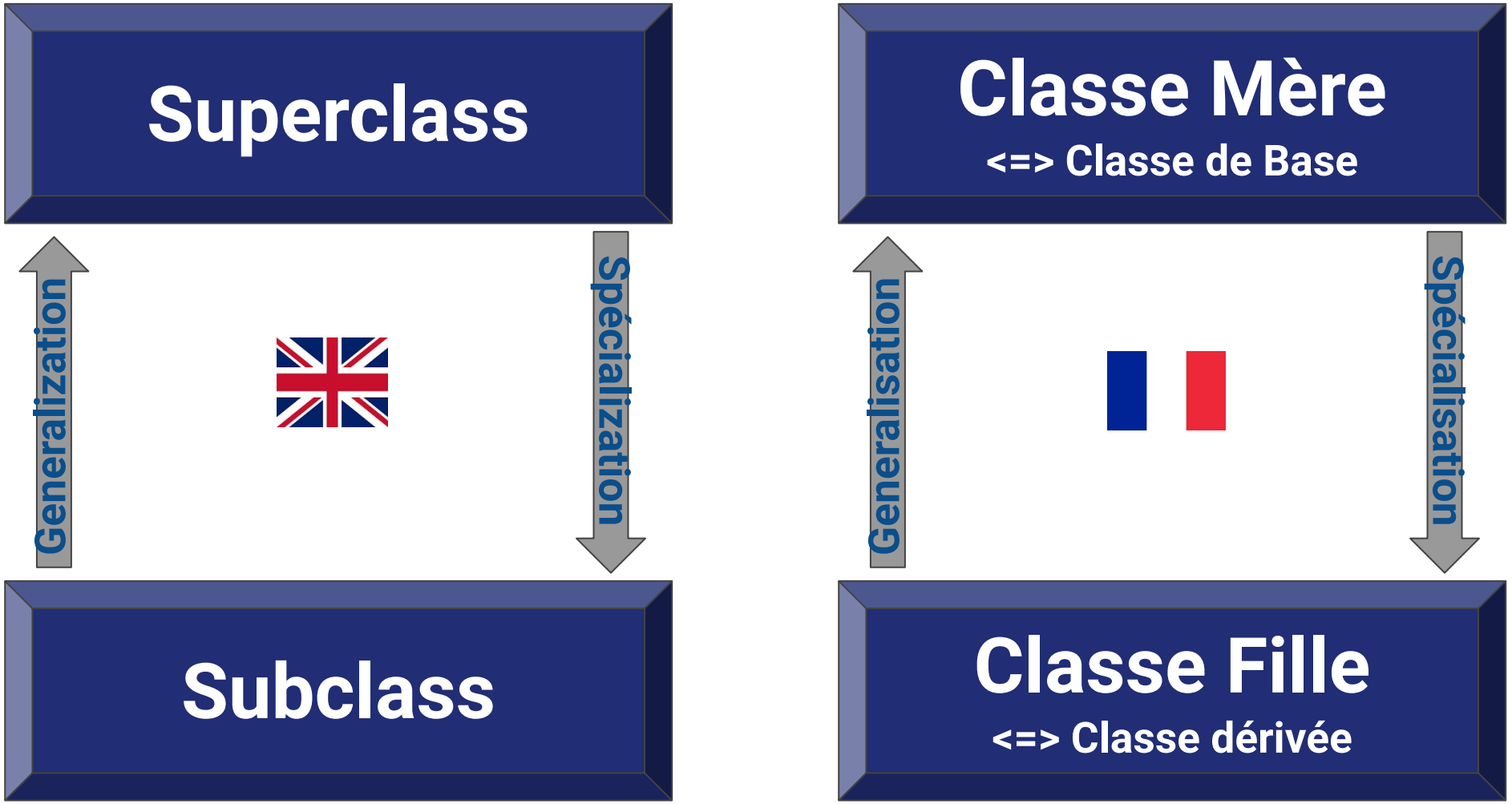


2.2.
2nd fundamental concept

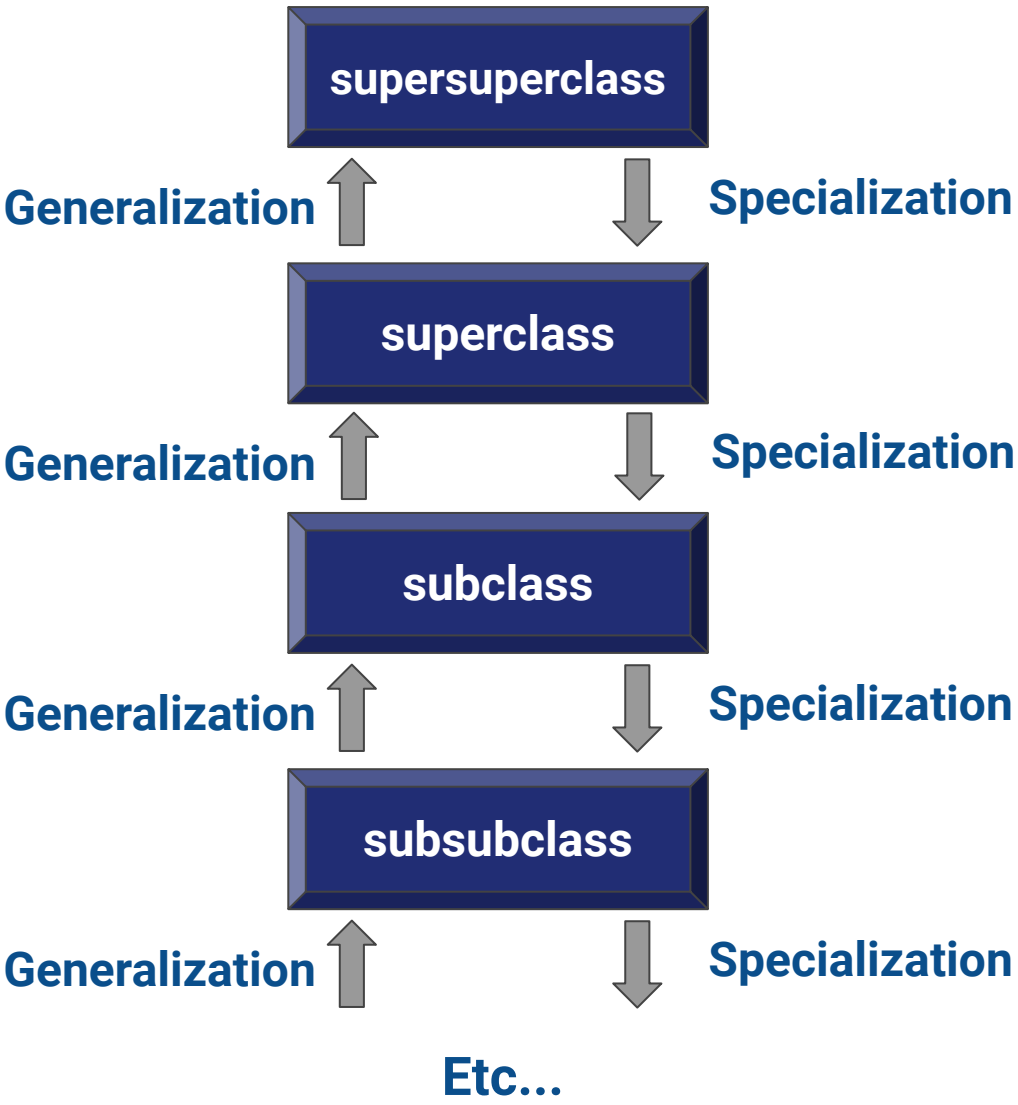
Inheritance / Héritage



Inheritance / Héritage



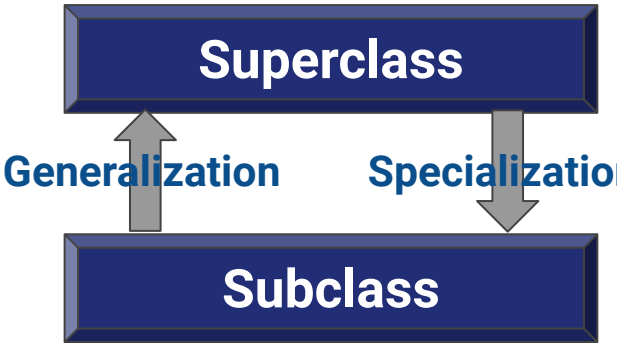
generation after generation

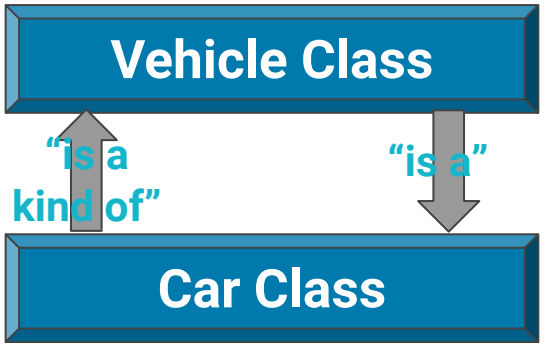


Inheritance / Héritage

Main points (1/2)

- An inheritance link says: "**is a**" or "**is a kind of**",
  - / Une relation d'héritage se dit : "est une" ou "est une sorte de" ;
- Inheritance allows you to build class hierarchies,
  - / L'héritage permet de construire des hiérarchies de classes,
- Inheritance can be single or multiple.
  - L'héritage peut être simple ou multiple.

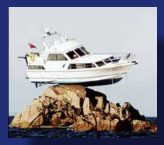




Multiple Inheritance / Héritage Multiple

Car

Boat

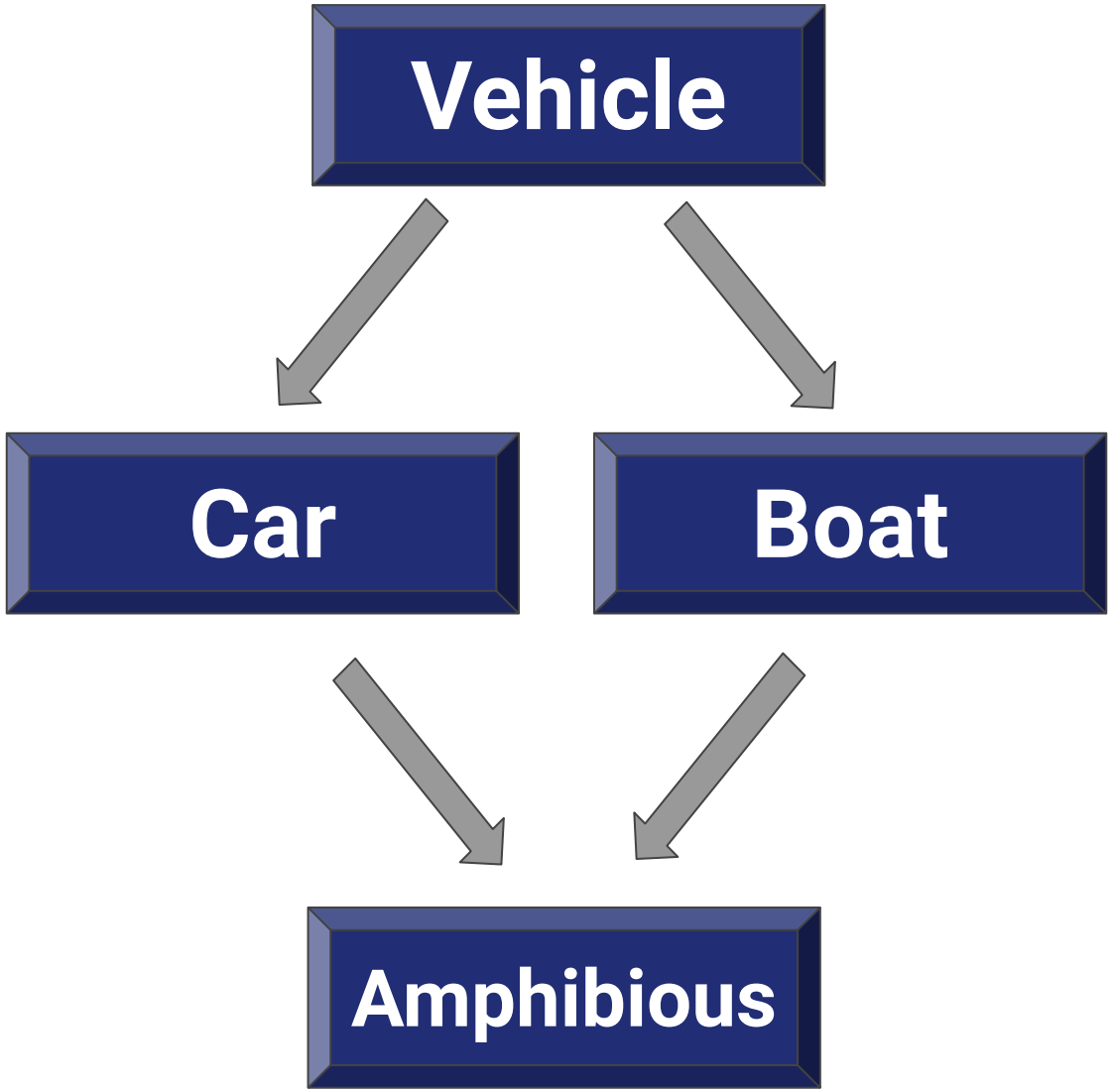


Double Specialization

Amphibious

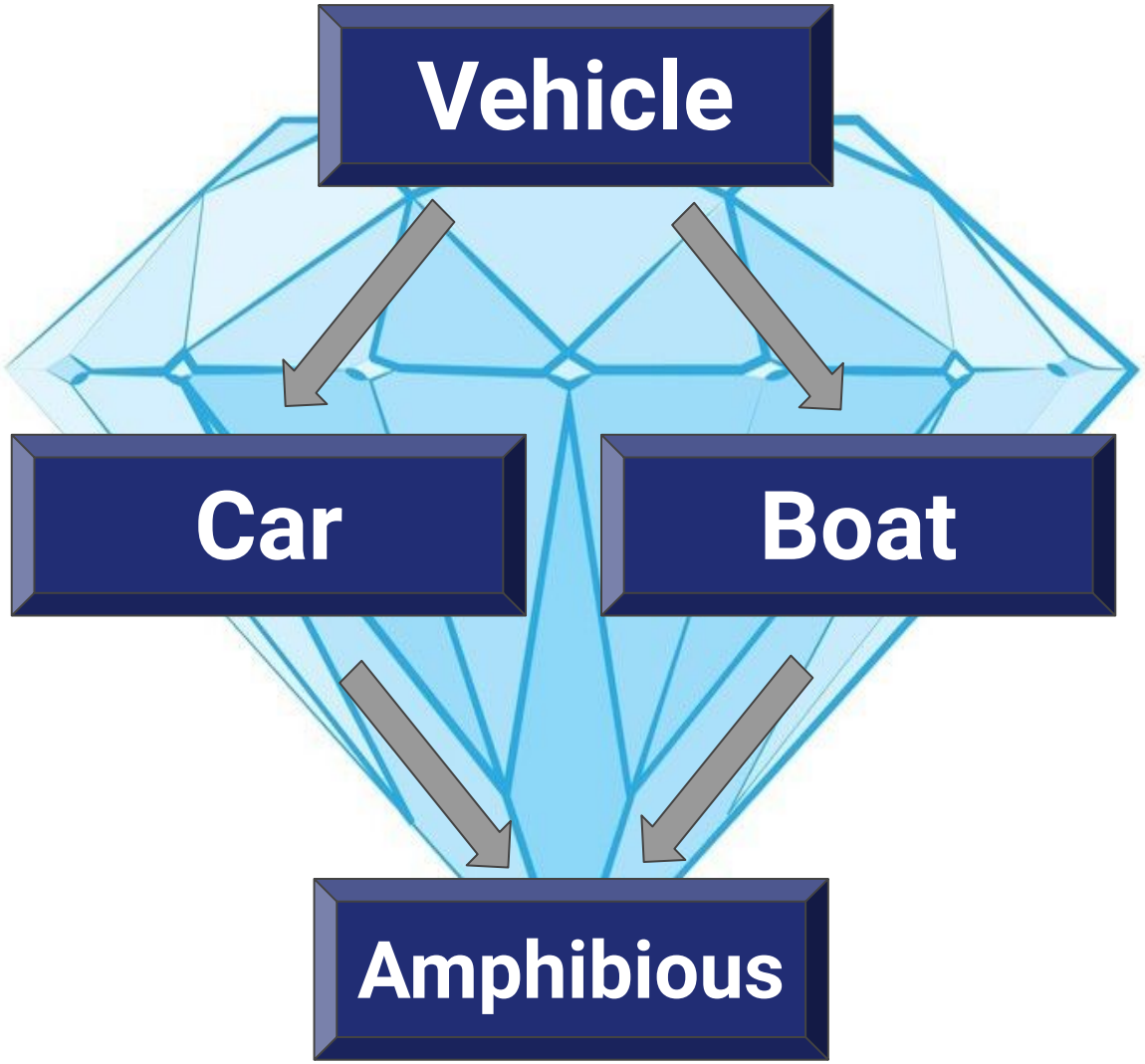
Note: we're not using UML class diagram here where inheritance relations are using an arrow targeting the super class.

Multiple Inheritance and its problems...



Question: What problem are we going to have with Amphibious?

Multiple Inheritance and its problems...

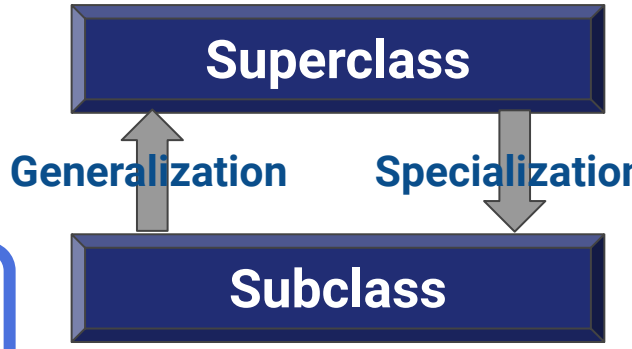


Pb: Amphibian receives **two copies of Vehicle** (data and methods).
We call it: the **diamond inheritance** / **héritage en diamant**.

Inheritance

Main points (2/2)

- **There is no partial inheritance:**
  - The state and behavior (i.e., all data and methods) of the superclass are inherited in the subclass.



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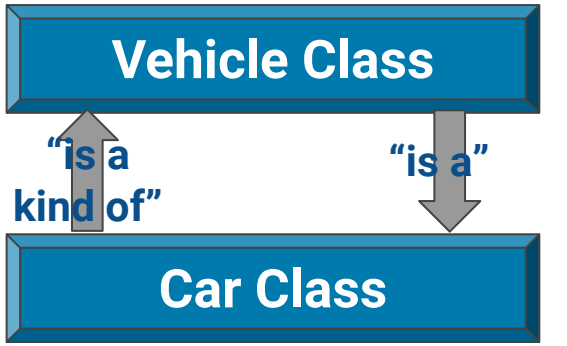
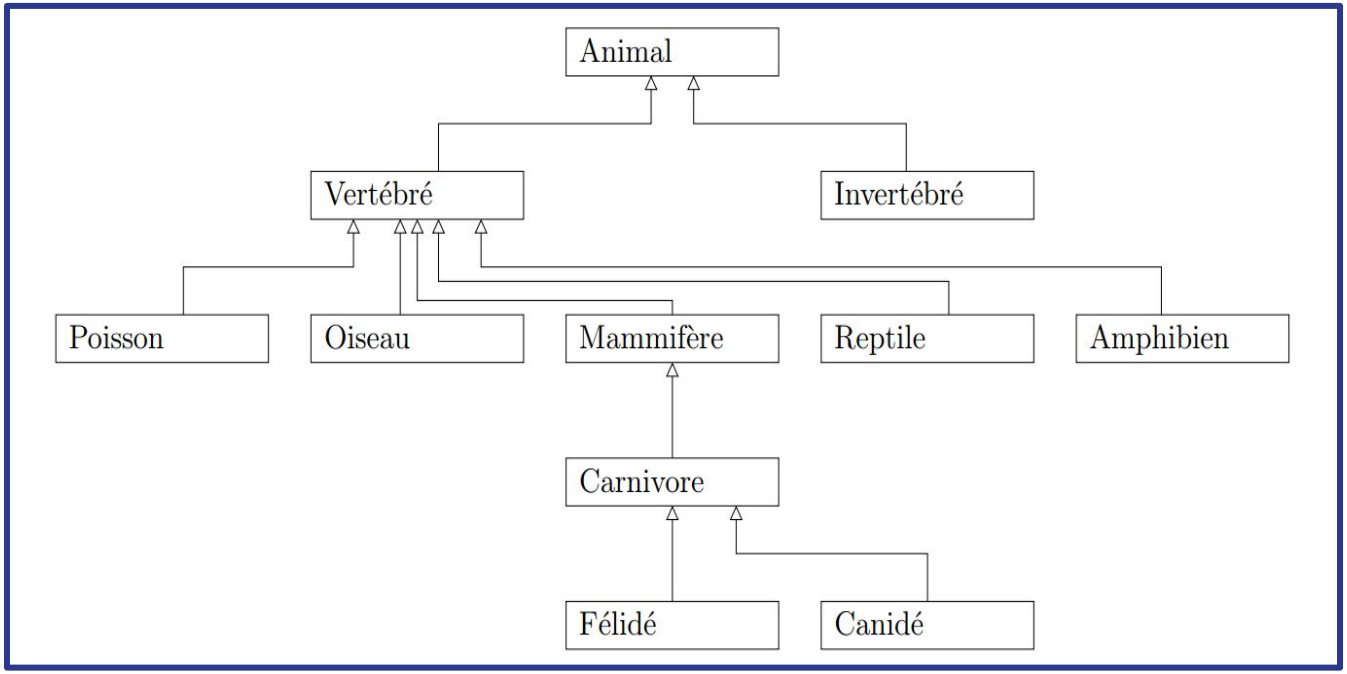
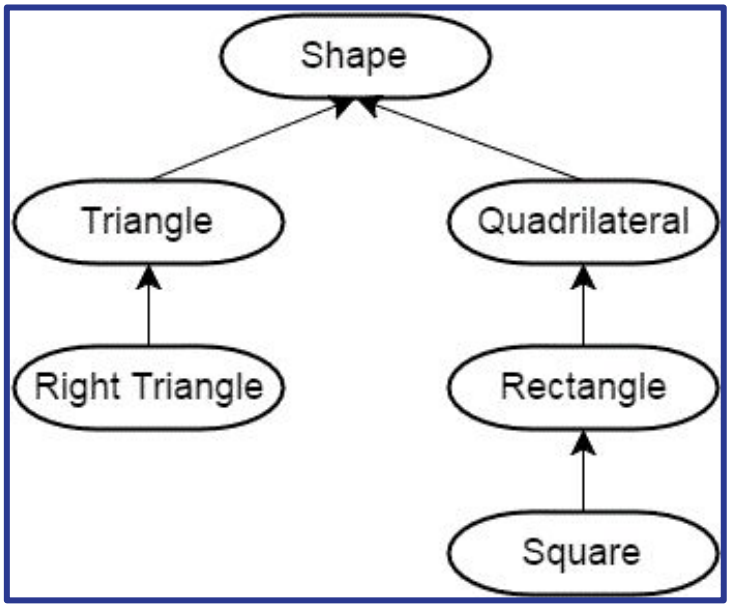


Inheritance - Examples



Generalization

Specialization



Note. In UML, the right type of arrow in the one above.

Back on Data Accessibility in JAVA

Private

Data accessible in the class itself.

Protected

"Private" rules + accessibility for the **subclasses**.

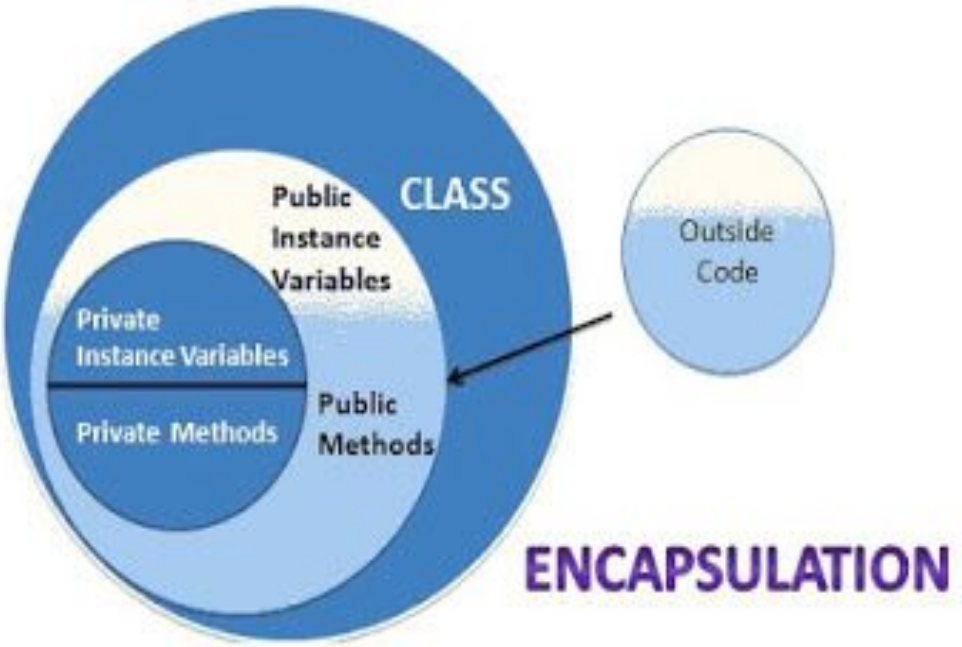
Public

Data accessibility for all

Package

("*Friendly*") By default but to be avoided. (≈*friend* en C++)

Back on Data Accessibility in JAVA



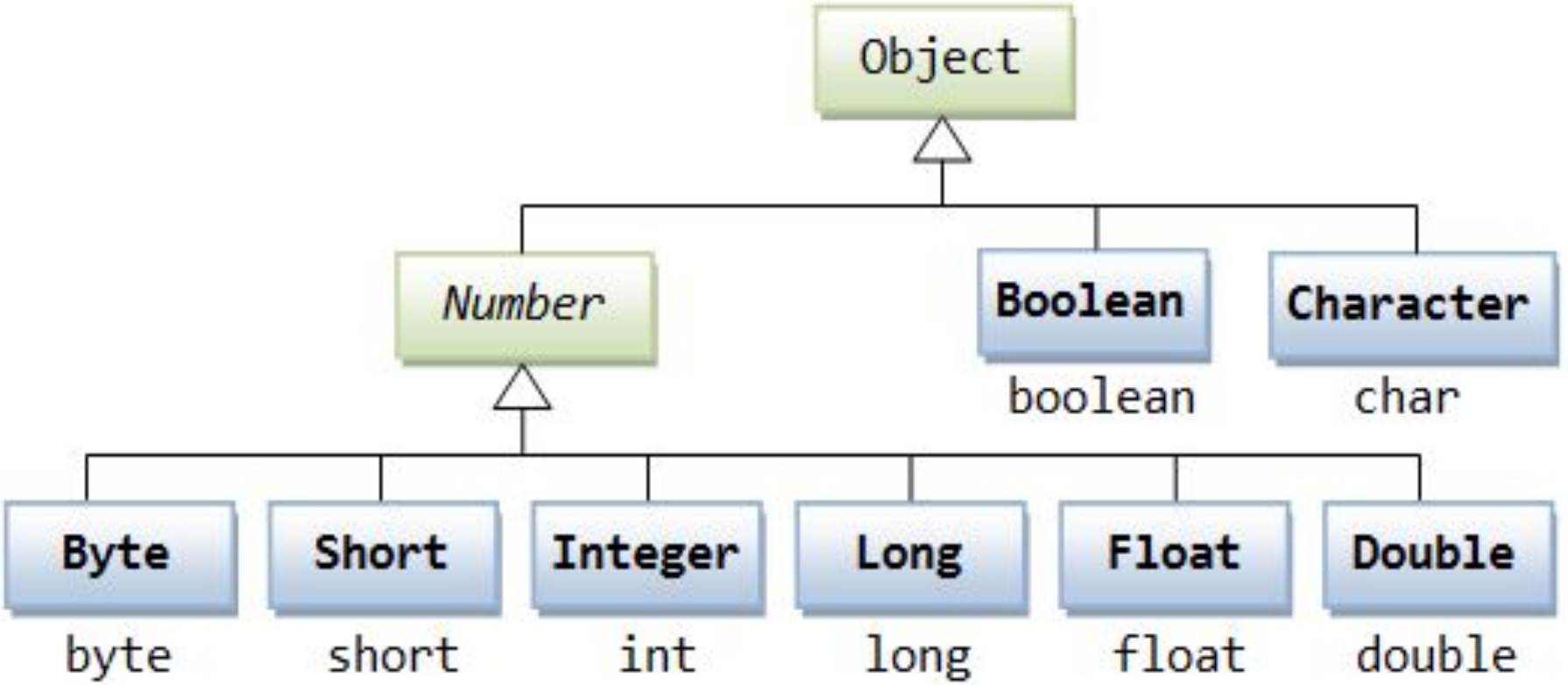
"Protected Data and Public Methods" is a good way to go ... But the world is more complicated than that!

Examples:

- Some superclass data must remain private
- Some constructors (which are methods) are private.
  - cf. Design Pattern Singleton (later in this course).
- Non secured if inheritance.

Pic Source image : http://chowdpa.blogspot.com/2016/04/object-oriented-programming-oop-in-java_17.html

Inheritance & JAVA

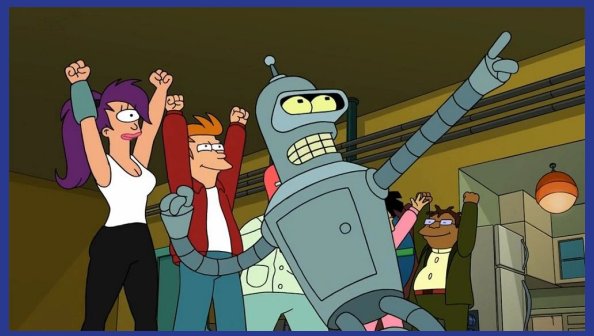


Documentation on java.lang.object : https://docs.oracle.com/en/java/javase/12/docs/api/java.base/java/lang/Object.html
Pic source : ttps://www.ntu.edu.sg/home/ehchua/programming/java/J3c_OOPWrappingUp.html

Practical Work
/ Travaux Pratiques

Practical Work 2

(Maybe the most important one for the simulation project)



Back to the lecture

2.3.
3rd Fundamental Concept

Polymorphism /e

Simple Polymorphism

Polymorphic Methods

- Literally:
  - (which can takes) several forms.
- Methods with the same name and the same number of parameters. E.g. :
  - `sum(int a, int b, int c) & sum(double a, double b, double c),`
  - `divide(int a, int b) & divide(double a, double b).`

(more complicated...)

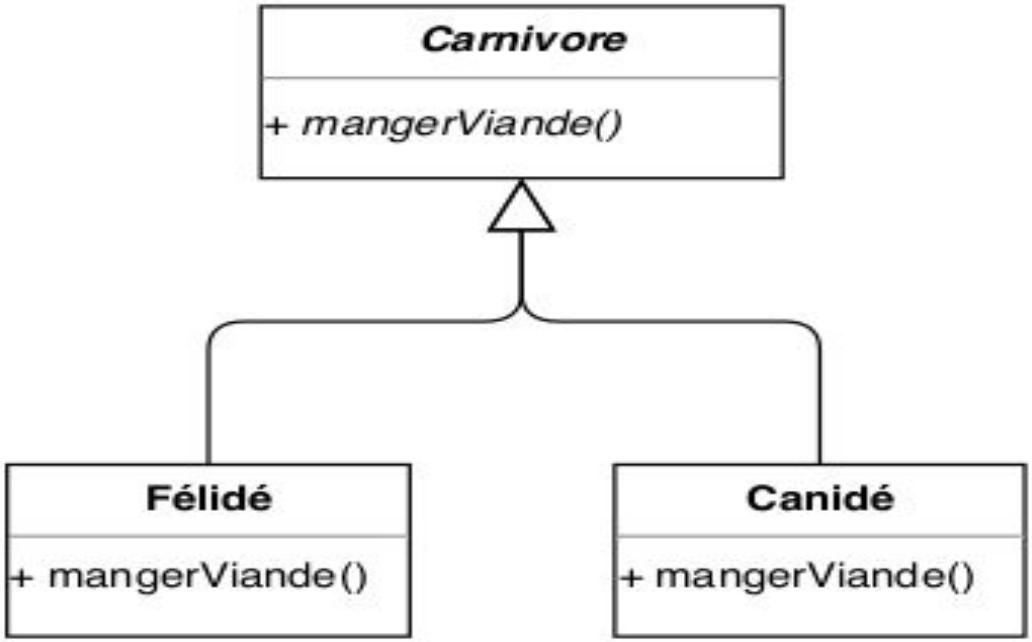
Inheritance & Polymorphism

Abstract methods and classes

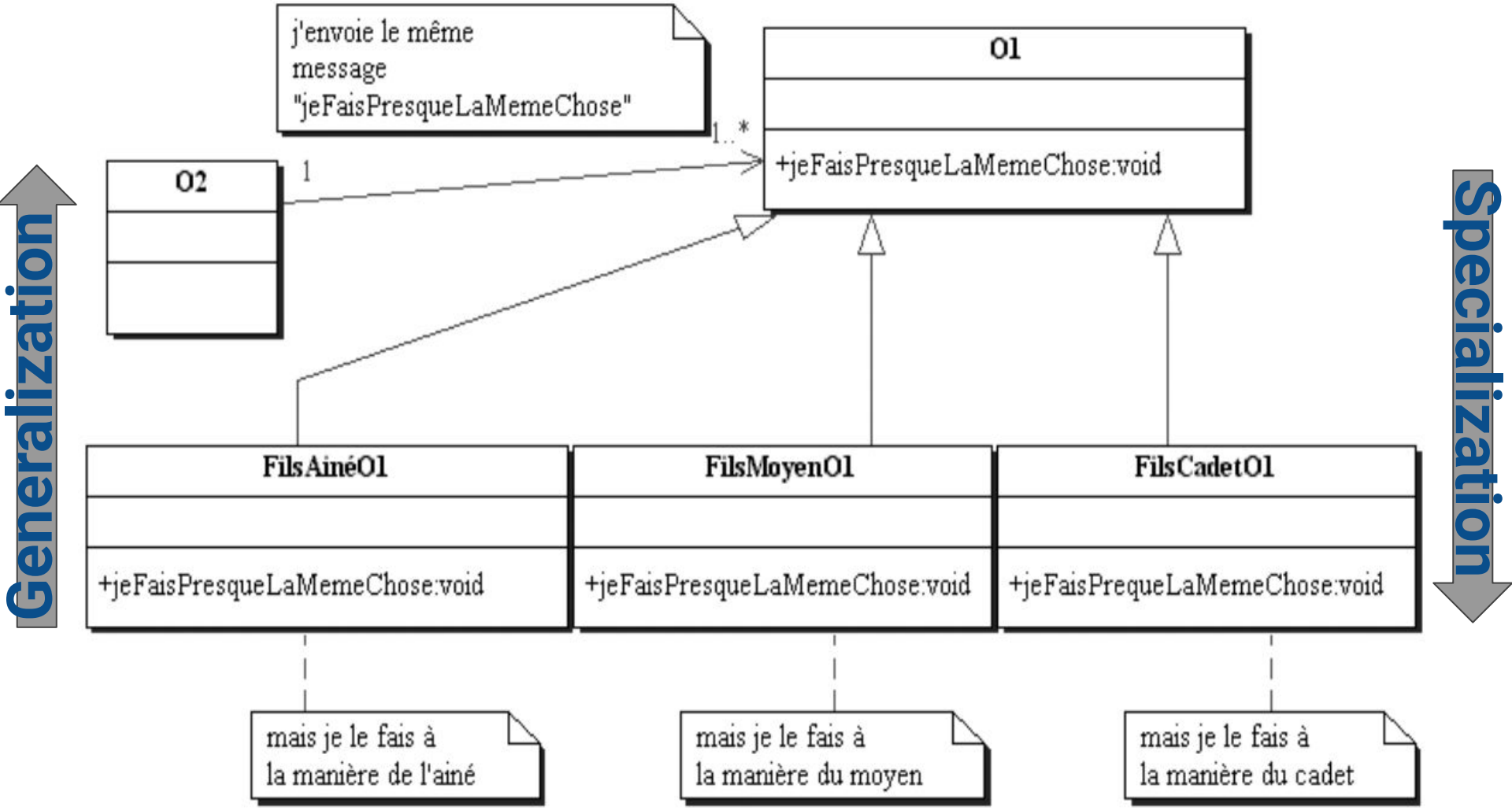
- **Abstract Method** / **Méthode abstraite**
  - Signature known / Signature connue,
    - (name & parameters) ;
  - Unknown algorithm,
  - The subclasses define the algorithm (according to the class particularities);
- **Abstract Class** / **Classe abstraite**
  - A class is abstract if it has at least one abstract method,
  - An abstract class cannot be instantiated.

(more complicated...)

Inheritance & Polymorphism Example



Inheritance & Polymorphism Example



Pic Source : Hugues Bersini

Polymorphism & JAVA

MainClass.java

```java
public class MainClass {

}
```

- an Array of Vehicles,
- the calls of all their `move()` method.

Vehicle.java

```java
abstract class Vehicle {
    /*
     * Default Constructor
     */
    public Vehicle()
    {
        km = 0;
    }
    /*
     * Methods
     */
    abstract void move();
    /*
     * Attributes
     */
    protected int km;
}
```

Car.java

```java
public class Car extends Vehicle {
    /*
     * Default Constructor
     */
    public Car()
    {
        super();
    }
    /*
     * Methods
     */
    public void move()
    {
        super.km += 10;
    }
}
```

Bike.java

```java
public class Bike extends Vehicle {
    public Bike()
    {
        super();
    }
    /*
     * Methods
     */
    public void move()
    {
        super.km ++;
    }
}
```

- **super** : call to the superclass from the subclass,
- **super()** : call of the constructor of the superclass,
- **abstract** : to declare an abstract method and an abstract class,
- **extends** : to inherit from a class.

```java
public final class ClasseFinal {
    ...
}
```

Note: The **final** keyword can be used to forbid inheritance of the class.

About the `@Override` keyword in Java

- '`@Override`' is written right before a child class method signature for **Dynamic Polymorphism.**
- If an object of a parent class is used to invoke the method, then the version in the parent class will be executed, BUT if an object of the subclass is used to invoke the '`Overrided`' method, then the version in the child class will be executed. In other words, it is the type of the object being referred to (not the type of the reference variable) that determines which version of an overridden method will be executed.

```
class SuperClass {
    void show()
    { System.out.println("SuperClass's method"); }
}
// Inherited class
class SubClass extends SuperClass {
    @Override
    void show()
    { System.out.println("Child's method"); }
}
```

```
class Main {
    Run | Debug
    public static void main(String[] args)  {
        // If a Parent type reference refers
        // to a Parent object, then Parent's
        // show is called
        SuperClass obj1 = new SuperClass();
        obj1.show();
        // If a Parent type reference refers
        // to a Child object Child's show()
        // is called. This is called RUN TIME
        // POLYMORPHISM.
        SuperClass obj3 = new SubClass();
        obj2.show();
    } }
```

Reference (not the object)

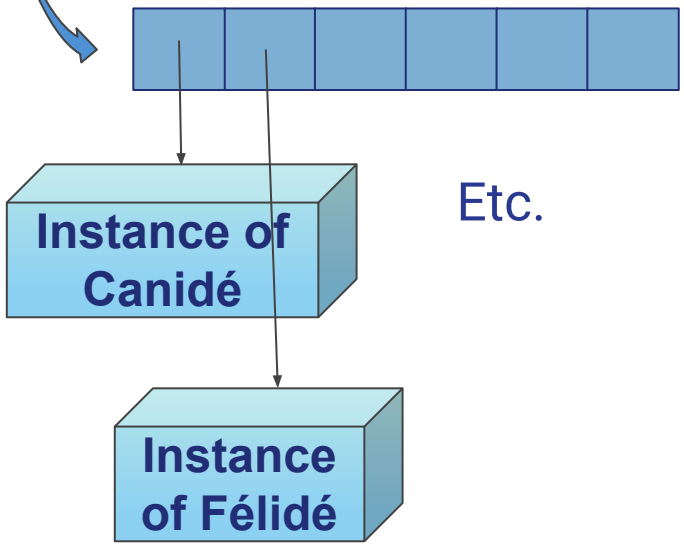
object

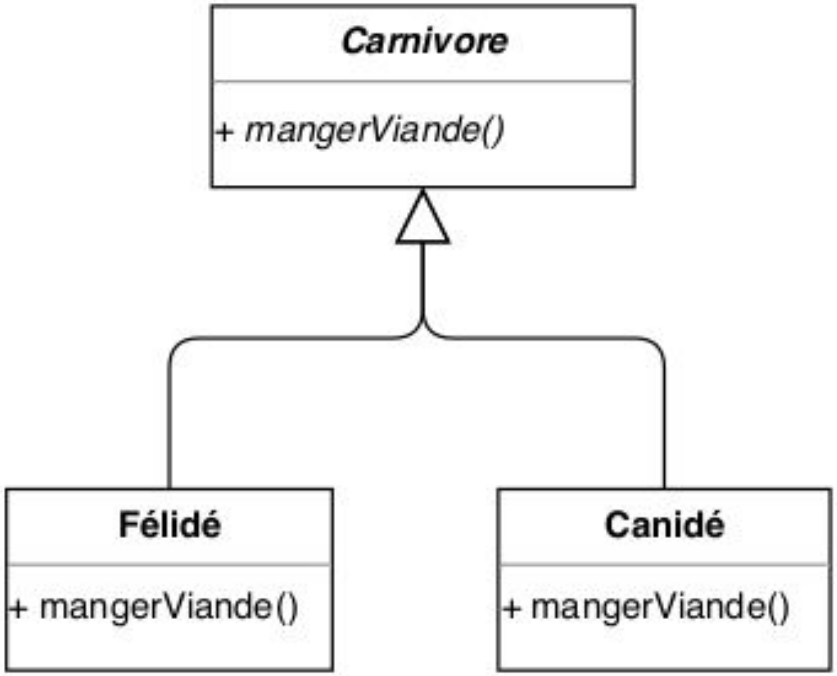
Ref: Based on a GeekForGeeks tutorial.

Polymorphism - C/C++ Example

```
Carnivore ** tabAnimal;

// [...]

for (uint i = 0 ; i < AnimalNumber ; i++)
{
        tabAnimal[i]->mangerViande();
}
```

*tabAnimal is a pointer table **on Carnivores** which can be either Felide or Canide.*





Polymorphism ensures that the correct **eatMeat()** method will be called (either Felide's or Canide's).

Inheritance & Polymorphism & C++

```
class Personne {
 …
 virtual void afficher(void) const
 { cout << nom << " " << prenom; }
 …
};
```

```
class Etudiant : public Personne {
 …
 void afficher(void) const {
  Personne::afficher();
   cout << " " << ecole;
 }
 …
};
```

- **superclass::** : call to the superclass from the subclass,
- **subclass : public superclass** : to inherit from a class,
- **virtual** : the method must be redefined in the **subclasses**,
- **abstract method**: called “pure virtual function” (**ends with ‘=0’**).

Question "in C++" (Try to code it in JAVA according to your language)

```
class EcoleIngenieur
{
public:
   void M1() { cout << "M1
              EcoleIngenieur" << endl; }
  virtual void M2() { cout << "M2
              EcoleIngenieur" << endl; }
};


class EcoleJUNIA :
        public EcoleIngenieur
{
public:
   void M1() {
     cout <<"M1 EcoleJUNIA"<< endl; }
   void M2() {
     cout <<"M2 EcoleJUNIA"<< endl; }
};
```

```
int main()
{
    EcoleIngenieur a;
       a.M1();
       a.M2();
    EcoleJUNIA b;
       b.M1();
       b.M2();


    EcoleIngenieur * pa
                  = new EcoleJUNIA;
       pa->M1();
       pa->M2();
}
```

—— **What the "cout"' will display?**

Question "in C++" (Try to code it in JAVA according to your language)

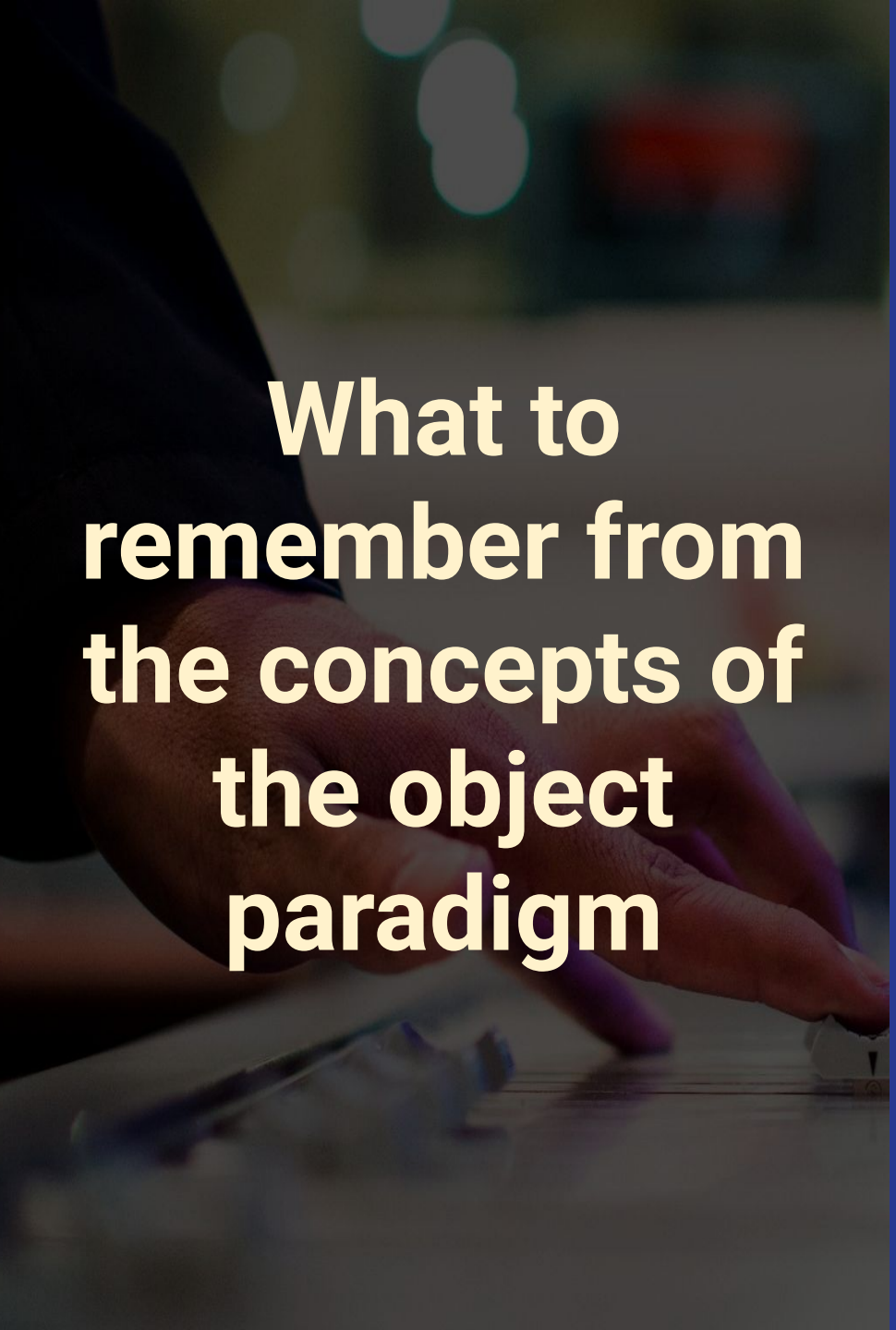
```
class EcoleIngenieur
{
public:
   void M1() { cout << "M1
              EcoleIngenieur" << endl; }
  virtual void M2() { cout << "M2
              EcoleIngenieur" << endl; }
};


class EcoleJUNIA :
        public EcoleIngenieur
{
public:
   void M1() {
     cout <<"M1 EcoleJUNIA"<< endl; }
   void M2() {
     cout <<"M2 EcoleJUNIA"<< endl; }
};
```

```
int main()
{
    EcoleIngenieur a;
        a.M1();
        a.M2();
    EcoleJUNIA b;
        b.M1();
        b.M2();

    EcoleIngenieur * pa
                = new EcoleJUNIA;
        pa->M1();
        pa->M2();
}
```

Response

```
class EcoleIngenieur
{
public:
   void M1() { cout << "M1
              EcoleIngenieur" << endl; }
  virtual void M2() { cout << "M2
              EcoleIngenieur" << endl; }
};


class EcoleJUNIA :
        public EcoleIngenieur
{
public:
   void M1() {
     cout <<"M1 EcoleJUNIA"<< endl; }
   void M2() {
     cout <<"M2 EcoleJUNIA"<< endl; }
};
```

```
int main()
{
   EcoleIngenieur a;
   a.M1(); // M1 de EcoleIngenieur
   a.M2(); // M2 de EcoleIngenieur
   EcoleJUNIA b;
   b.M1(); // M1 de EcoleJUNIA
   b.M2(); // M2 de EcoleJUNIA
   EcoleIngenieur * pa
                  = new EcoleJUNIA;
   pa->M1(); // M1 de EcoleIngenieur
   pa->M2();
   // M2 de EcoleJUNIA ("virtual")
     EcoleIngenieur *Ec1 = &b;
   Ec1->M1(); // M1 of EcoleIngenieur
   Ec1->M2();
   // M2 of EcoleJUNIA (car "virtual")
}
```



What to remember from the concepts of the object paradigm

- Definition of:
  - **object**,
  - **instance**,
  - **class**;
- The 3 fundamental concepts:
  - **Encapsulation**,
  - **Inheritance**,
  - **Polymorphism**.

3. Unified Modeling Language (UML)

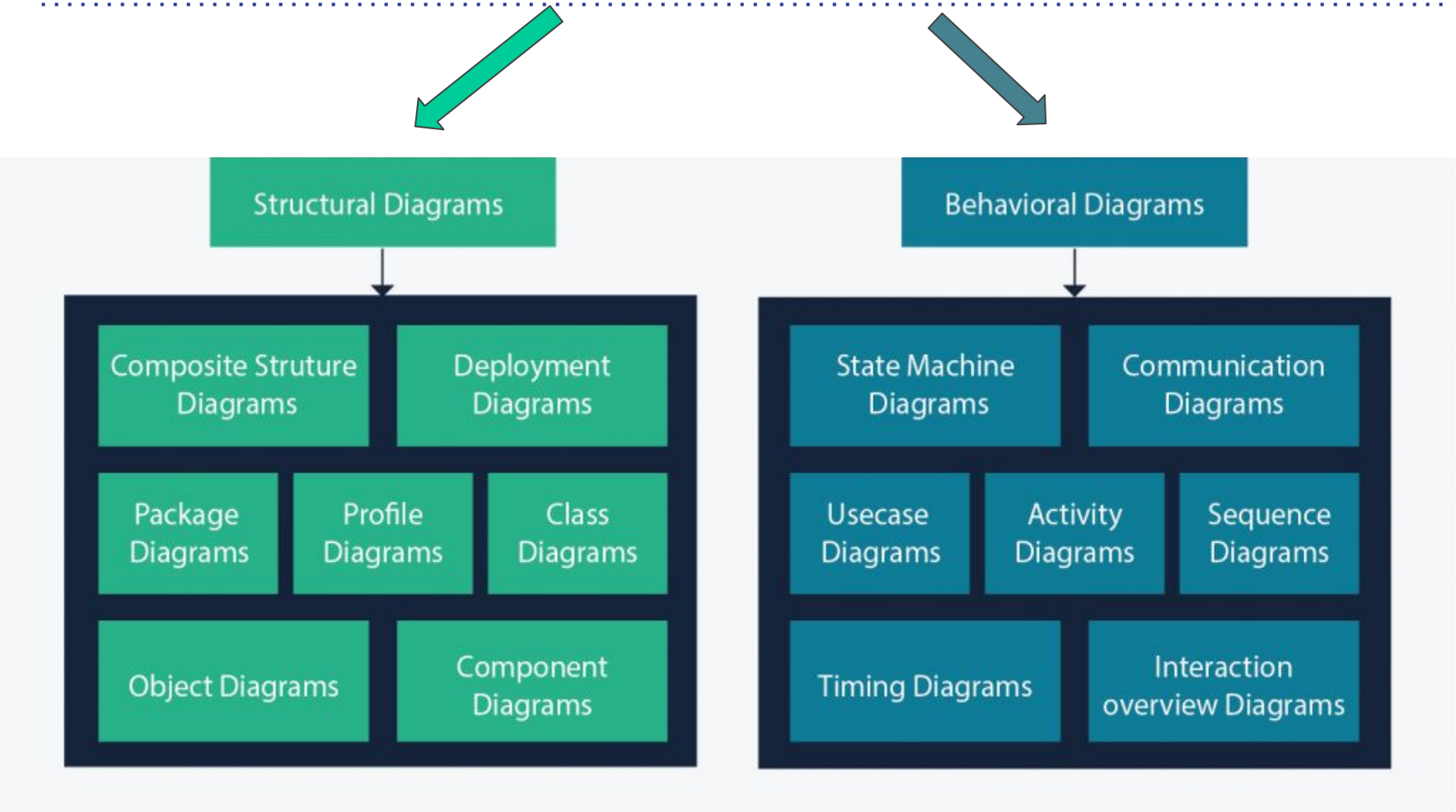
3.1. History and Overview

- Early **80'** : Objects escape from laboratories
  - C++ is born;
- **1980 --> 1994** : Birth of object-oriented methods
  - e.g. **OMT** (Object Modeling Technique) ;
- **1994**: Beginning of Unified Methods
  - **UM**: **U**nified **M**ethods (by *Rational Software*) ;
- **1995**: **UML 0.8**;
- **1996**: **UML 1.0** normalised by the Object Management Group ;
- ...
- **Since 2017** (Déc) : **UML 2.5.1**

- **For modeling software systems**
  - To decompose large scale systems,
  - Data Security Visualization
  - To help the communication between developers
    - e.g., with the use of different programming languages
- **Use of object-oriented software systems**
- **Evolving “before, during, after” the development process**
- **Collaborative effort associated with the object concept**
  - Agile Method

The **UML** today (Version 2.5)

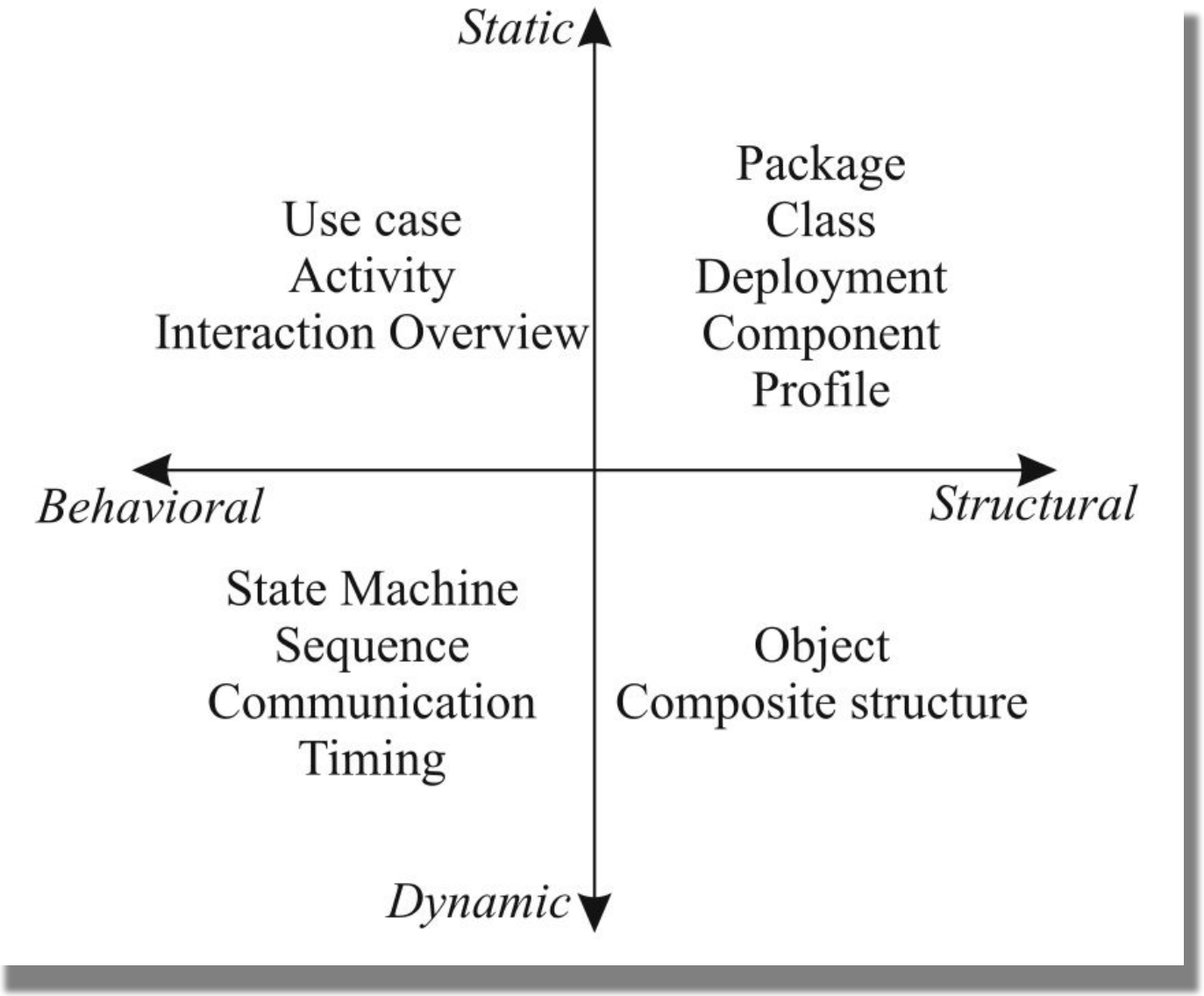
14 diagrams, 2 types: **structural** or **behavioral**



Source schéma : https://creately.com/blog/diagrams/uml-diagram-types-examples/

The **UML** today (Version 2.5)

14 diagrams, 2 types: **structural** or **behavioral**



Structural Diagrams

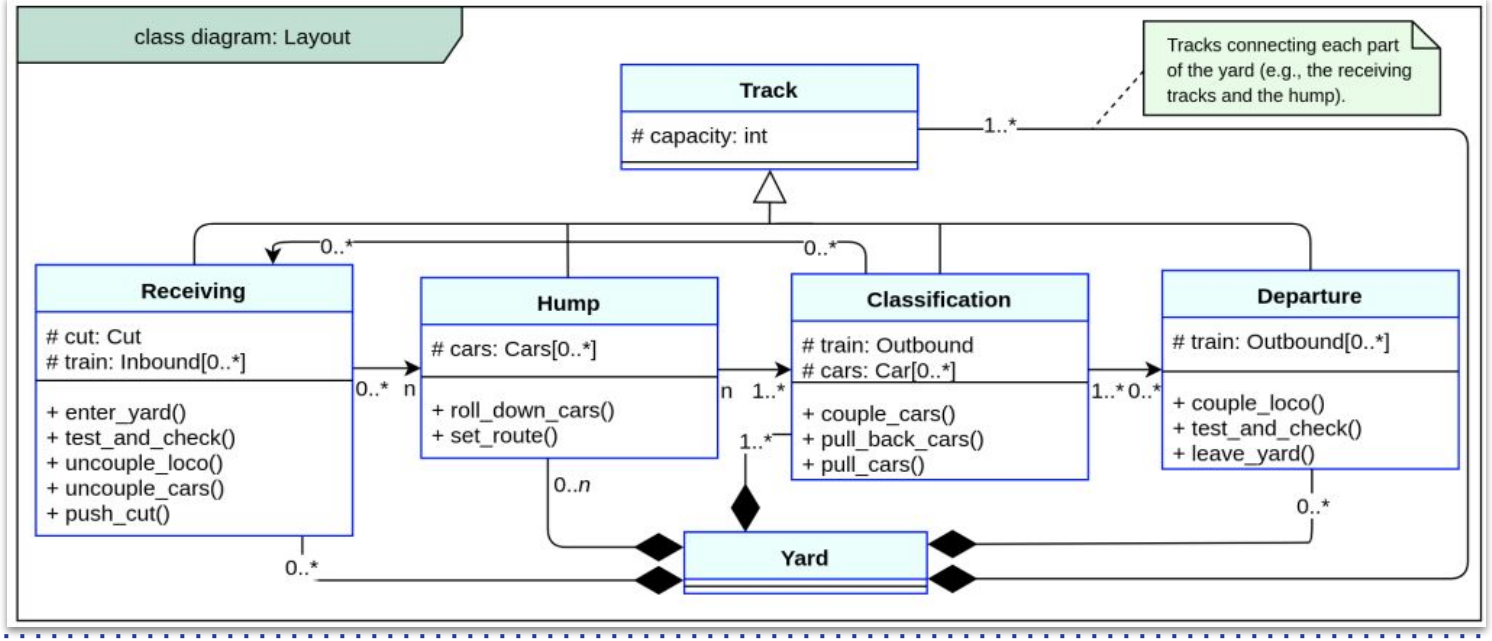
Behavioral Diagrams

UML
in this course

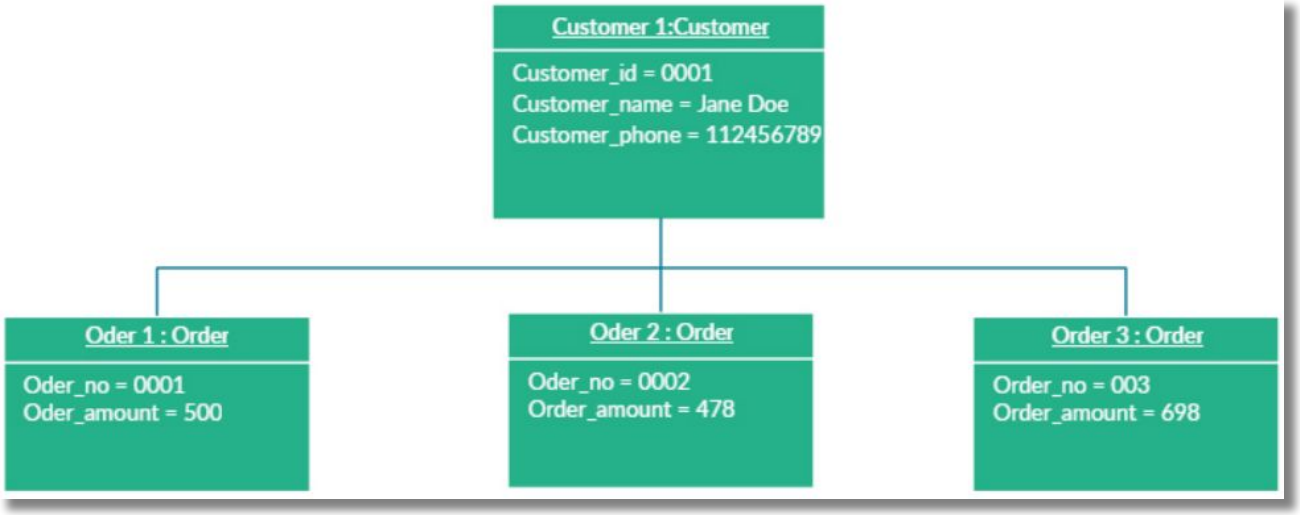
We will study the following diagrams:

- ***class diagrams*** / diagrammes de **classes**
- ***object diagram*** / diagrammes d'**objets**
- ***state machine diagram*** / diagramme d'**états-transitions**
- ***Use case diagram*** / diagramme de **cas d'utilisation**
- ***sequence diagram*** / diagramme de **séquence**
- ***activity diagram*** / diagramme d'**activités**

Quick overview of the 14 UML diagrams



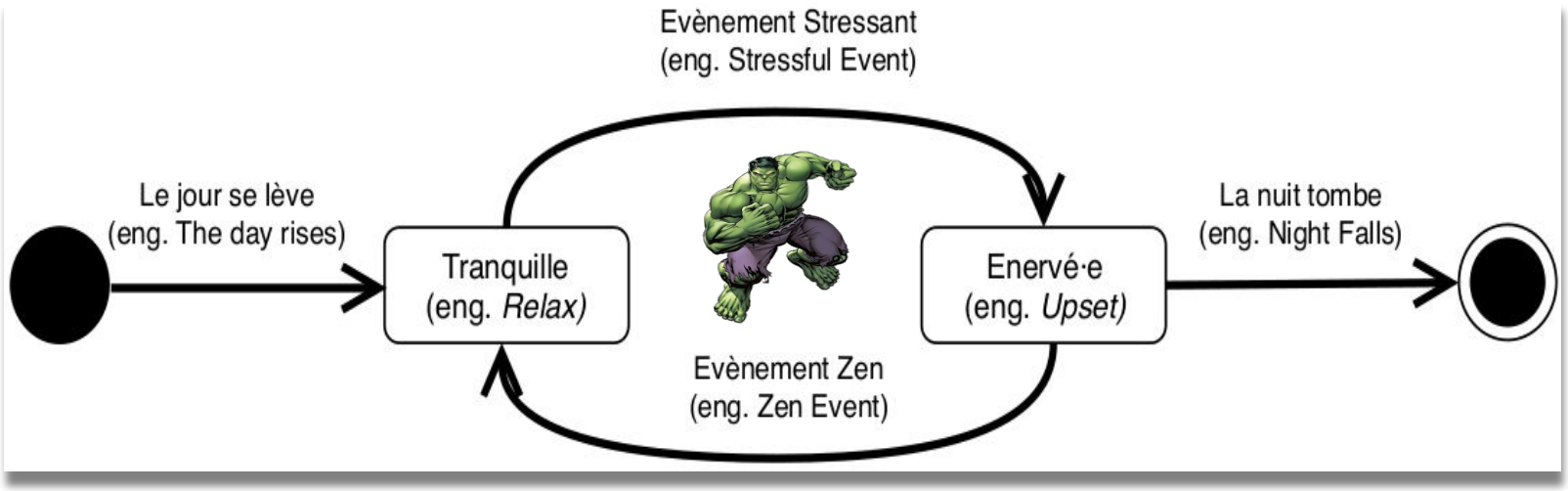
Class Diagram



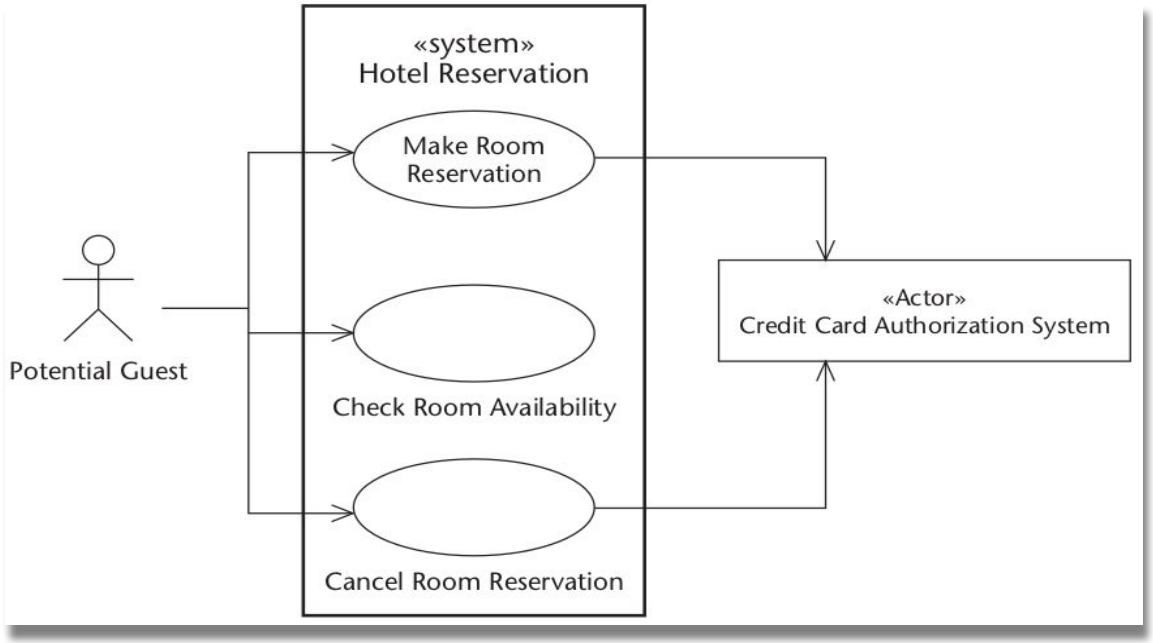
Object Diagram

Pics Source: https://creately.com/blog/diagrams/uml-diagram-types-examples/

Quick overview of the 14 UML diagrams

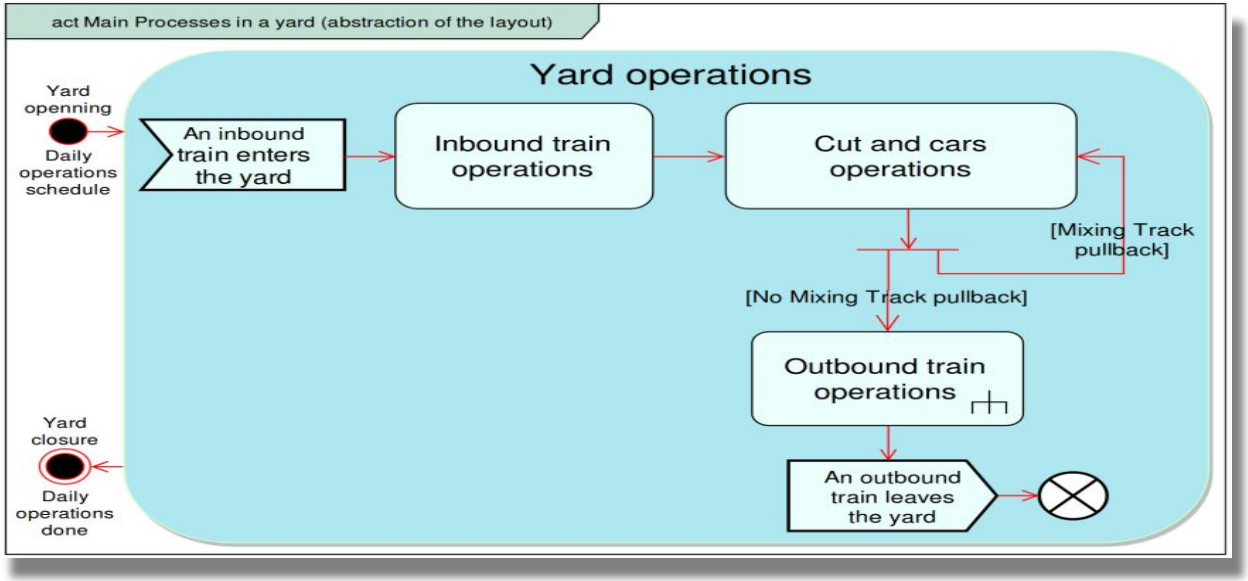


State Machine Diagram

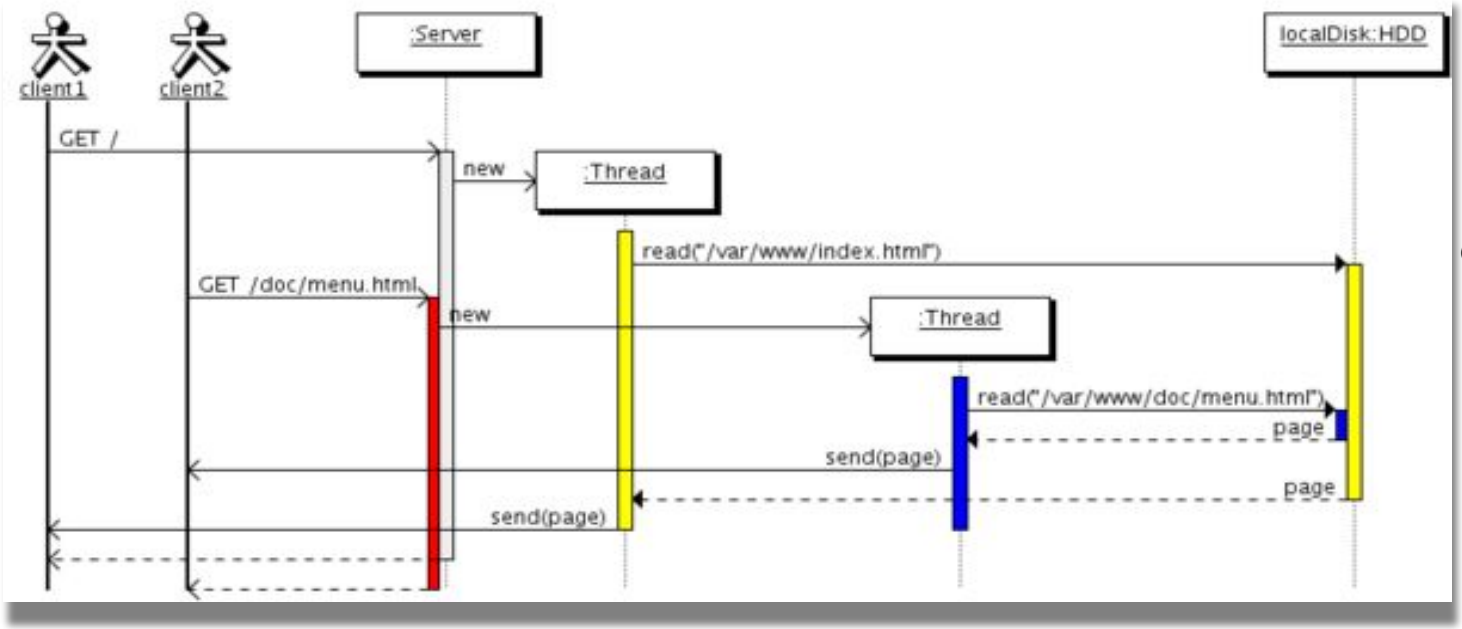


Use case Diagram

Quick overview of the 14 UML diagrams



Activity Diagram

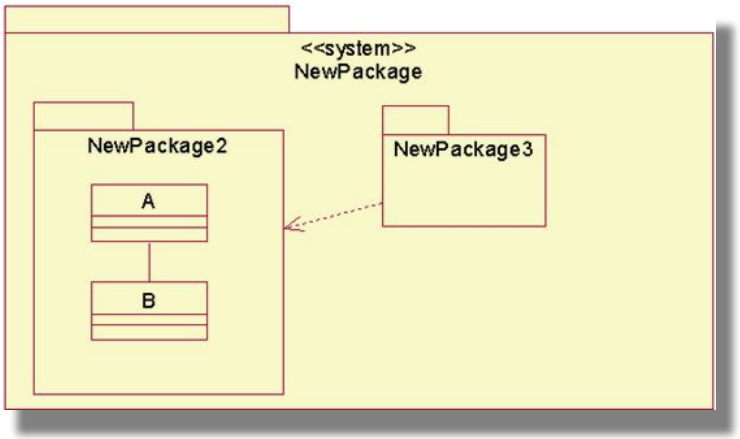


Sequence Diagram

UML
NOT
in this course

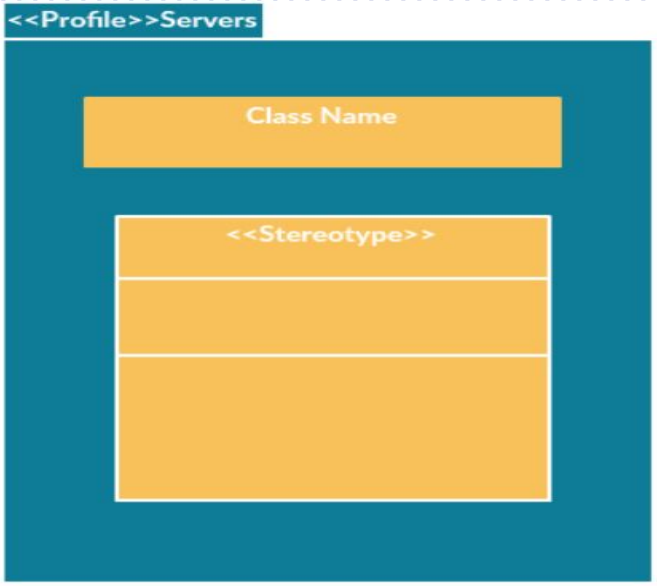
Very very very short overview of the other diagrams.

Quick overview of the 14 UML diagrams



Package Diagram

Profile diagram, a kind of structural diagram in the Unified Modeling Language (UML), **provides a generic extension mechanism for customizing UML models for particular domains and platforms**.

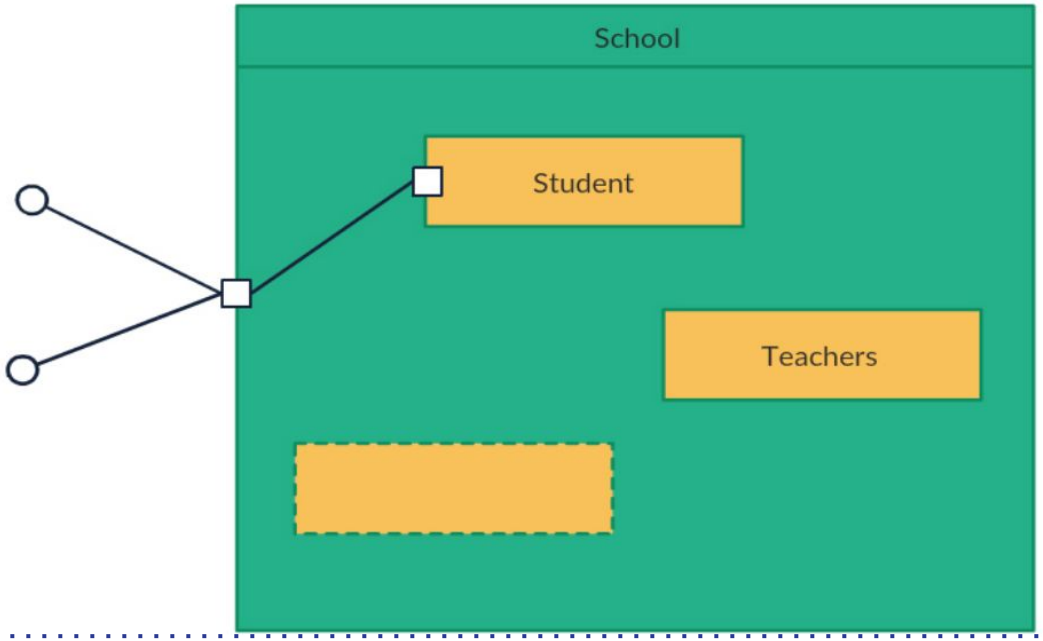


Profile Diagram

Source: https://creately.com/blog/diagrams/uml-diagram-types-examples/

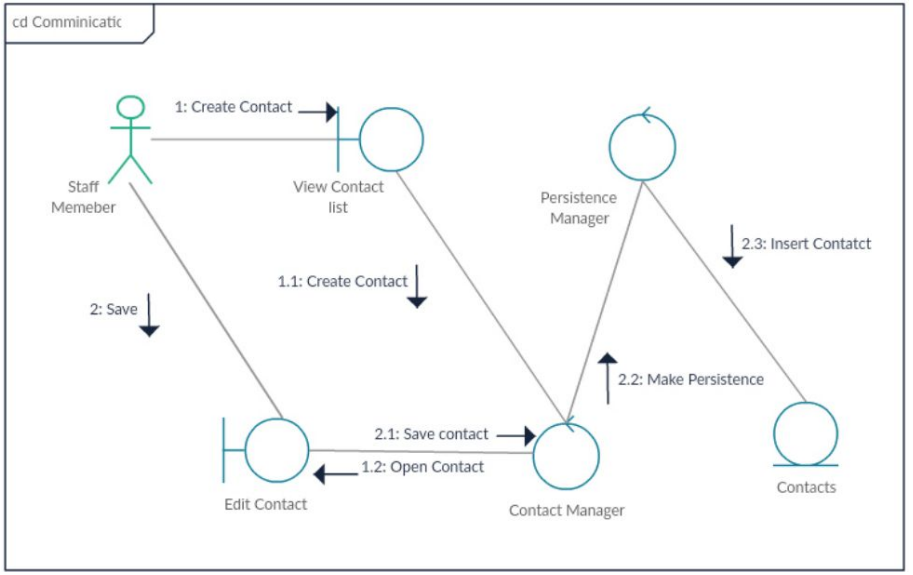
Quick overview of the 14 UML diagrams

A composite structure diagram is a UML structural diagram that contains classes, interfaces, packages, and their relationships, and that provides a logical view of all, or part of a software system. **It shows the internal structure** (including parts and connectors) **of a structured classifier or collaboration.**



Composite Structure Diagram

UML communication diagrams, like the sequence diagrams - a kind of interaction diagram, **shows how objects interact.** A communication diagram is an **e**xtension of object diagram that shows the objects along with the messages that travel from one to another.



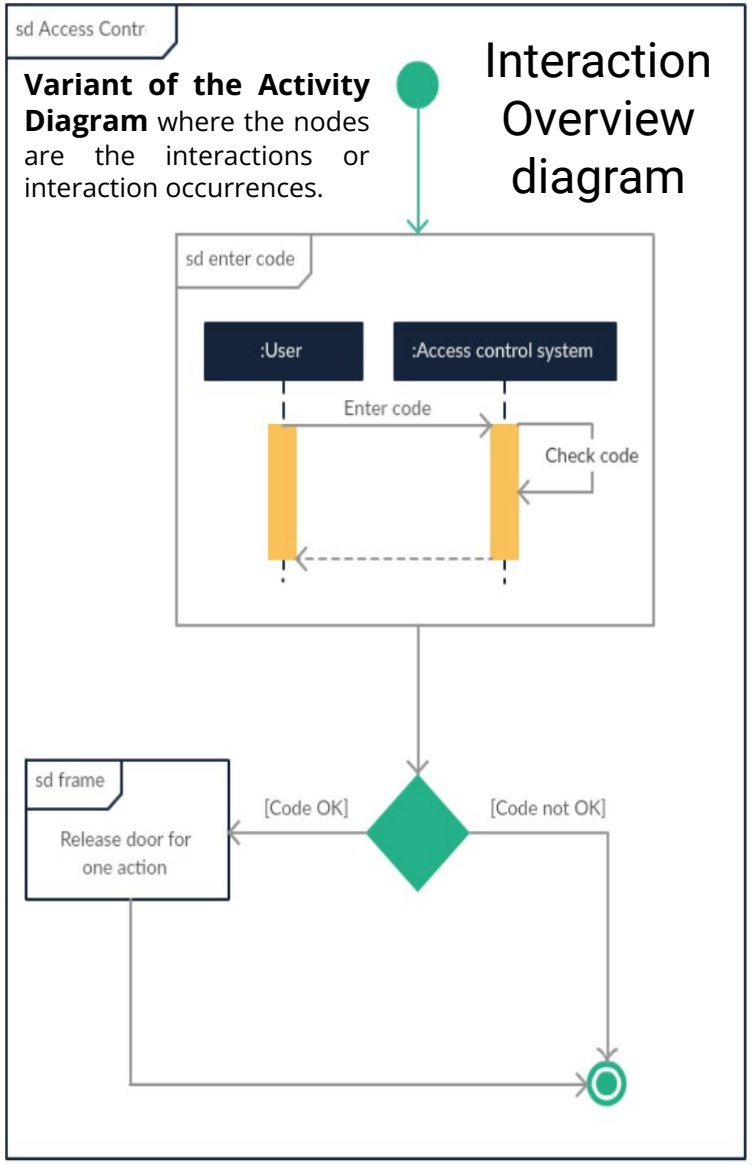
Communication Diagram

Source: https://creately.com/blog/diagrams/uml-diagram-types-examples/

Quick overview of the 14 UML diagrams

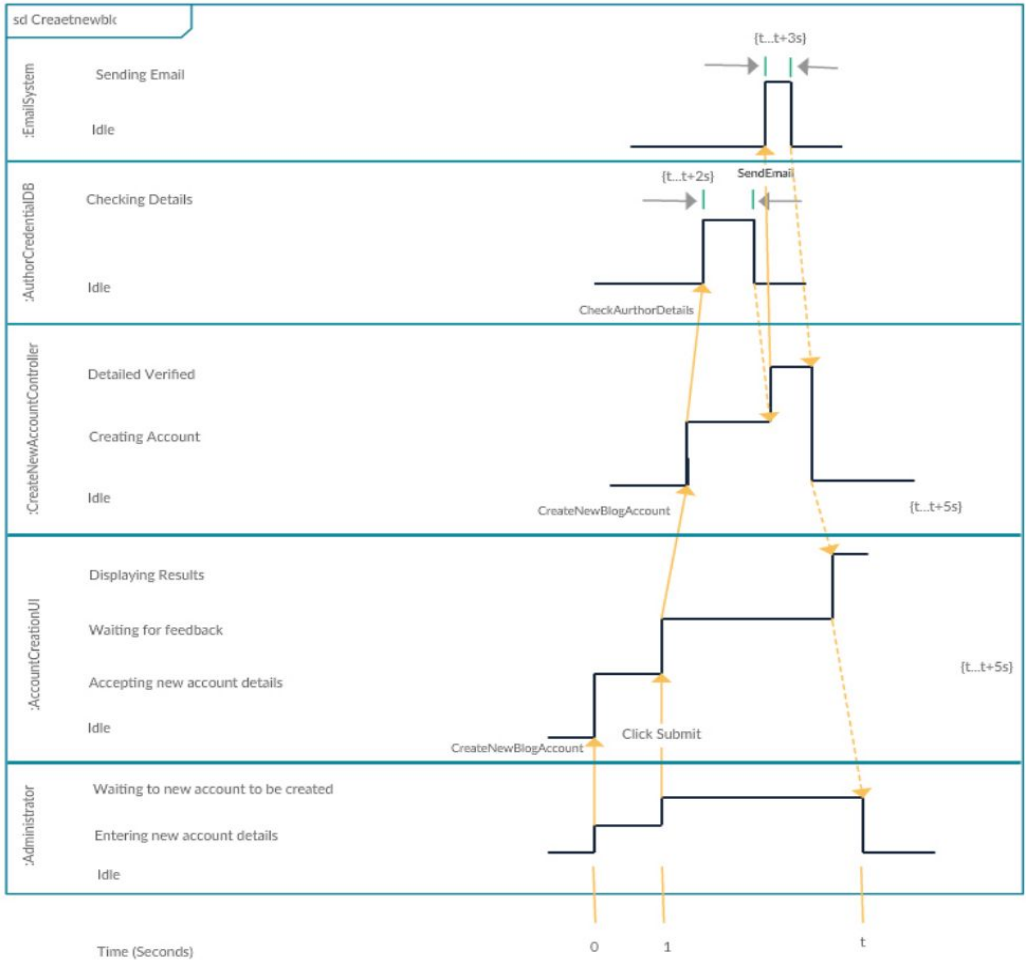
Interaction Overview diagram

Variant of the Activity Diagram where the nodes are the interactions or interaction occurrences.



Timing Diagram

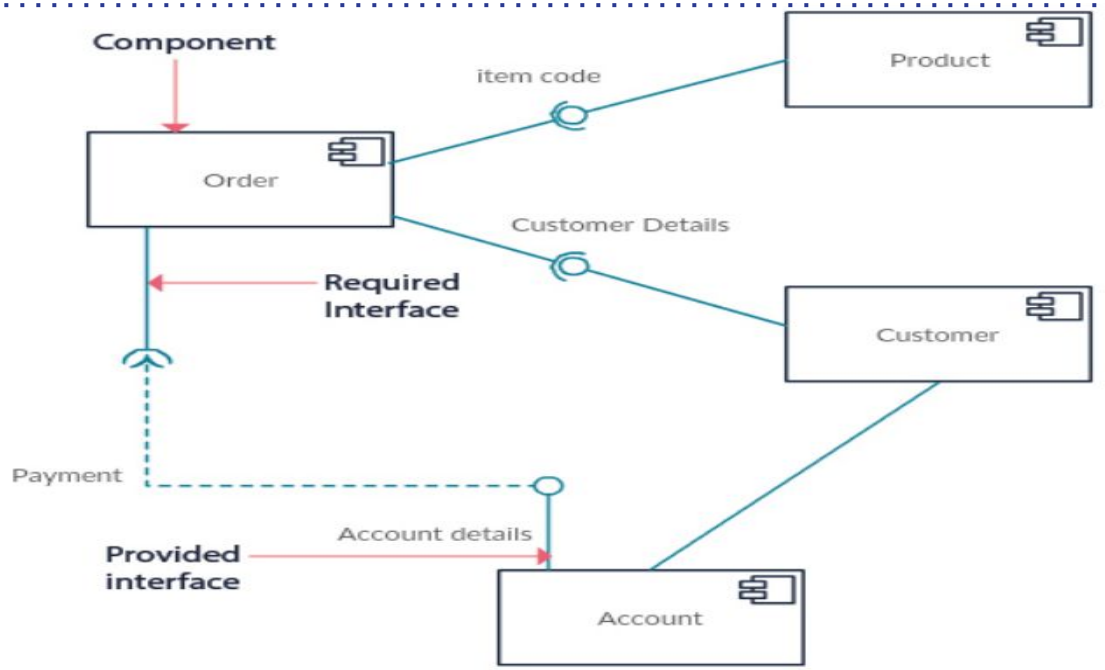
Timing diagrams are UML interaction diagrams used to **show interactions** when a primary purpose of the diagram is to reason **about time**.



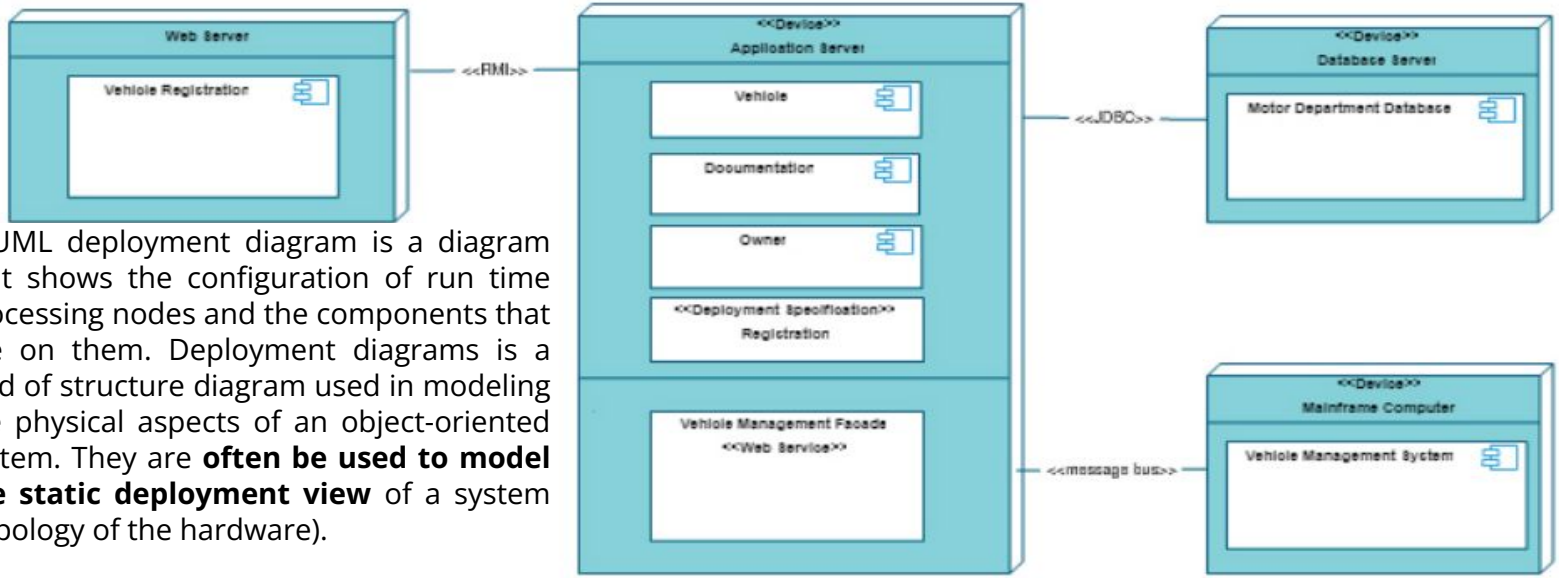
Pics Source: https://creately.com/blog/diagrams/uml-diagram-types-examples/

Quick overview of the 14 UML diagrams

Component diagrams are used in **modeling the physical aspects of object-oriented systems** that are used for visualizing, specifying, and documenting component-based systems and also for constructing executable systems through forward and reverse engineering.



Component Diagram



Deployment Diagram

A UML deployment diagram is a diagram that shows the configuration of run time processing nodes and the components that live on them. Deployment diagrams is a kind of structure diagram used in modeling the physical aspects of an object-oriented system. They are **often be used to model the static deployment view** of a system (topology of the hardware).

Source: https://creately.com/blog/diagrams/uml-diagram-types-examples/

Concept Object & IT Project.

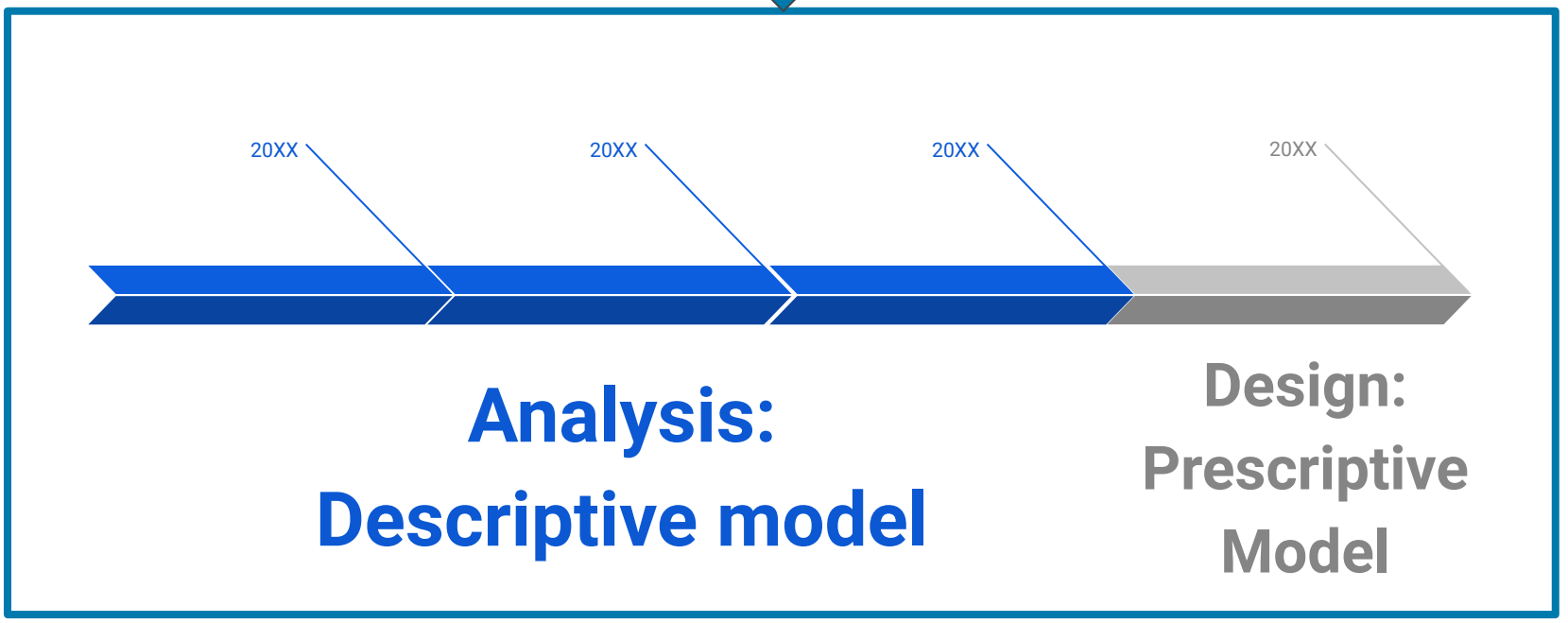
UML & IT Projects

2 methods:

- The procedural approach,
- **The object approach.**

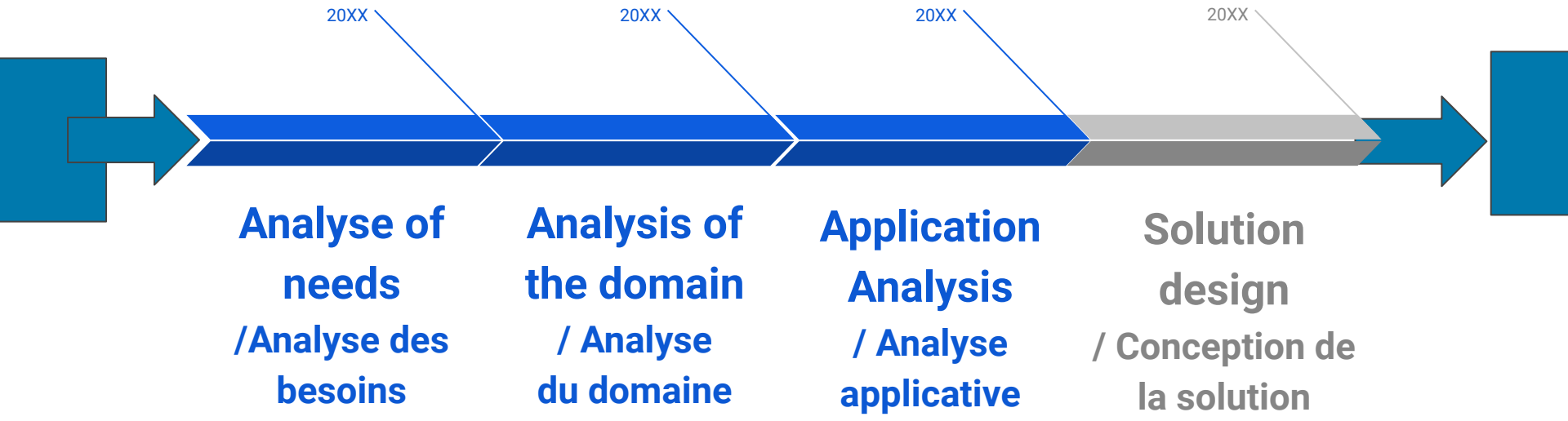
Concept Object & IT Project.

UML & IT Projects



Concept Object & IT Project.

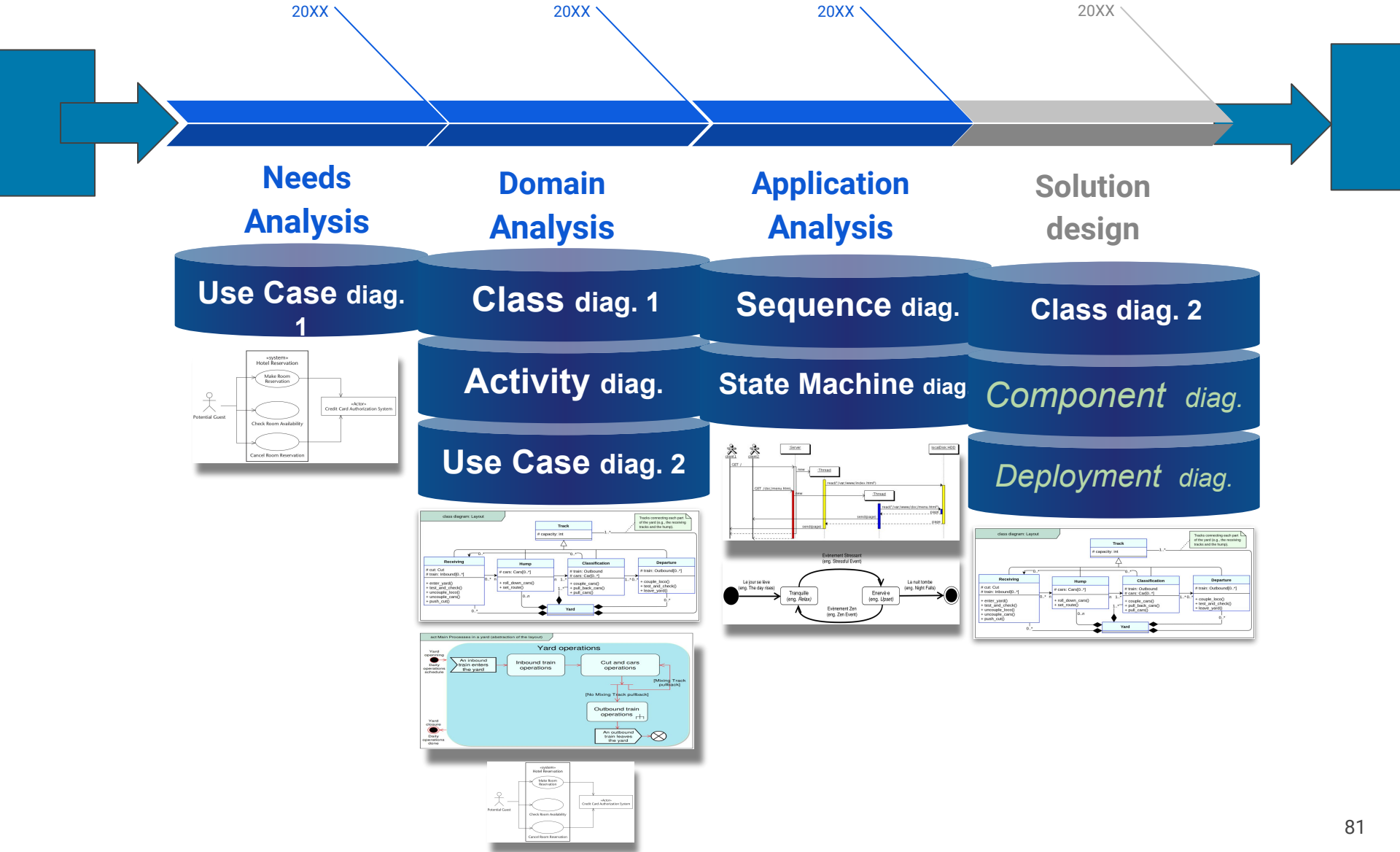
UML & IT Projects

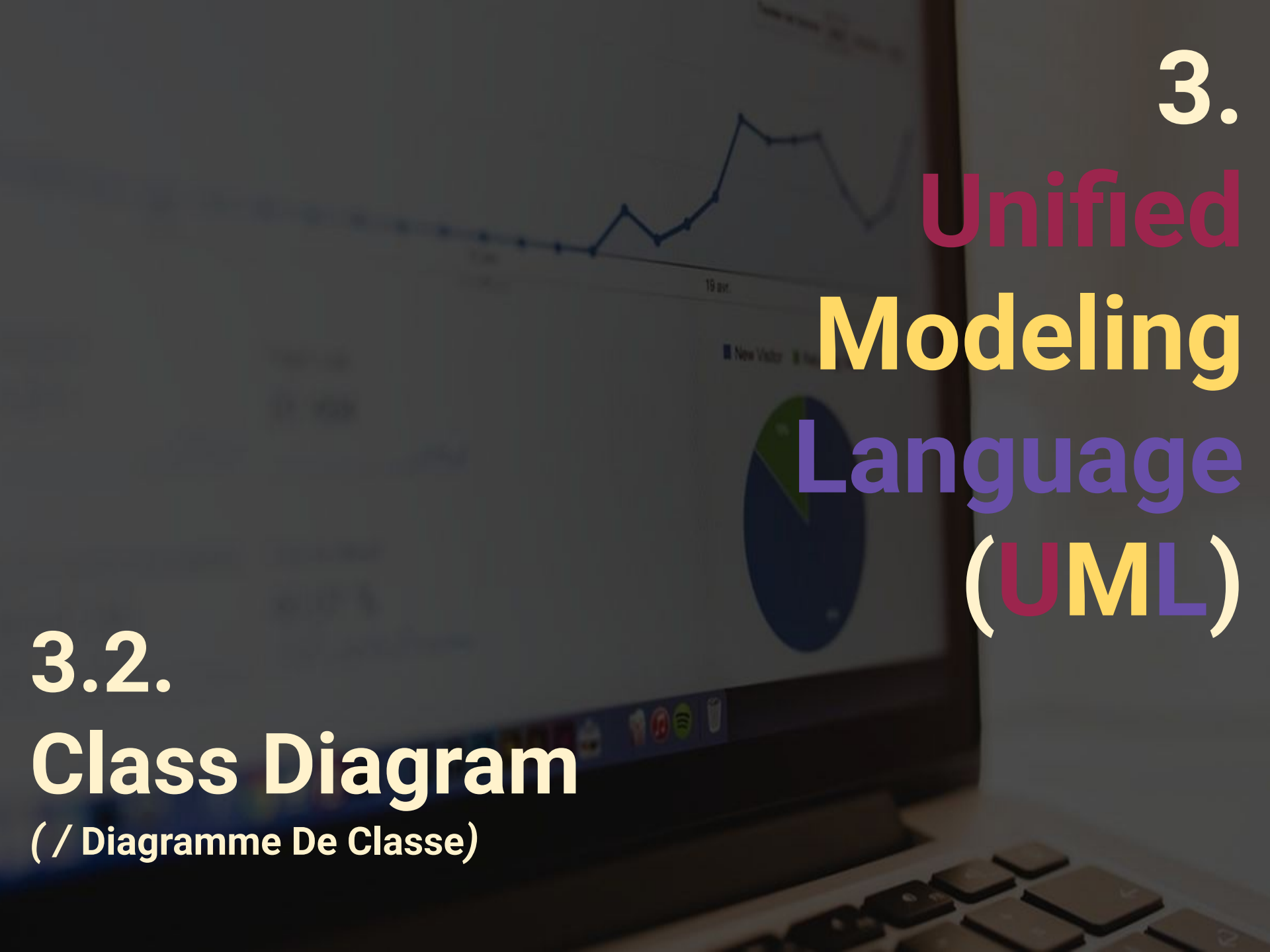


=> We will see UML diagrams for each of these steps according to the object paradigm.

Concept Object & IT Project.

UML & IT Projects





3. Unified Modeling Language (UML)

3.2. Class Diagram

(/ Diagramme De Classe)

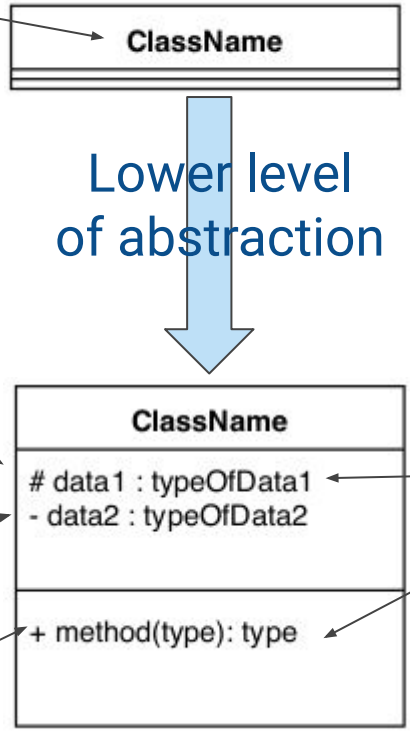
Class diagram

- **Central point of object-oriented development,**
- **Static modeling,**
- Level of abstraction varying according to the stage of the project:
  - Description of all classes (always),
  - Attributes and methods (depending on the stage),
  - Links between classes (depending on the stage),
- Brings up the 3 Basic Object Concepts:
  - **Encapsulation**,
  - **Inheritance** (/ héritage),
  - **Polymorphism**.

Class diagram

Modeling a class

Class name starting with 1 uppercase



\# "**Protected**" data

\- "**Private**" data

\+ "**Public**" Method

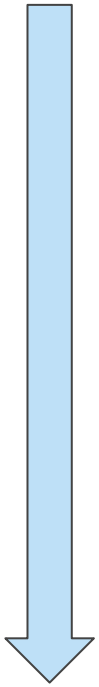
The data type of the attribute and the data type returned by a method.

Note: attributes and methods are generally written in camelCase. (e.g., word1Mot2Mot3Mot4Mot5Mot6Mot7Etc)

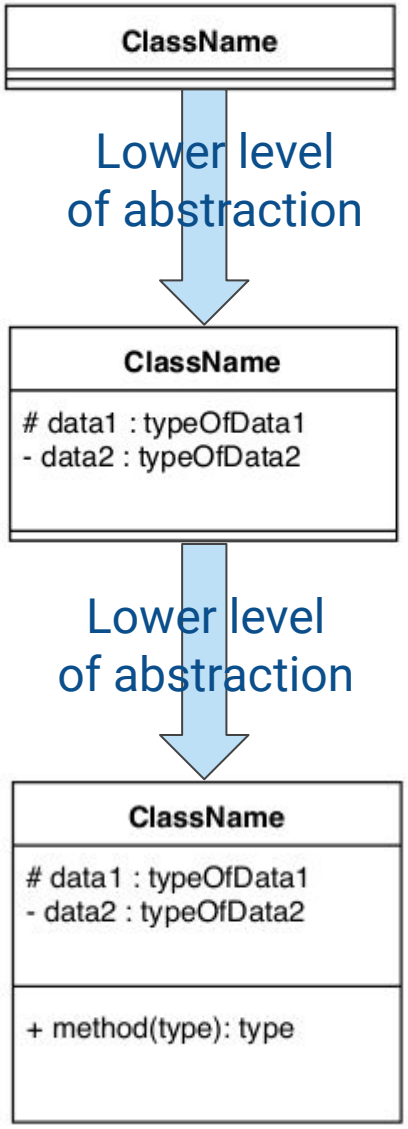
Class diagram

Modeling a class

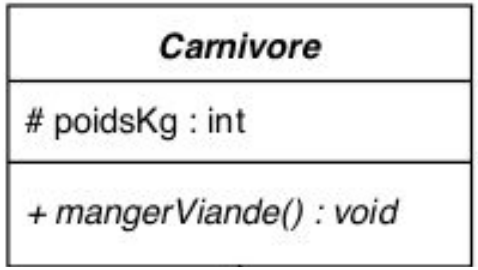
Analysis level

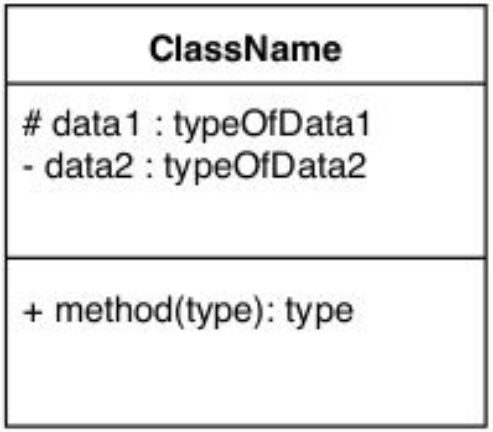


Technical level (software design)



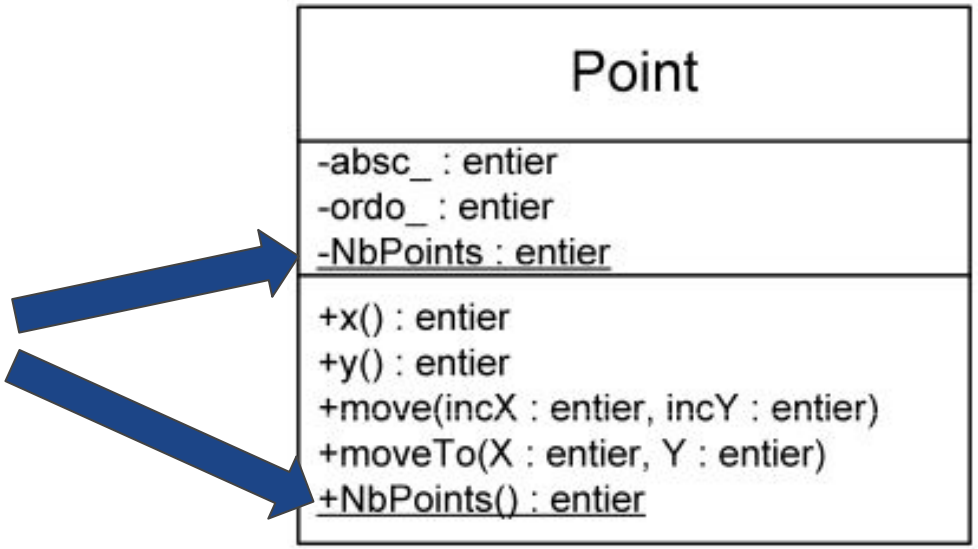
Class diagram
Class examples





Example with **static** data and **static** methods

We underline the “static” attribute or method



Recall: *Static* Data & *Static* methods in java

```
public class MyStaticMembClass {

    public static final int INCREMENT = 2;

    public static int incrementNumber(int number){
        return number+INCREMENT;
    }
}
```

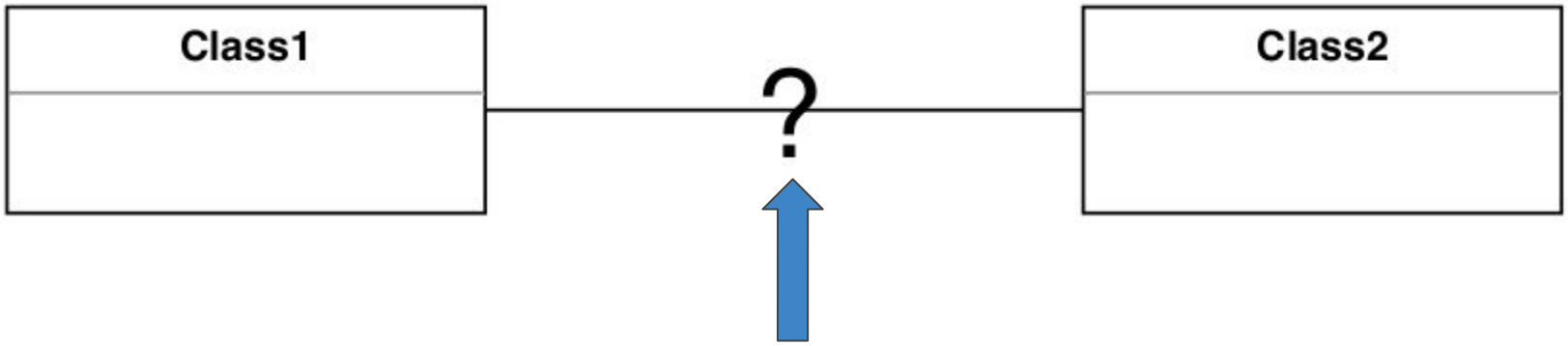
```
public class MyStaticImportExmp {

    public static void main(String a[]){
        System.out.println("Increment value: "+INCREMENT);
        int count = 10;
        System.out.println("Increment count: "+incrementNumber(count));
```

Output:

Increment value: 2
Increment count: 12

Ref: https://www.java2novice.com/java-fundamentals/static-import/

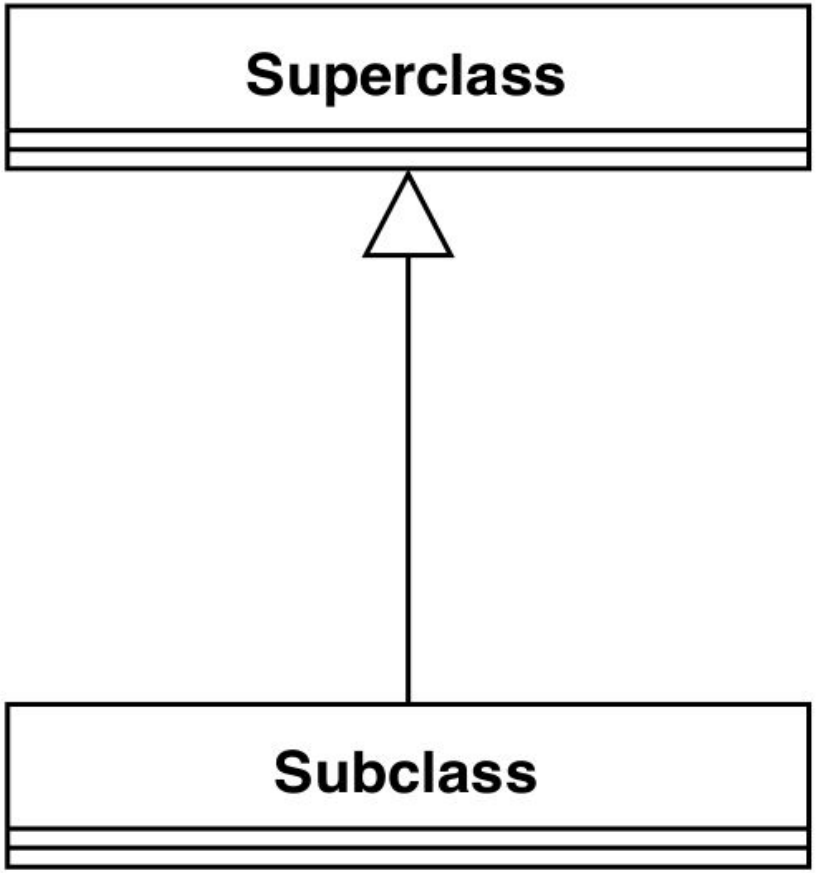
Links between two classes



What kind of link have we already seen in this course?

Class diagram

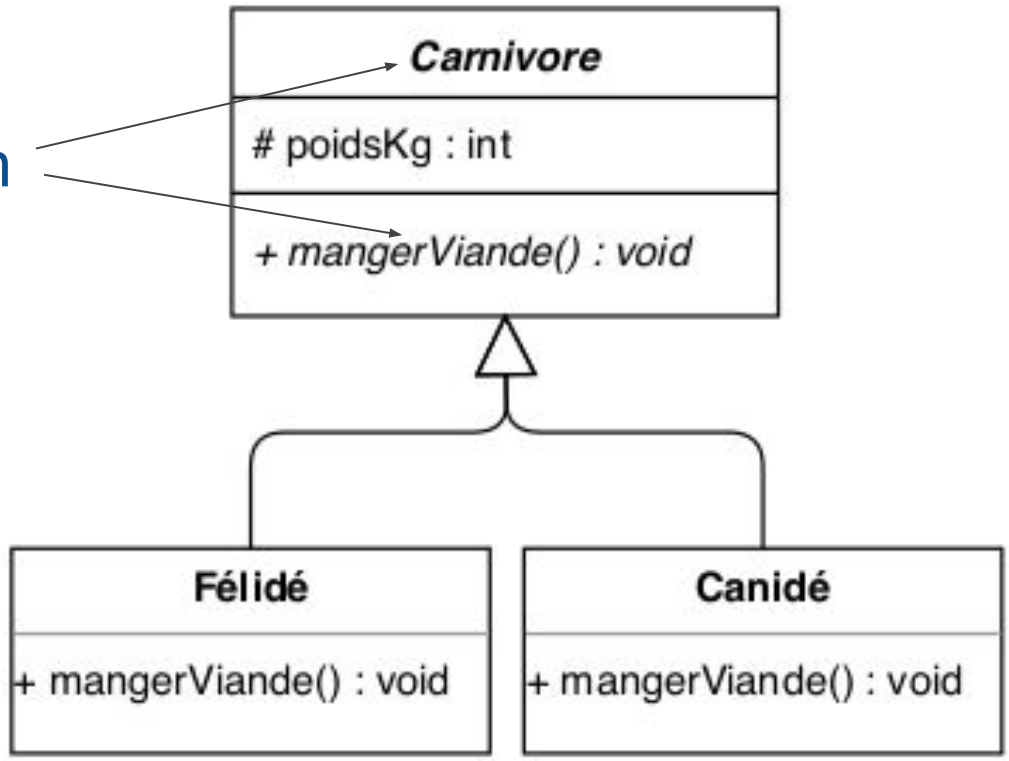
Inheritance



Reminder: **Inheritance** should be seen as a specialization of a superclass: an instance of subclass will retrieve everything from superclass in addition to its own elements.

Abstract class and abstract method

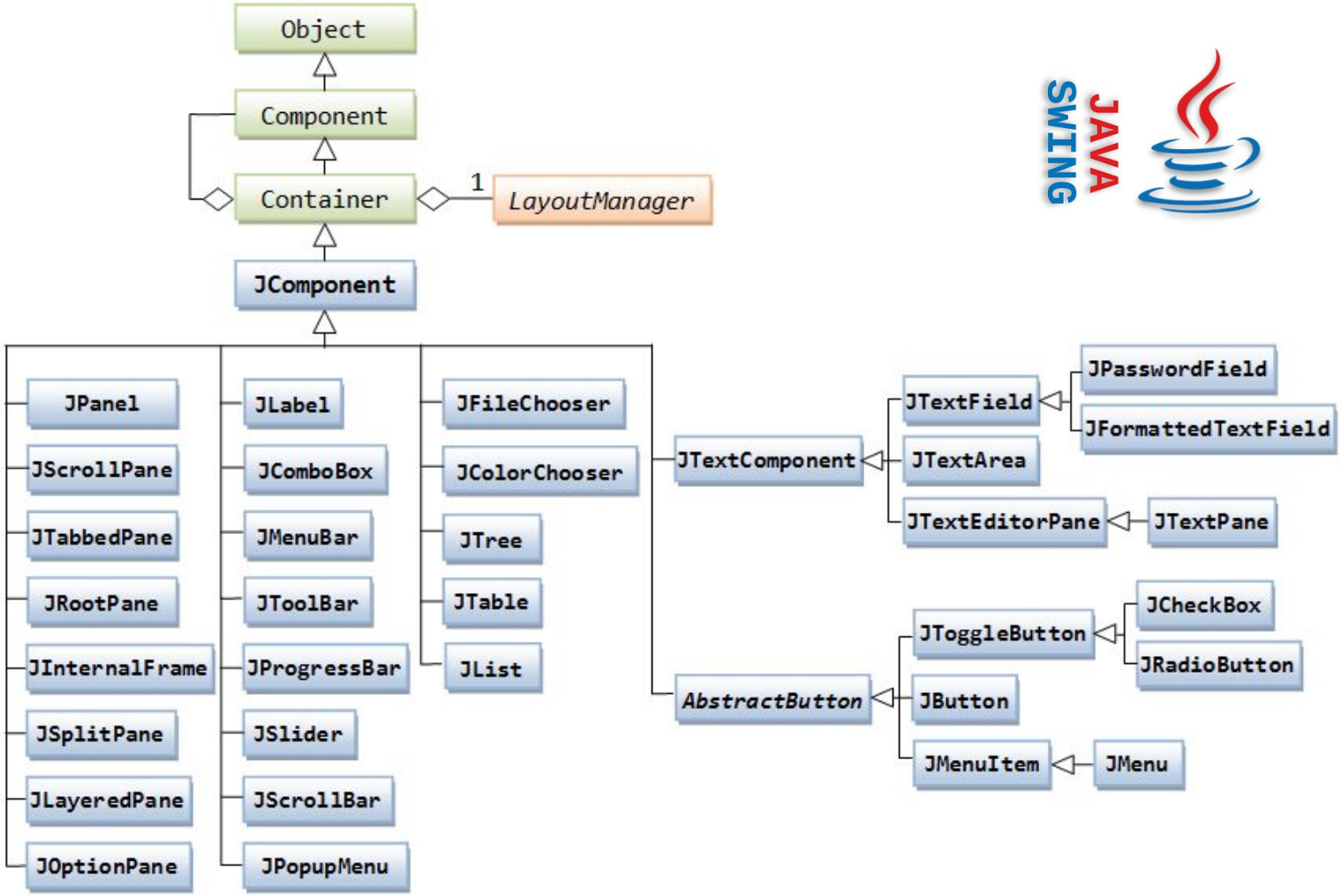
Abstract classes and methods are in **italics**.




Qt
Swing
Example
-
Inheritance
in the
graphics libraries
GTK
OpenGL

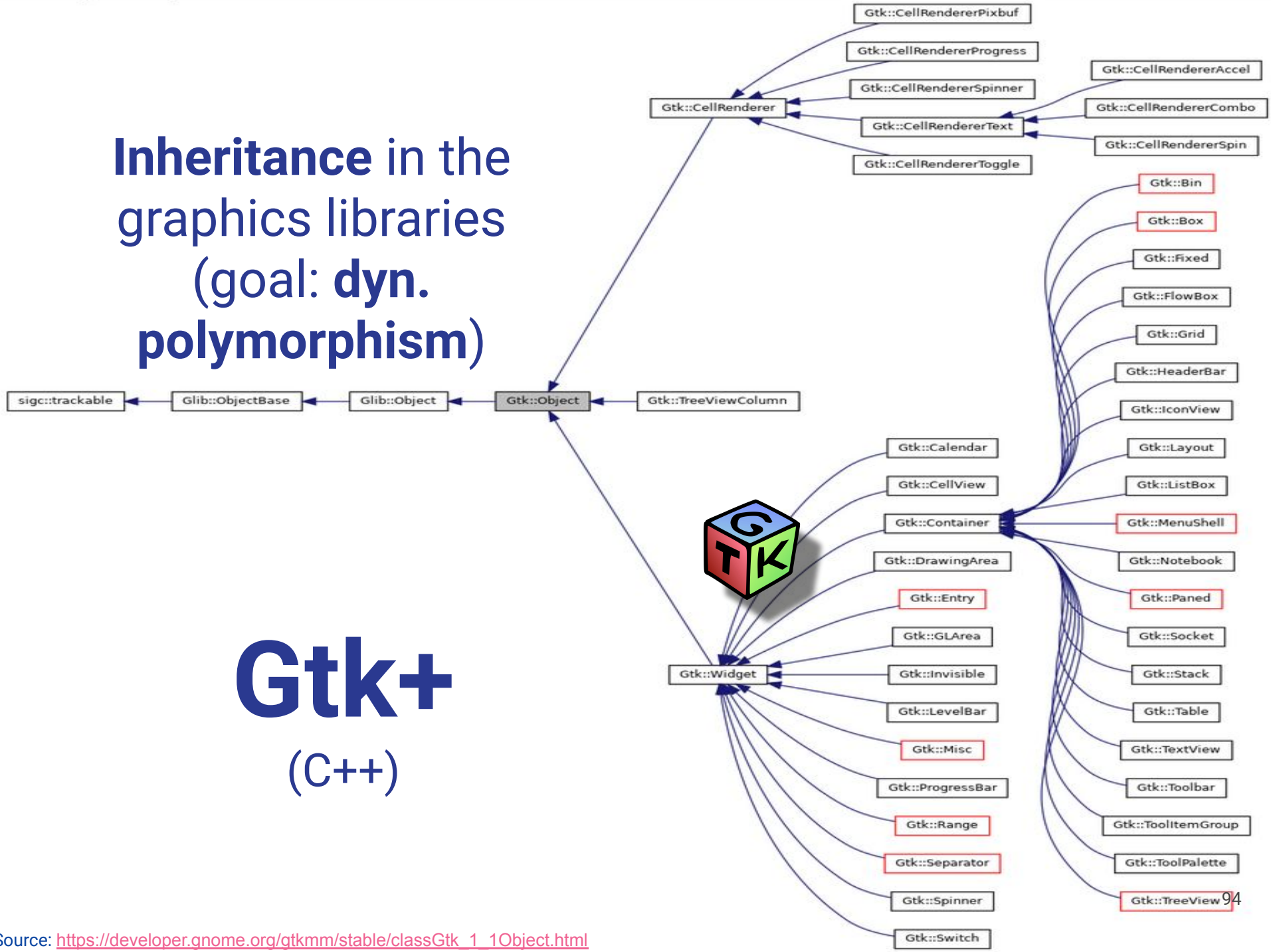
Inheritance in the graphics libraries (Goal: **dyn. polymorphism**)

Swing Component (Java)



Source: https://www.ntu.edu.sg/home/ehchua/programming/java/J4a_GUI_2.html

Inheritance in the graphics libraries (goal: **dyn. polymorphism**)



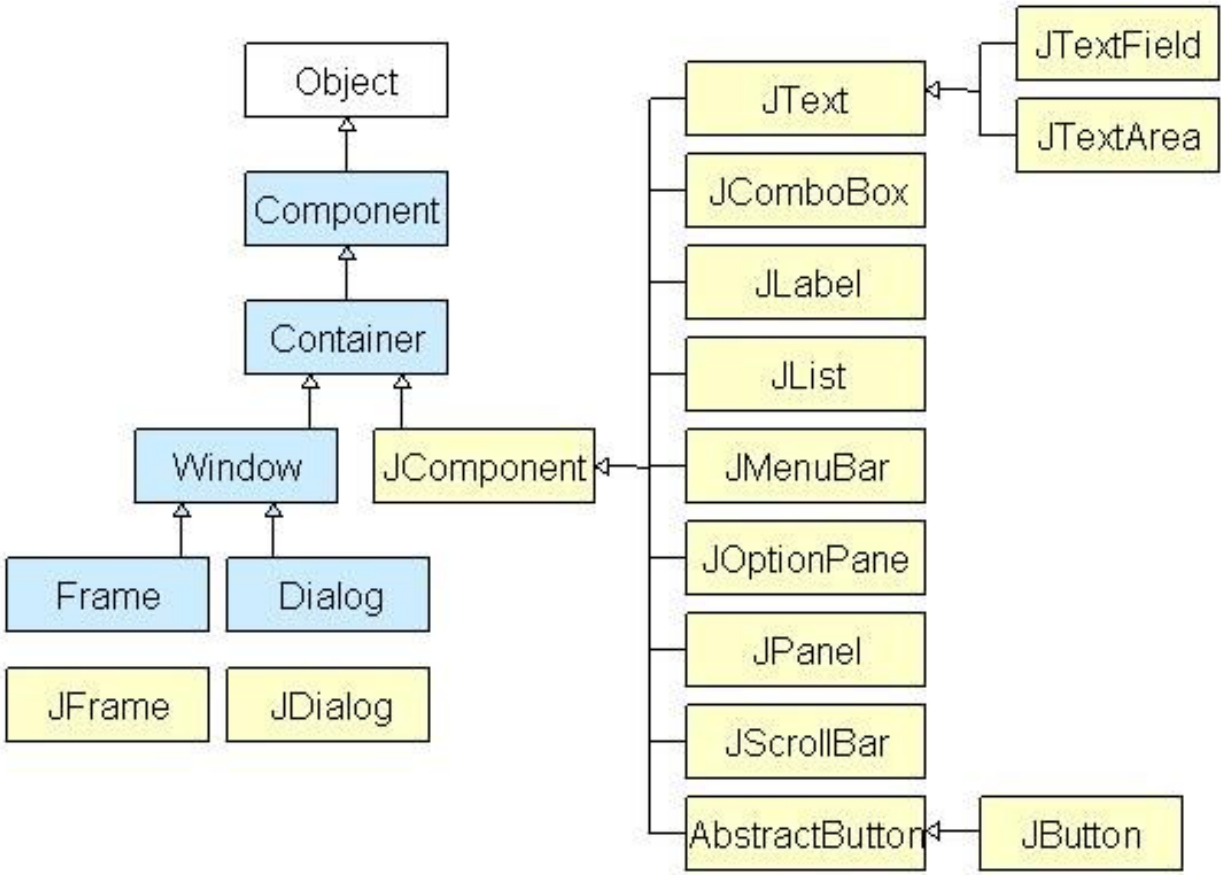
Gtk+

(C++)

Source: https://developer.gnome.org/gtkmm/stable/classGtk_1_1Object.html

Inheritance in the graphics libraries (Goal: **dyn. polymorphism**)

Qt (C++)



Source: https://creately.com/blog/diagrams/uml-diagram-types-examples/

Class diagram: Inheritance
- EXERCISE: *Tolkien* -

Among Tolkien's Mid-Earth LivingBeings, the good guys and the bad guys have two types:

- Orcs and Trolls on the BadSide,
- Elves and Humans on the GoodSide.

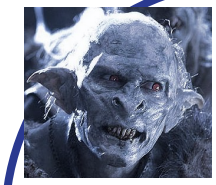
Objective: Draw a coherent UML class diagram with the underlined words as entities.

Parmi les Êtres_vivants de la terre du milieu de Tolkien, les gentils et les méchants ont chacun deux types :

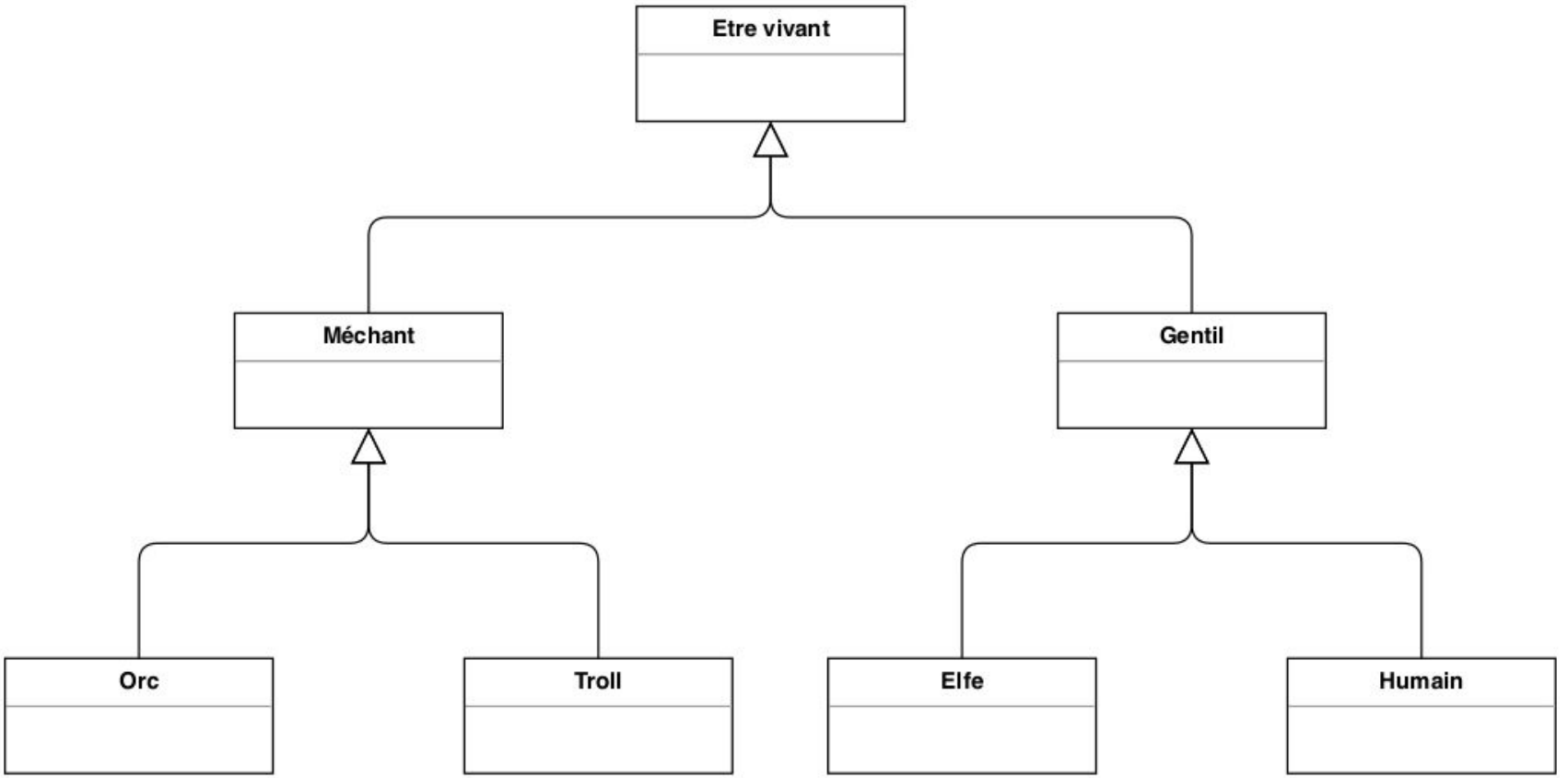
- Les Orcs et les Trolls sont Méchants,
- Les Elfes et les Humains sont Gentils.

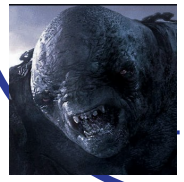
Objectif : Dessiner un diagramme de classe UML cohérent en vous servant des mots soulignés comme entités.

PS: Sorry for the aficionados of Tolkien's worlds for this light flight over middle earth, the hobbits will find themselves in this message.



Class diagram: Inheritance
- *CORRECTION Tolkien* EXERCICE -

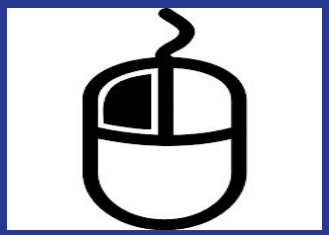




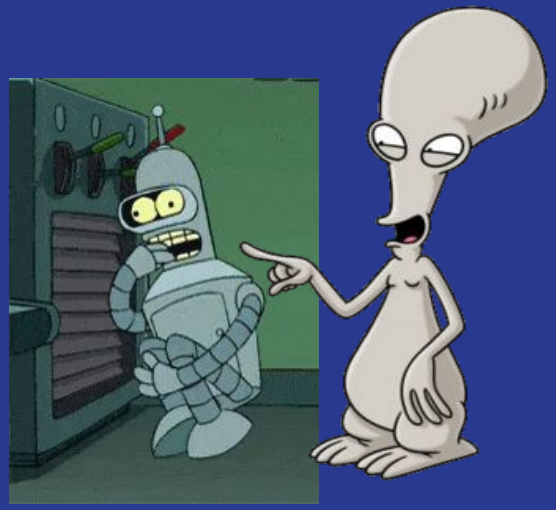
Question: Considering the unlikely union between a Troll and an Elf, what kind of inheritance would we have to do with?

Practical Work
/ Travaux Pratiques

Practical Work 3



Back to the lecture / Retour au cours

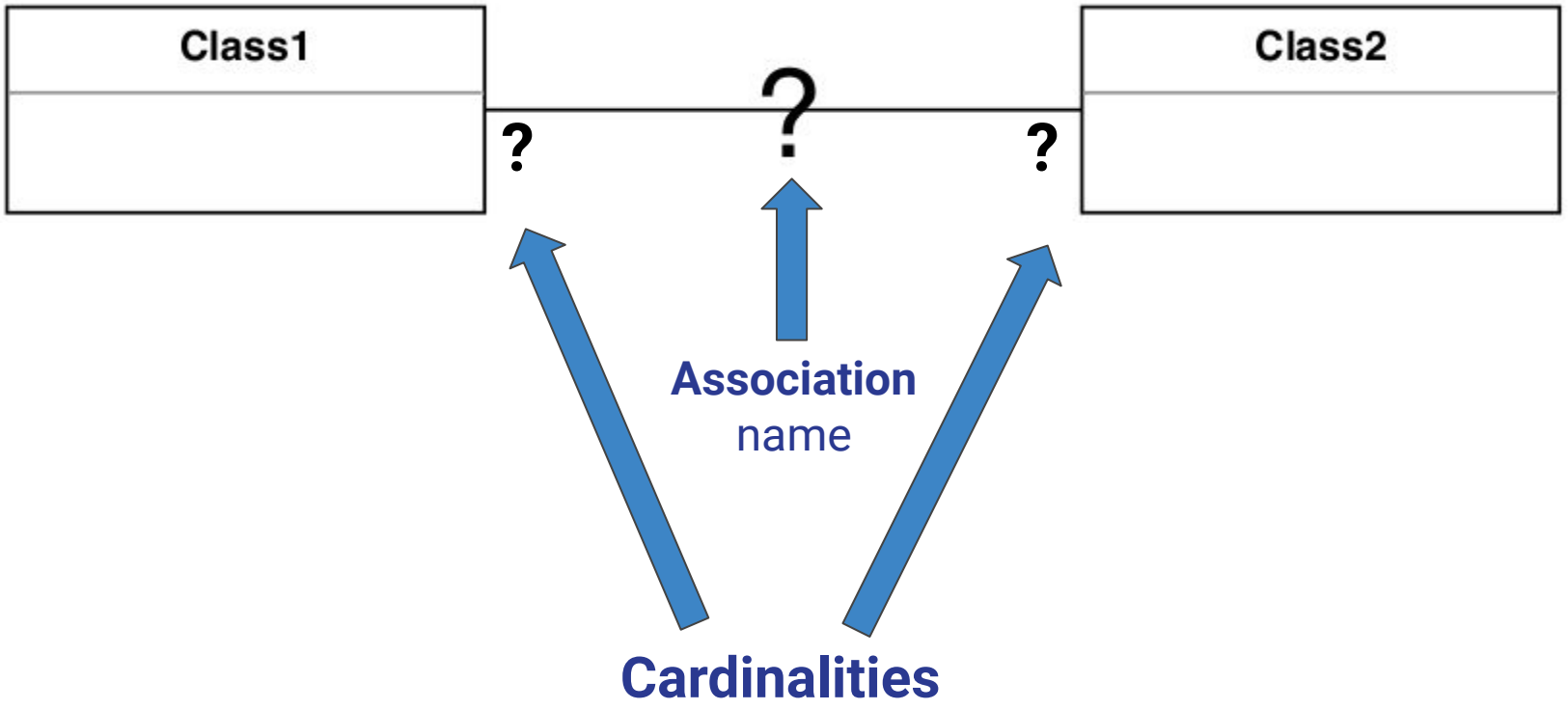


UML Class diagram

Associations & Cardinalities

Fr :
/ Associations
/ Cardinalités

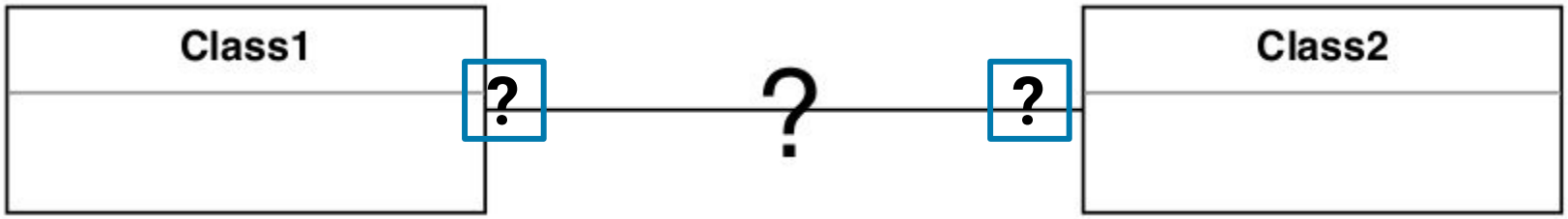
An association specifies the links between 2 classes.



Remarks:
(1) **There is no cardinality for inheritance relationships** (not considered as "association").
(2) Cardinalities are also called multiplicities.

UML Class diagram

Associations & Cardinalities

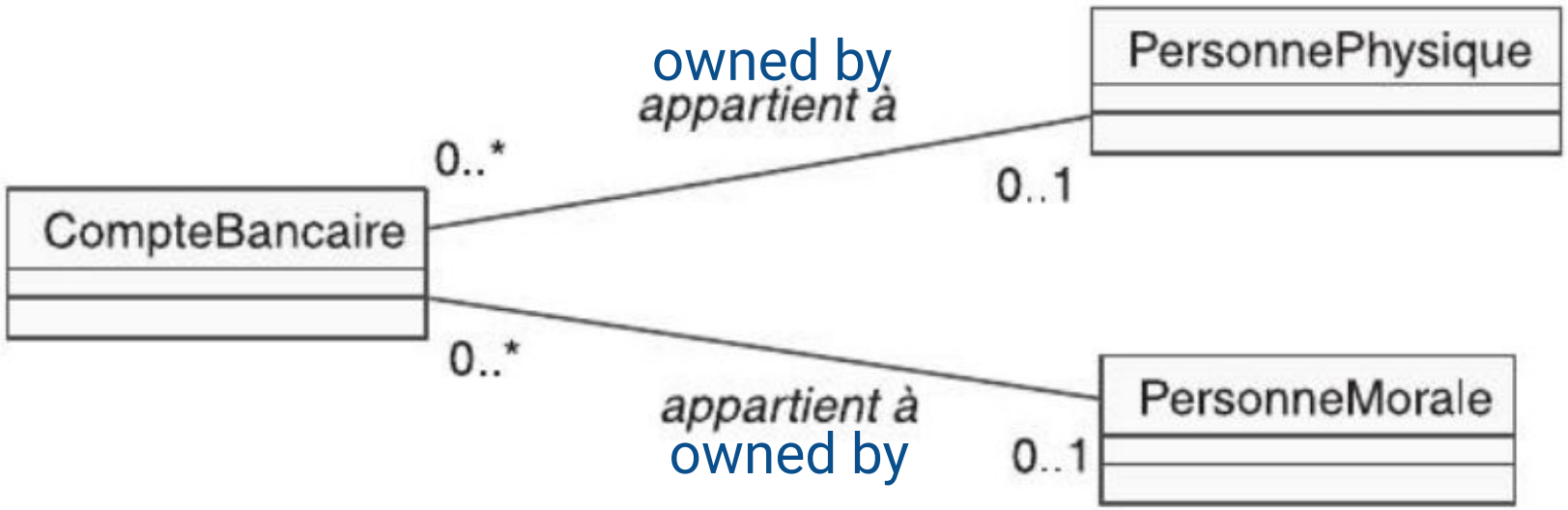


Cardinality	Alternative	Meaning
1	**1..1**	Exactly 1
*	**0..***	0 or 1 or more
n	**n..n**	Exactly n
1..*		1 or more
0..1		0 or 1 (equiv. “max 1”)
1..n		1 or more

Difference between **n** et * :

- **n** is known,
- * is unknown.

Association Simple



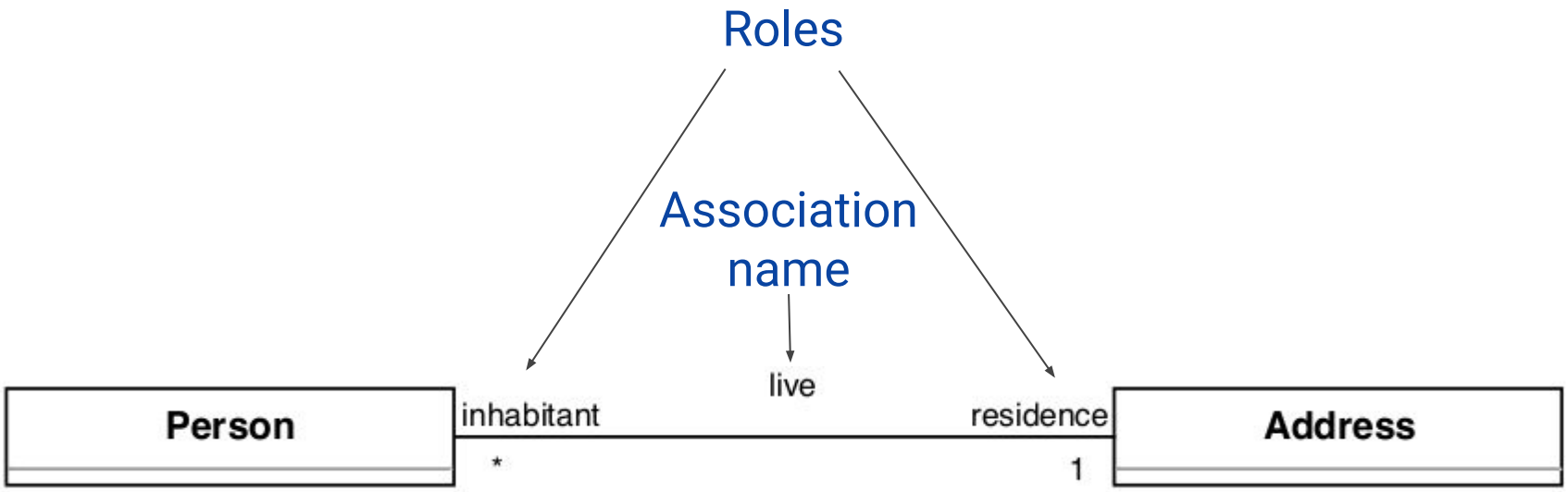
Cardinalities details:

- A bank account is **owned by 0 or 1 person** (moral or physical): **0..1**
- A person (Moral or Physical) **owned one or more** bank accounts: **0..***

Ref: “UML 2.5 par la pratique, Roques”.

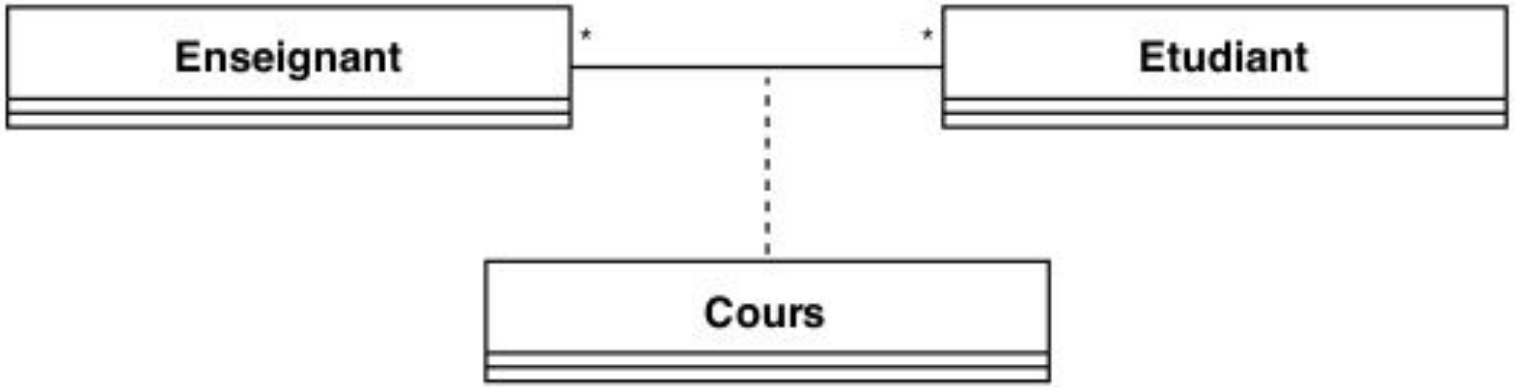
Association

We can specify:
- The name of the association,
- The role of each class.



Classe d'Association

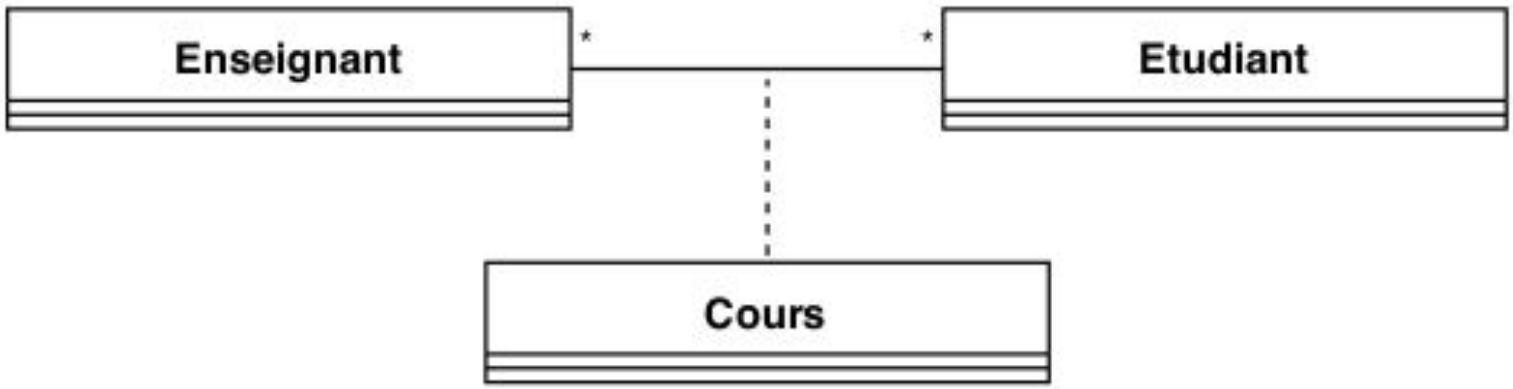
An association class is inseparable from the association between two classes. It allows a strong link to be modeled without going into the details of attributes and methods. It is used in the early stages of a project.



Une classe d'association est indissociable de l'association entre deux classes. Elle permet de modéliser un lien fort sans rentrer dans le détail des attributs et méthodes. Elle est utilisée dans les premières étapes d'un projet.

Classe d'Association

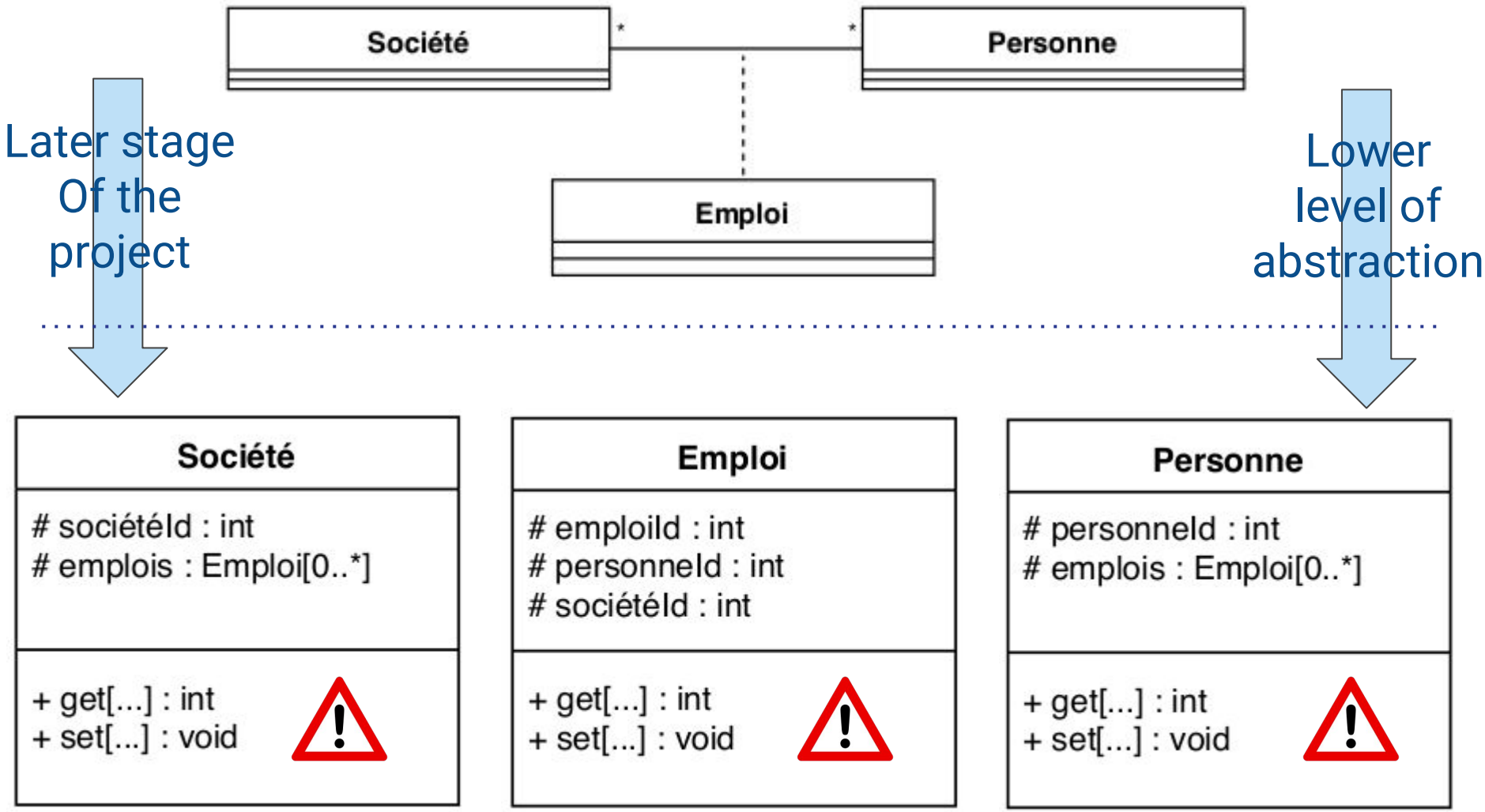
Mnemonic aid: **if the link is broken between the two main classes, the third is no longer necessary.**
> On the example: If the link is broken between teachers and students, the course no longer exists.



Aide mnémotechnique : **si le lien est rompu entre les deux classes principales, la troisième n'a plus lieu d'être.**
> Sur l'exemple : Si le lien est rompu entre enseignants et étudiants, le cours n'existe plus.

Diagramme de classe

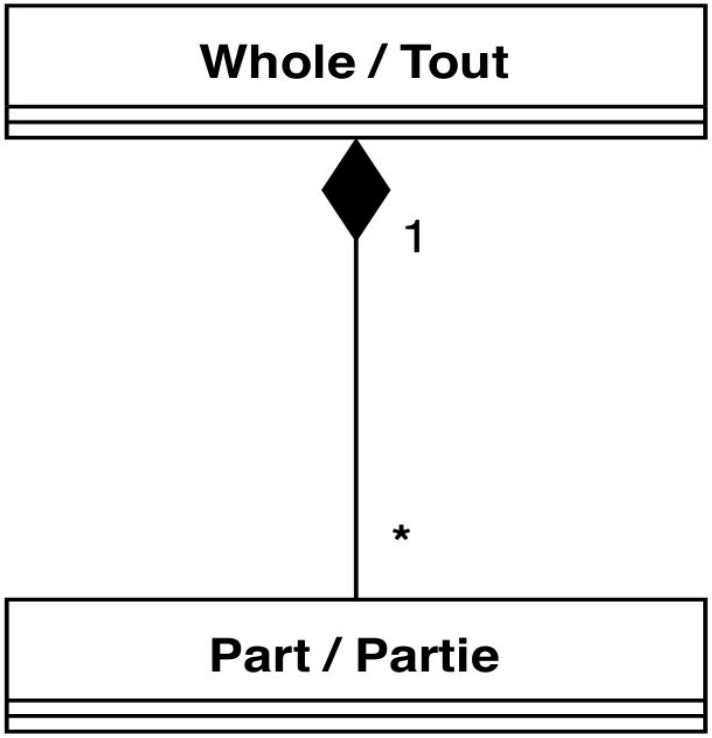
Classe d'Association



> Example: If the link is broken between Société and Personne, there is no more Emploi.

/ > Exemple : Si le lien est rompu entre Société et Personne, il n'y a plus d'Emploi.

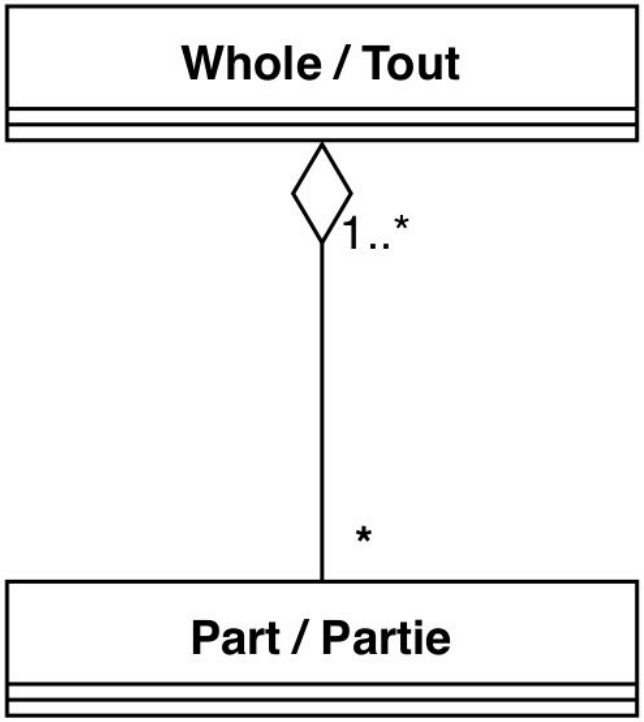
Composition



If we destroy an instance of a **Whole** class, the object of the **Part** class which is linked to the first one will disappear.

Si on détruit une instance de la classe **Tout**, l'objet de la classe **Partie** qui est liée à la première, va disparaître.

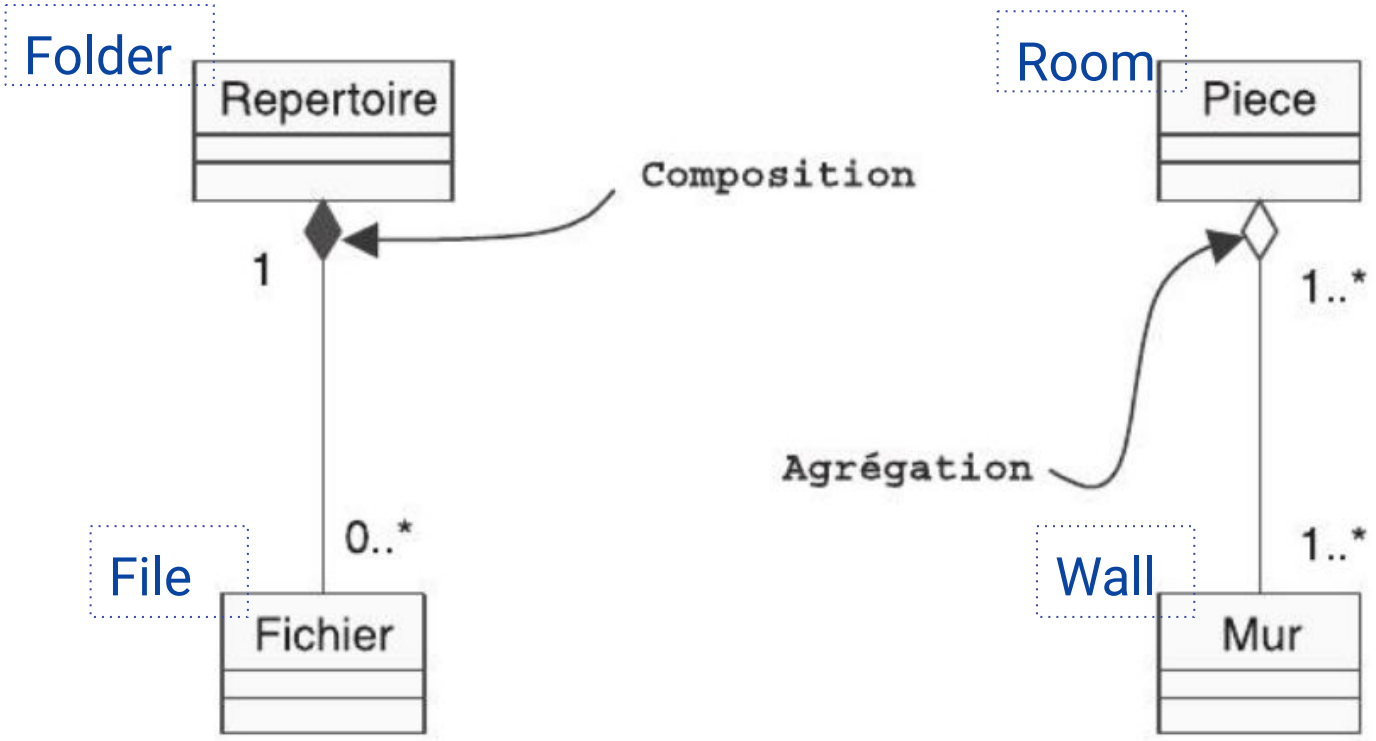
Aggregation / Agrégation



If we destroy an instance of the **Whole** class, the instance of the **Part** class which is linked to the first one will not disappear.

Si on détruit une instance de la classe **Tout**, l'instance de la classe **Partie** qui est liée à la première, ne va pas disparaître.

types of Association between classes
Example : Aggregation & Composition



Ref: “UML 2.5 par la pratique, Roques.”

Class diagram : Aggregation & Composition
- Exercise: *JPod* -

> A friend only understands UML and its diagrams. You try to explain to him why he didn't lose all of his .mp3 songs when he mistakenly deleted all the playlists in his jPod.
> Draw a UML diag. with the **Song**, **Album**, and **Playlist** classes and their relationships.

> Un·e ami·e ne comprend que le langage UML. Vous essayez de lui expliquer pourquoi il n'a pas perdu tous ses .mp3 lorsqu'il a supprimé par erreur toutes les *playlists* de son jPod.
> Dessiner un diag. UML avec les classes **Morceau** (titre), **Album** et **Playlist** ainsi qu'avec leurs relations.

Class diagram : Aggregation & Composition
- EXERCISE: *FS* -

- Represent associations between **File**, **Shortcut** and **Folder** into a UML class diagram as they exist in a operating system.
- Think about the **Folder** class, and how to represent the fact that a folder contains "*" subfolders and that a subfolder is contained in only one directory.

- Représentez les associations entre **Fichier**, **Raccourci** et **Dossier** dans un diagramme de classes telles qu'elles existent dans un système d'exploitation.
- Réfléchir également à la classe **Répertoire**, et à comment représenter le fait qu'un répertoire contient '*' sous-répertoires et qu'un sous-répertoire n'est contenu que dans un seul répertoire.

Class diagram : Aggregation & Composition
- EXERCISE *GEOGRAPHY* -

- Link the **Country**, **City** and **Capital** classes together. Think about everything that can happen (war etc.).
- name, language, currency, nbOfInhabitants, Area are the attributes that can appear in at least one class.

- Lier les classes **Pays**, **Ville** et **Capitale** entre elles. Pensez à tout ce qui peut se passer (guerre etc.).
- nom, langue, monnaie, nbHabitants, superficie sont autant d'attributs qui peuvent apparaître dans au moins une classe.

Class diagram : Aggregation & Composition
- EXERCISE : *Chess 1* -

By taking all the chess pieces, and differentiating them by name (e.g., the **King** class), model the links between a **Player** and his pieces during a game with a UML class diagram. Reminder: all **Pawn**s can be changed into **Queen**, **Knight** etc.

En reprenant toutes les pièces d'un jeu d'échecs, et en les différenciant par leur nom (e.g., la class **Roi**), modéliser les liens entre un **Joueur** et ses pièces durant une partie grâce à un diagramme de classe UML. Rappel : tous les **Pion**s peuvent se changer en **Reine**, **Cavalier** etc.

Class diagram: Inheritance, Aggregation & Composition
- EXERCICE : *Chess 2* -

Add the **ChessBoard**, **Tile** and **Piece** classes. Represent the correct relationship between:

- **Piece** and the different forms it can take (**Pawn**, **King** etc.),
- **Tile** & **ChessBoard**, **Piece** & **ChessBoard**,
- Place the attributes and methods in the appropriate classes while determining the data types and their abstraction:
  - color, moved (related to the castling) , check (king),
  - move(), getOutOfTheBoard(), castling(), promote().

Ajouter les classes **Echiquier**, **Case** et **Pièce**. Représenter la bonne relation entre :

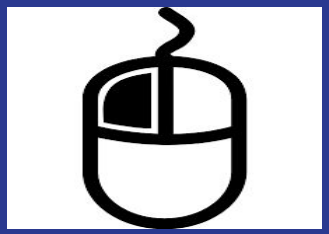
- **Pièce** et les différentes formes qu'elle peut prendre (**Tour**, **Pion**, etc.).
- **Case** & **Echiquier**, **Pièce** & **Echiquier**,
- Placer les attributs et méthodes dans les classes qui conviennent tout en déterminant les types de données et leur abstraction :
  - couleur, aBougé (lié au roque) , estEnEchec (roi),
  - seDéplacer(), sortirDeLEchiquier(), roquer(), promouvoir().

Practical Work
/ Travaux Pratiques

Practical Work 4

&

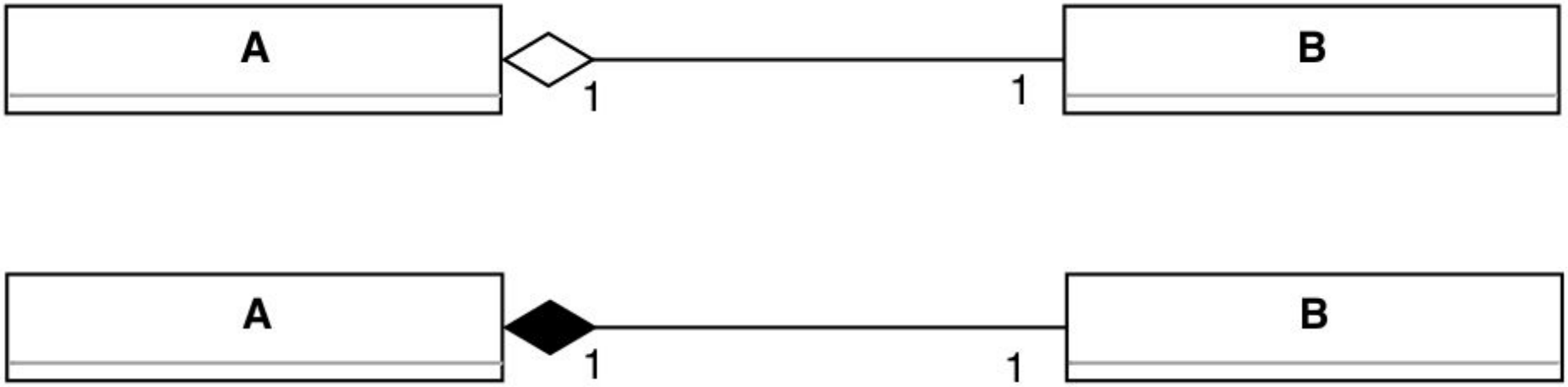
Practical Work 5



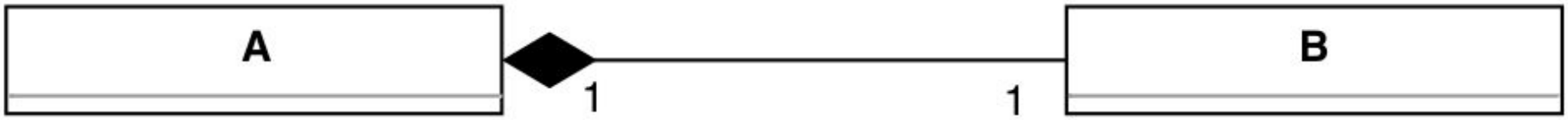
Back to the lecture

Aggregation & Composition
- JAVA -

Question: How to distinguish the case of **aggregation** and **composition** in JAVA?



Example of Composition
- JAVA -



The instance of class *B* which makes up an instance of A **is created when A is constructed**.

The link between these two classes from the point of view of B, **is set by the Setter setA**.

A.java

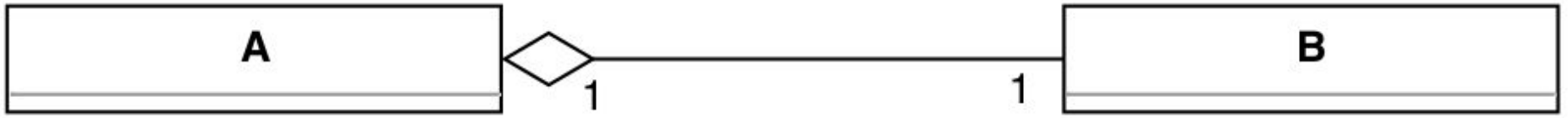
```
1
2  public class A {
3      protected B b;
4
5      public A() {
6          this.b = new B();
7          this.b.setA(this);
8      }
9  }
10
11
12
```

B.java

```
1
2  public class B {
3      protected A a;
4
5      public A getA()
6      {
7          return a;
8      }
9
10     public void setA(A a)
11     {
12         this.a = a;
13     }
14 }
```


You might find in the literature no link from B to A (even if JAVA does it implicitly).

Example of Aggregation
JAVA



The link between the two classes from the point of view of B as from the point of view of A, is informed by the **Setters**.

The difference lies in the fact that **it is the setB of A which will make the two links** "It is A who has the monopoly of the links".

A.java

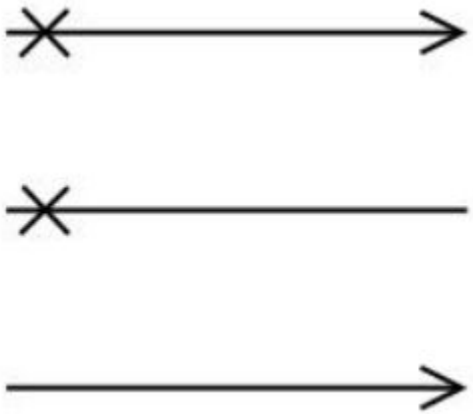
```
1
2  public class A {
3      protected B b;
4
5      public A() {
6      }
7
8      public void setB(B b)
9      {
10         this.b = b;
11         b.setA(this);
12     }
13 }
```

B.java

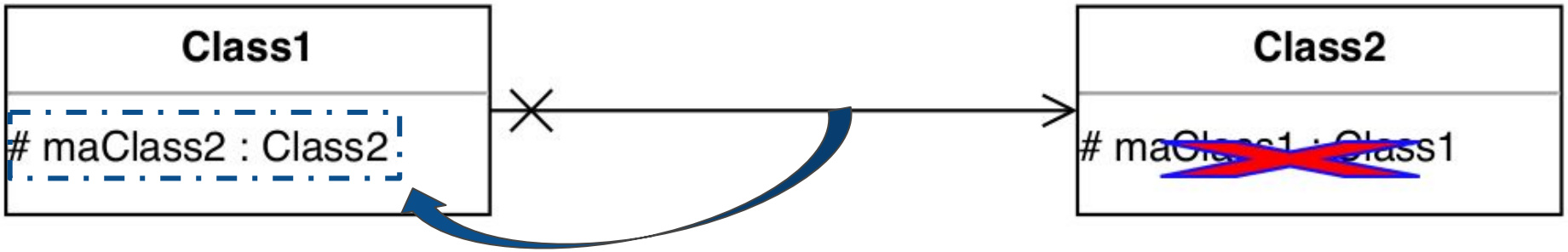
```
1
2  public class B {
3      protected A a;
4
5
6
7
8
9
10     public void setA(A a)
11     {
12         this.a = a;
13     }
14 }
```


You might find in the literature no link from B to A.

Restricted associations with the navigation-arrow symbol

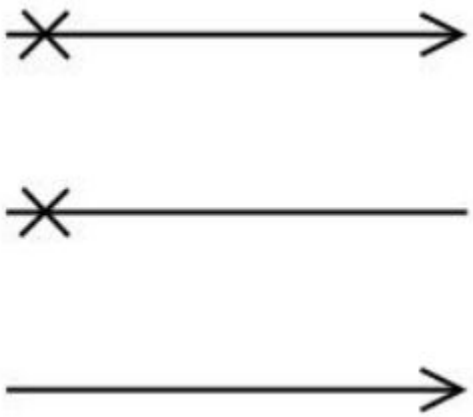


- These 3 arrows model **the same thing**,
- They limit an association to one direction.



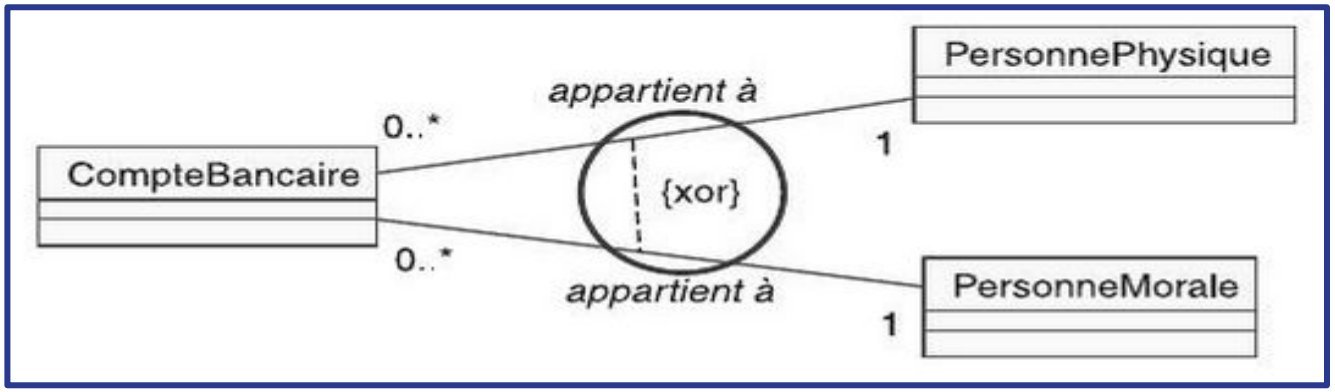
Restricted associations with the navigation-arrow symbol

Example

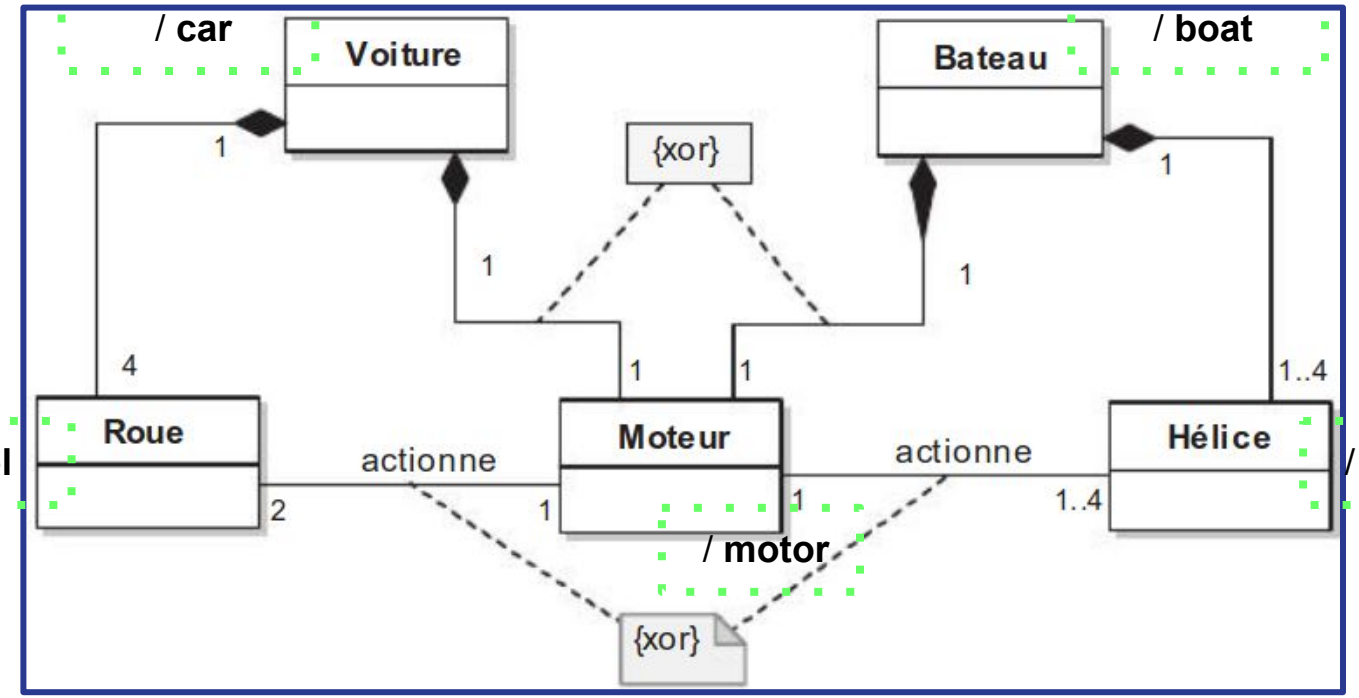


- These 3 arrows model **the same thing**,
- They limit an association to one direction.

Special Associations - 2 examples of {xor}

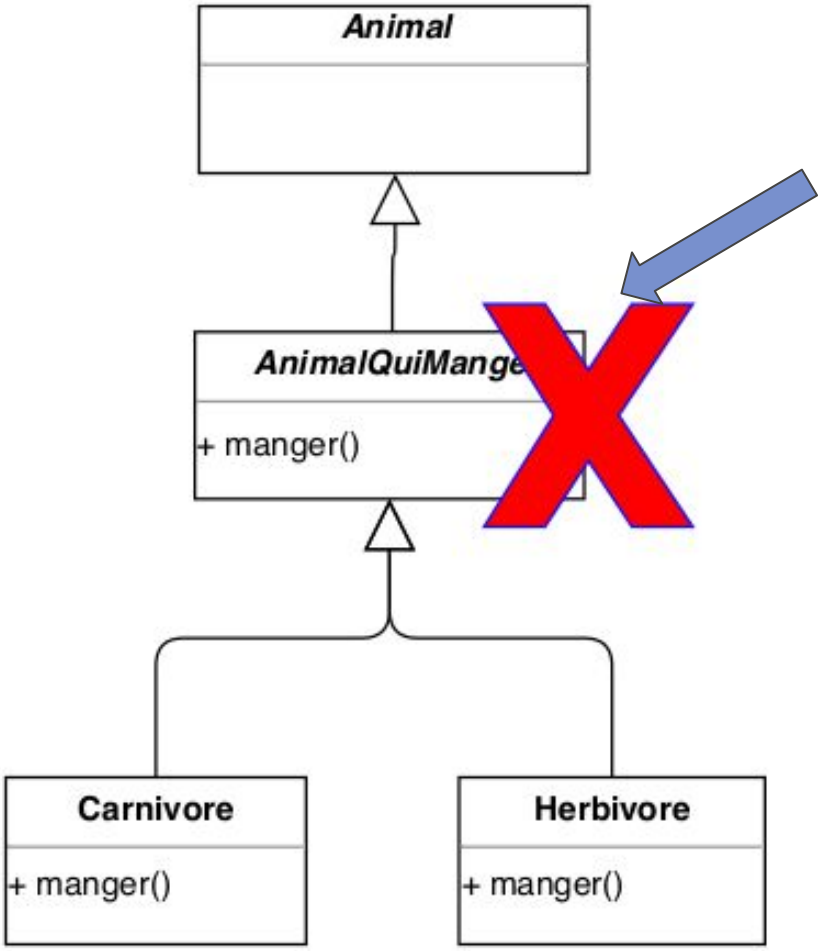


{xor} = {eXclusive OR}



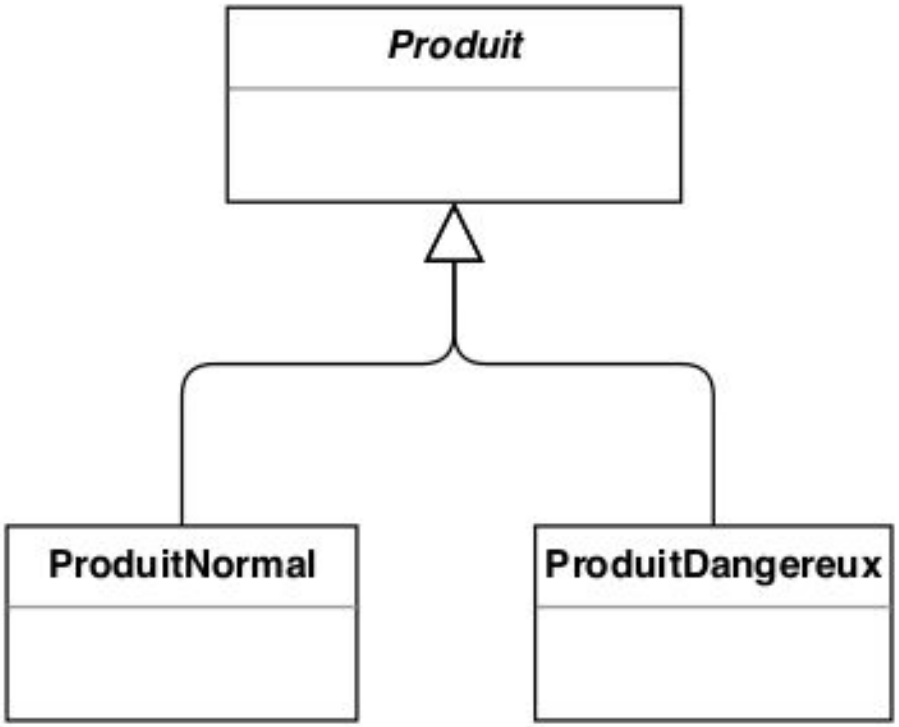
Ref: “UML 2.5 par la pratique, Roques”.

Some details on inheritance and associations



- **Avoid unnecessary tree structure**:
  - An inheritance is only justified if the subclass has at least one specific attribute, method or association;
- All associations of a superclass apply to subclasses.

Some details on inheritance and associations



Tiny Exercise “Product”

- Is this inheritance justified?
- If the answer is no (...), it needs to be improved!

Class Diagram (UML & JAVA)

Interface concept

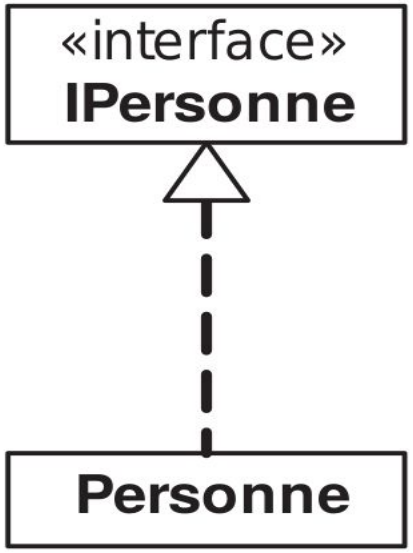
- **Must be implemented** by at least 1 class,
- **A class can implement several interfaces**,
- **An interface can be implemented by several classes**,
- Brings together a coherent set of properties and operations.

- Remarks:
  - An interface **defines** a kind of **contract** that must be respected by the classes which implement the interface.
  - **Solves problems related to multiple inheritances.**
  - **We can compare it to an abstract class having only constants and abstract methods** (Java ≥ 8).

Class Diagram (UML & JAVA)

Interfaces in UML

- Represented as a class,
- NO *italic*
- Indicated by << *interface* >> above the class name.



Another (but rare) way to represent an interface.

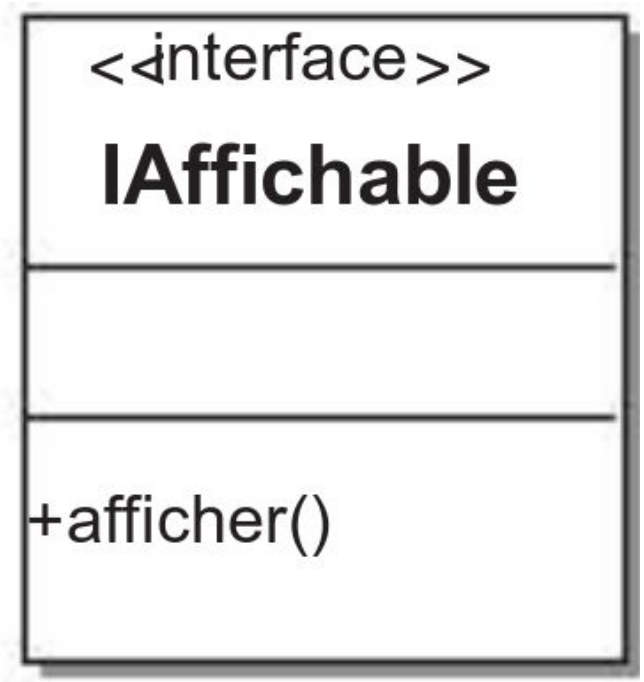
Interface & JAVA

In **Java**: unlike UML and C++, **only simple inheritance is allowed**, but can be “replaced” by interfaces.

interfaceName.java

```
1
2 public interface interfaceName {
3     // declare constant fields
4     // declare abstract methods
5 }
6
```

Example : UML & JAVA



UML

(Class diagram)

```
public interface IAffichable {
    public void afficher();
}
```

JAVA

Interface & JAVA

Properties of interfaces in Java 7 and earlier

- interfaces can be realized (i.e. **`implemented`**) by **several different classes**,
- **the classes can implement several different interfaces**,
- **All the methods of an interface are abstract**,
- All the methods of an interface must be implemented by the classes that implement it.

Since **Java 8**

- A **default implementation** can be provided (with the **default** keyword),
- Possibility of having static methods defined in the interfaces.

Example JAVA Version ≥ 8

```
2  public interface interfaceName {
3      // declare constant fields
4      public static final String exemple = "voilalexemple";
5      // declare abstract methods
6      public double otherMethod() ;
7      // declare default methods
8      default public double surface()
9      {
0          return - 1 ;
1      }
2      default public double perimetre()
3      {
4          return - 1 ;
5      }
6  }
```

Example JAVA
Implementation of an interface by a class

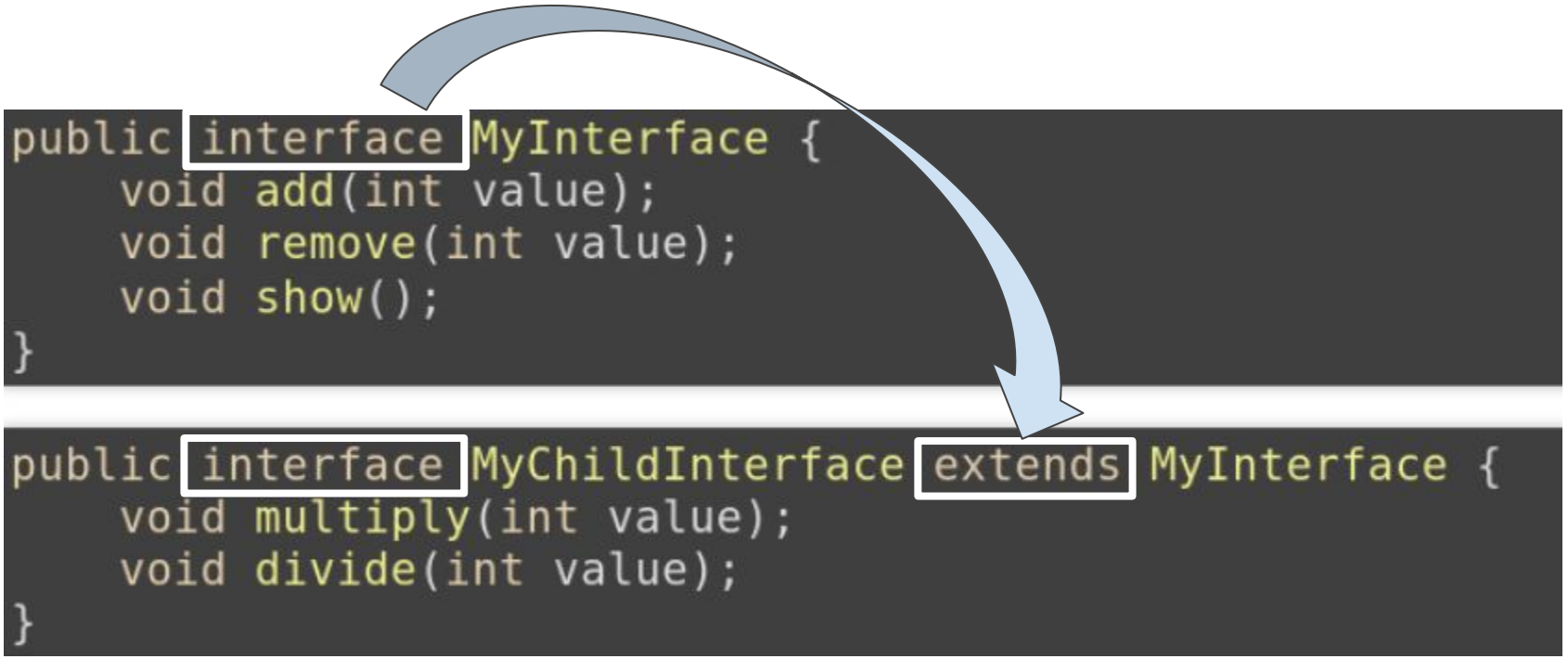
```java
public interface MyInterface {
    void add(int value);
    void remove(int value);
    void show();
}
```

```java
public class MyInterfaceRealization implements MyInterface {
    private int x;
    public void add(int value) {
        x += value;
    }
    public void remove(int value) {
        x -= value;
    }
    public void show() {
        System.out.println(x);
    }
}
```


Ref: http://www.ferdinandpiette.com/isen/concept_objet

Example JAVA

Inheritance between interfaces

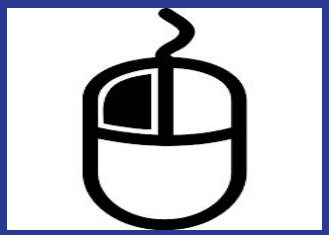


```
public interface MyInterface {
    void add(int value);
    void remove(int value);
    void show();
}
```

```
public interface MyChildInterface extends MyInterface {
    void multiply(int value);
    void divide(int value);
}
```


Ref: http://www.ferdinandpiette.com/isen/concept_objet

Practical Work 6



Java & interfaces

For C++: Try to adapt to the language specificities.

Practical Work 6

Implement a JAVA program with:

- a **Polygon** interface with an abstract method **getArea**() and a default method **getPerimeter**() which displays the perimeter of a polygon whose sides are given as parameters;
  - example : ...***getPerimeter***(3,8,9,10) displays 30.
- A **Triangle** class implementing the **Polygon** interface with its 3 sides (integer) as private data. A constructor retrieves the values of the 3 sides. **getArea**() "**Triangle** version" will output the area of the triangle.
- A main function instantiating one or more Triangles and where all the methods of the program are called and displayed.
- "BONUS": Try with other **Polygon**s such as **Rectangle**, **Pentagon**, **Hexagon** etc.

Java & interfaces

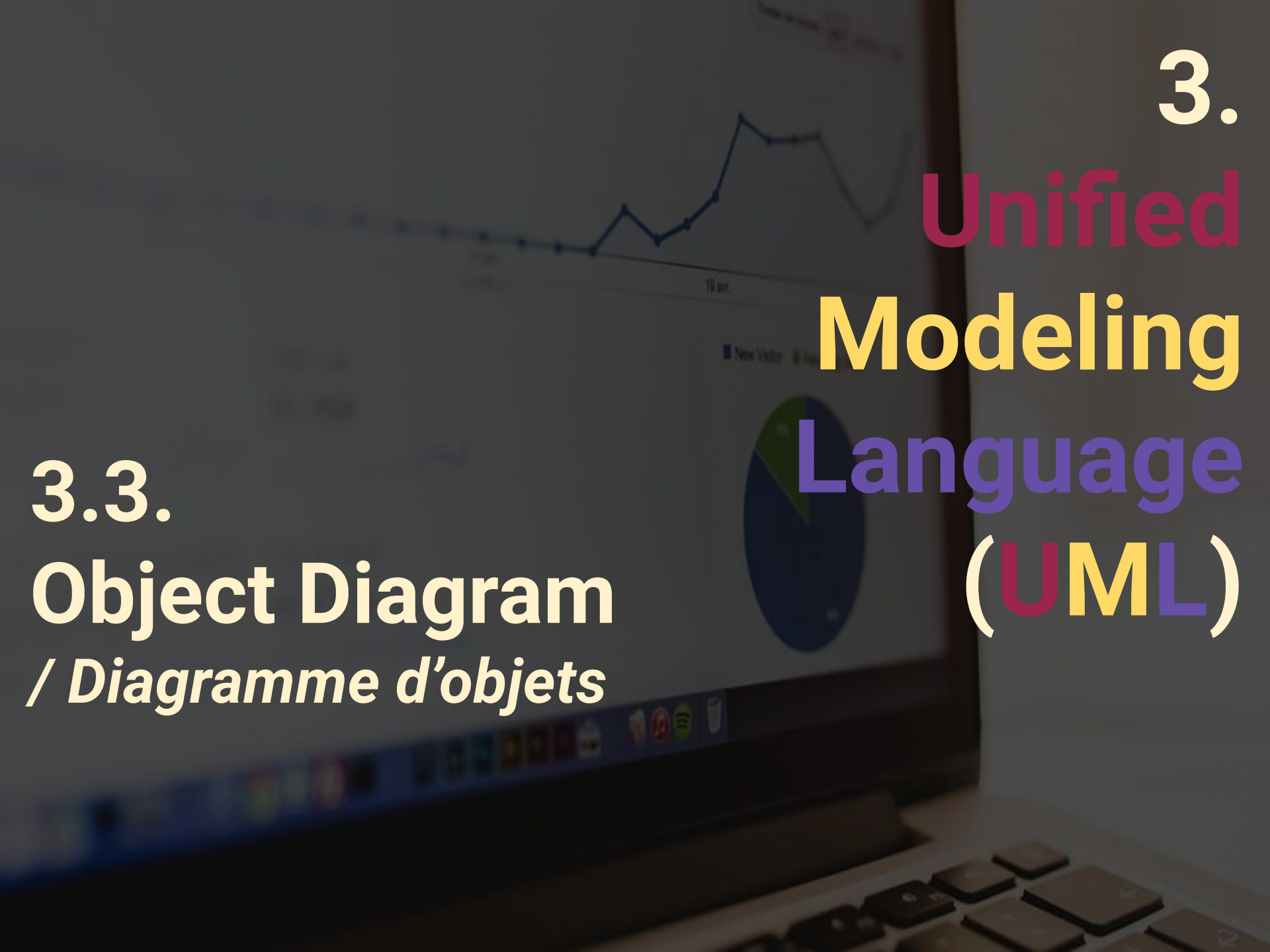
Practical Work 6

Implémenter un programme JAVA avec :

- une interface ***Polygon*** ayant une méthode *abstraite* ***getArea()*** et une méthode par défaut ***getPerimeter()*** qui affiche le périmètre d'un polygone dont les côtés sont donnés en paramètres ;
  - exemple : ...***getPerimeter***(3,8,9,10) affiche 30.
- Une classe **Triangle** implémentant l'interface ***Polygon*** avec comme données privées ses 3 côtés (entiers). Un constructeur récupère les valeurs des 3 côtés. ***getArea()*** "version **Triangle**" va afficher l'aire du triangle.
- Une fonction *main* instanciant un ou plusieurs **Triangle**s et où toutes les méthodes du programme sont appelées.

- "BONUS": Tenter l'expérience avec d'autres Polygones tels que le Rectangle, Pentagone, Hexagone etc.

Back to the lecture / Retour au cours



3. Unified Modeling Language (UML)

3.3. Object Diagram

/ Diagramme d'objets

Object diagram

An object diagram shows:

- **Class instances**,
- Links between objects,
- The state of the system at a given time (i.e. attributes values).

Somehow:

- the class diagram models the rules,
- **the object diagram models the facts.**

Note: The class diagram is often sufficient. The object diagram can express a special case or facilitate the understanding of a complex class diagram.

Un diag. d'objets représente :

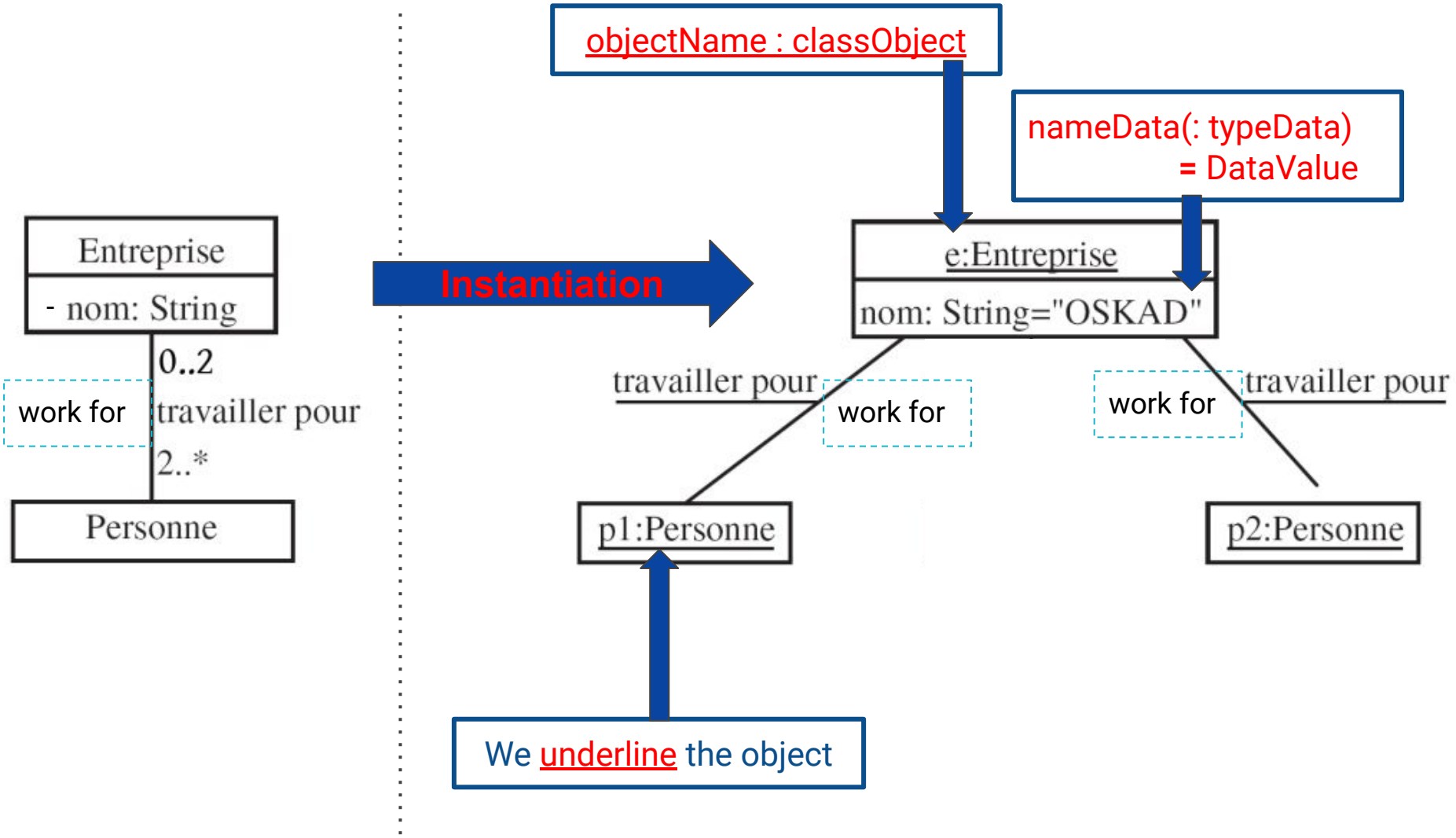
- des **instances de classes**,
- les **liens entre les objets**,
- l'état du système à un moment donné (valeurs des attributs),

D'une certaine manière :

- le diagramme de classe modélise les règles,
- **Le diagramme d'objet modélise les faits**.

Note : le diag. de classe est souvent suffisant. Le diag. d'objets peut exprimer un cas particulier ou faciliter la compréhension d'un diagramme de classe complexe.

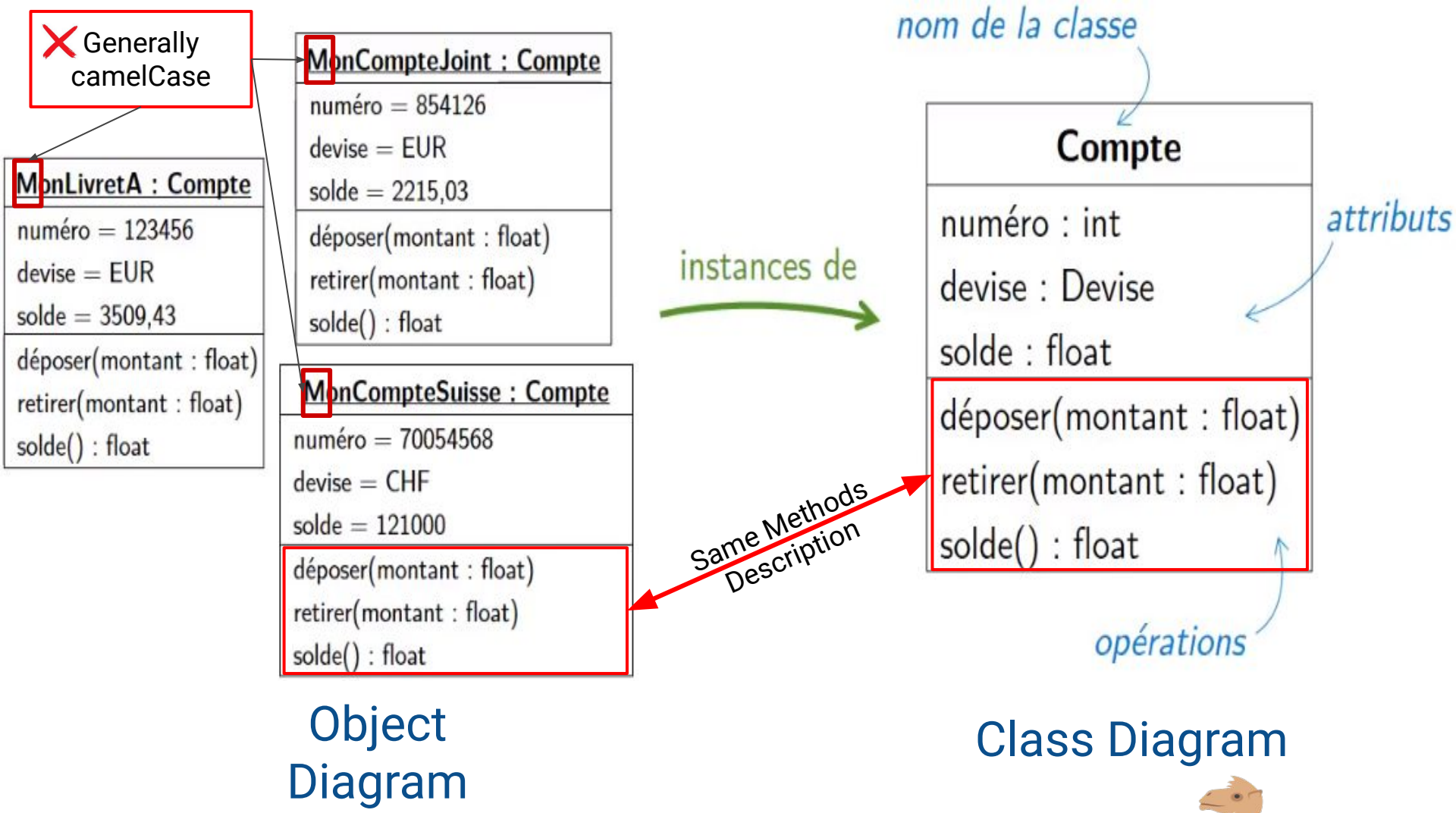
Object Diagram - Example 1



Class Diagram

Object Diagram

Object Diagram - Example 2

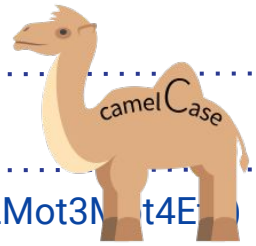


Object Diagram

Class Diagram

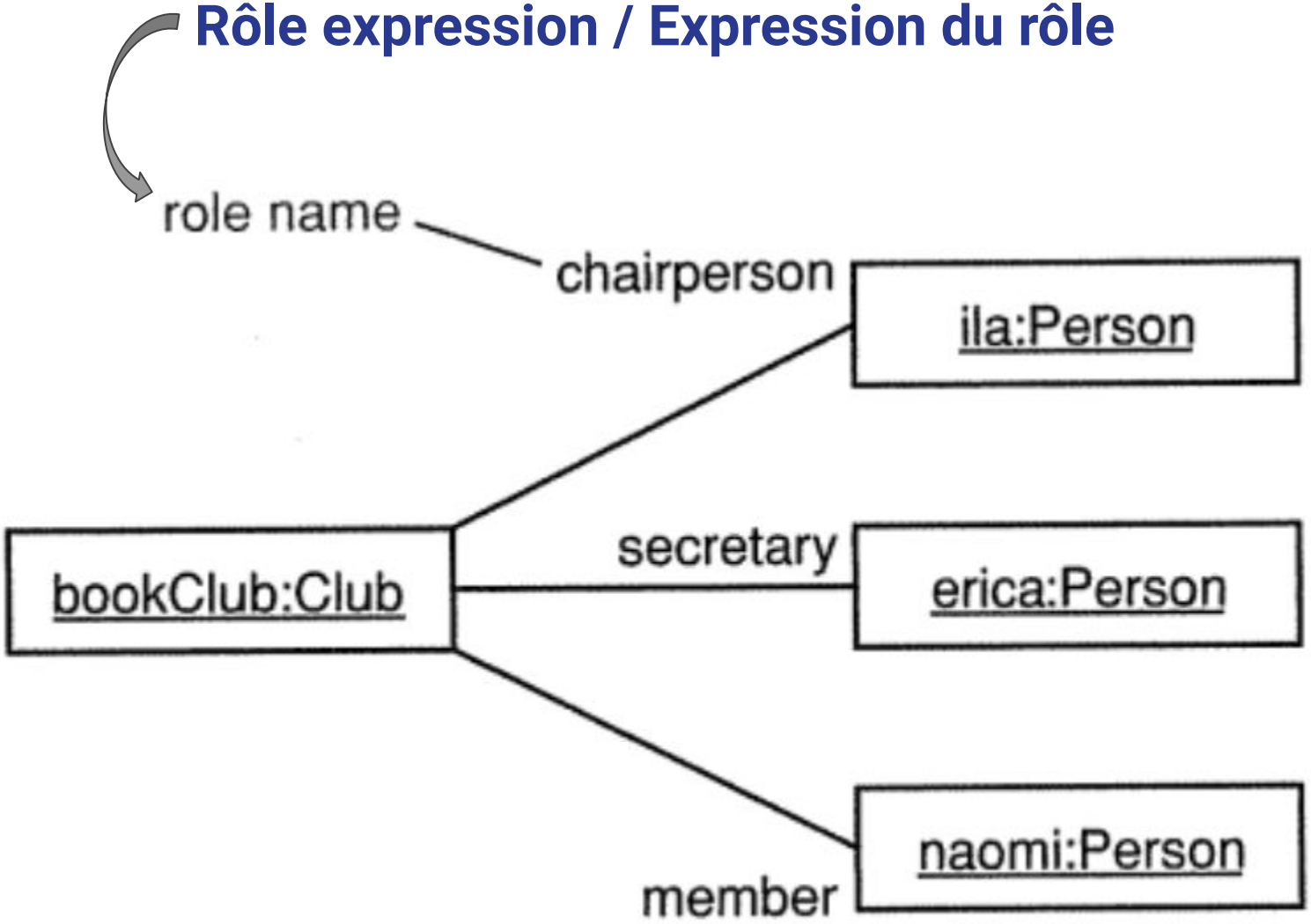
Ref: “Cours UML de L. Longuet”

Reminder: **Attributes** and **Methods** are more generally written in **camelCase**. (e.g., mot1Mot2Mot3M t4E)



Object Diagram - Example 3

Rôle expression / Expression du rôle

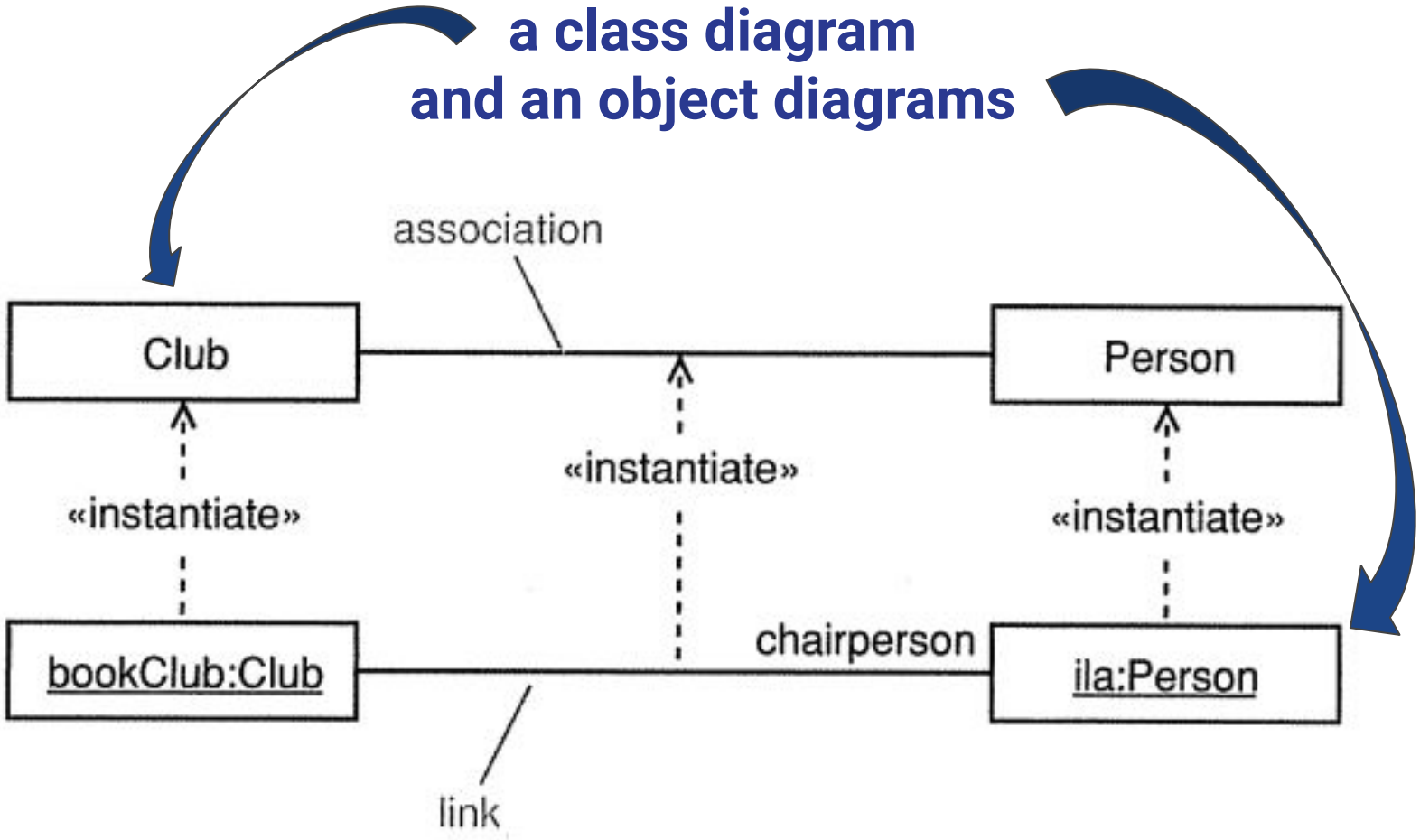


Object Diagram - Example 4

If necessary: mixing both types of diagrams

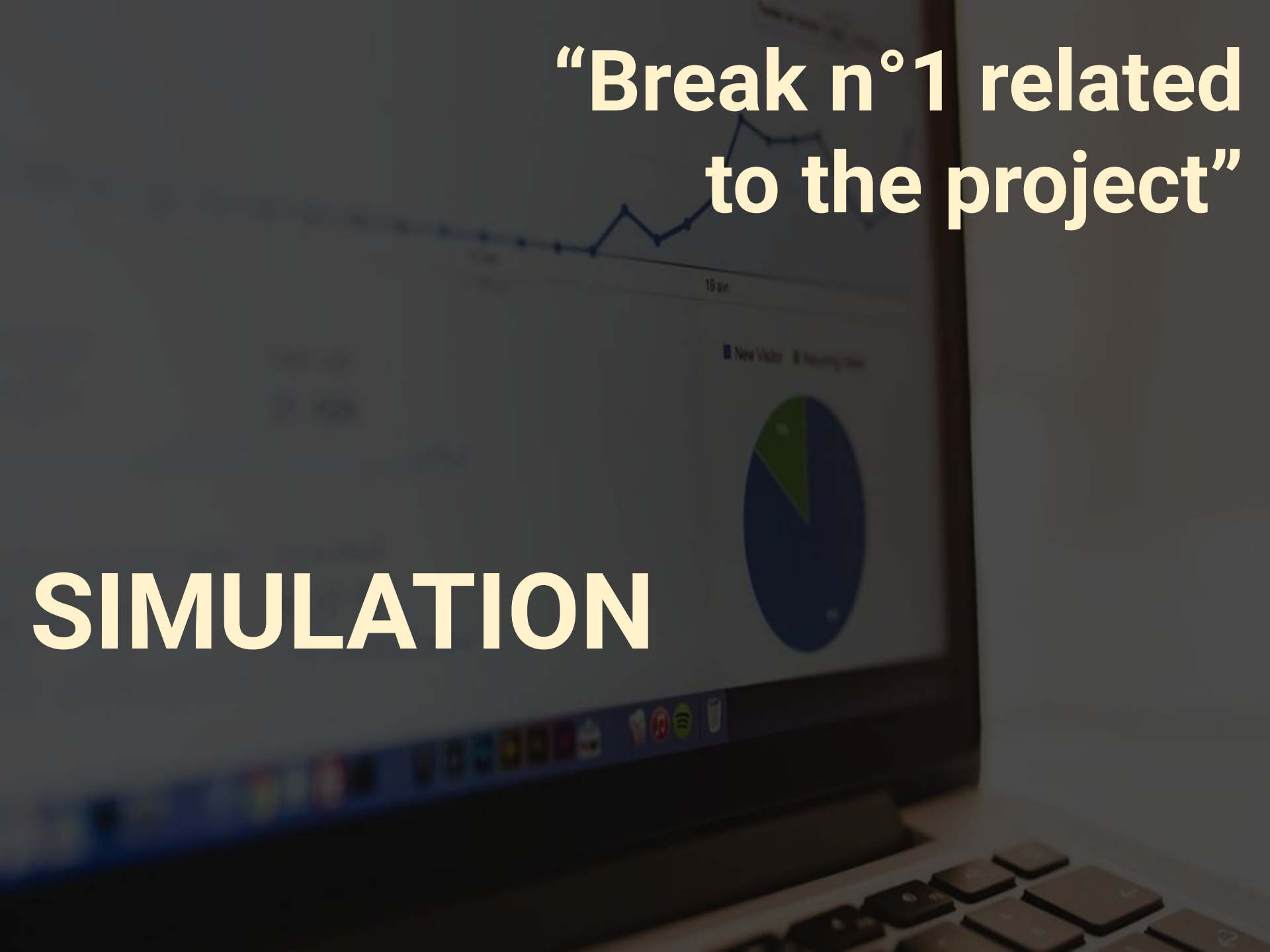
a class diagram

and an object diagrams



Object diagram
Exercise

- Draw an object diagram based on two classes:
  - **Polygon** (no data and no attribute),
  - **Point** (with x and y real types attributes),
  - and with these instantiations:
    - 1 **Polygon object** named ‘triangle’,
    - 3 **Point objects** all having a simple relation/link with ‘triangle’ named “PartOf” and with random (x,y) values.


“Break n°1 related to the project”
SIMULATION

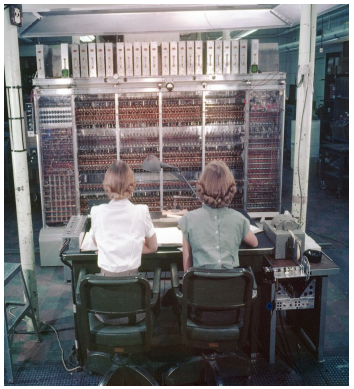
Simulation

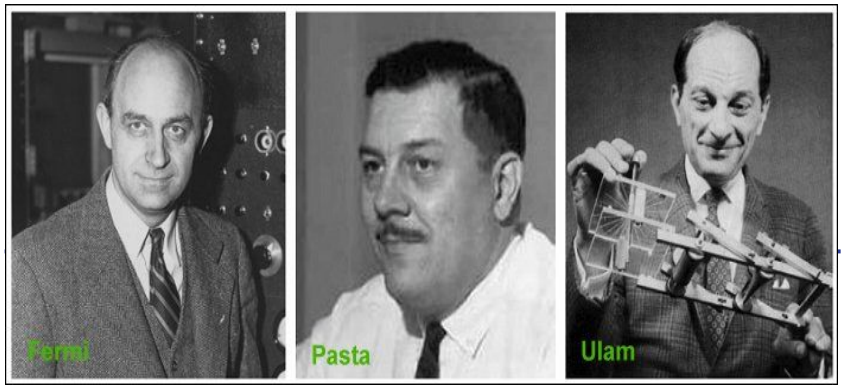
SECRETS d'HISTOIRE

- 2nd World War
  - Simulation (computer) within the framework of the **Manhattan project** in order to model the process of nuclear detonation,
  - Monte Carlo ;
- 1953
  - **Civil simulation** in theoretical physics,
  - 1st numerical simulation.

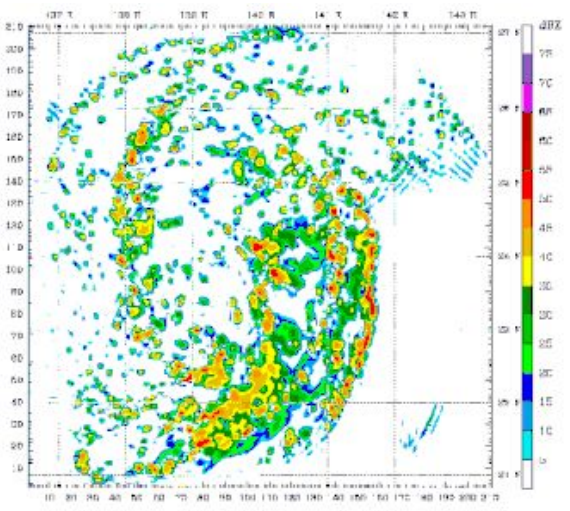
Manhattan Project

Fermi-Pasta-Ulam experiment





Example of SIMULATION
Climate & Weather



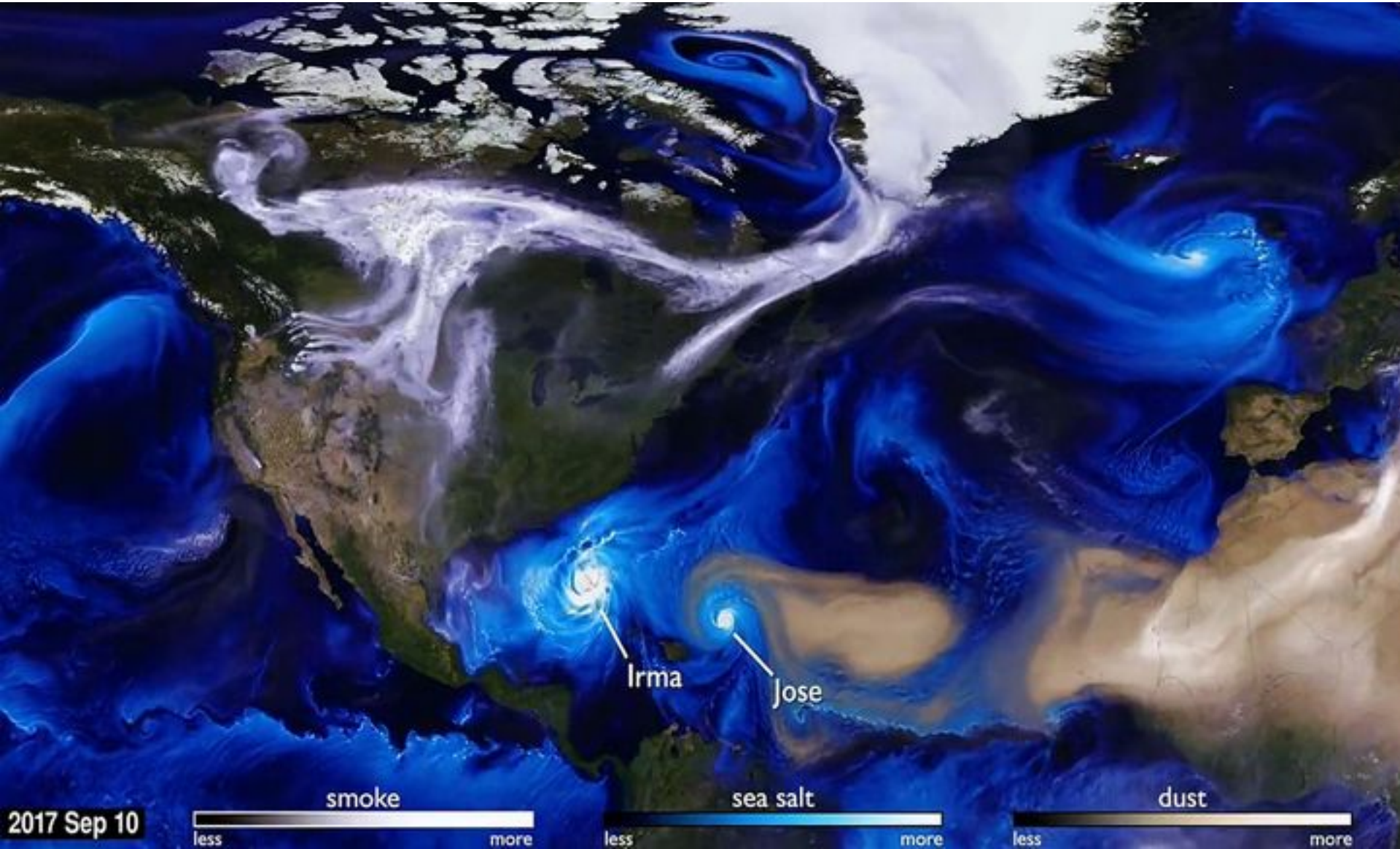
Simulation at the heart of forecasts (/Prévisions):

- Flood (/Inondation), Earthquake, etc.,
- (and even: simulation of economic wars!)

Scheme (*a simulation process life*):

- **Study of the System**,
- **Writing of a model** according to domain knowledge (functioning of the atmosphere, atmospheric phenomena, physical laws of gases, liquids and solids etc.),
- **Simulation development**,
- Target the **input data** of the simulation (e.g., current weather),
- **Analysis of outputs** (forecasts).

Example of SIMULATION
(Hurricanes/Ouragans - 2017)



SIMULATION &
Computing Power / Puissance de Calcul

- **Supercomputers are very often dedicated to simulation** in the following areas:
  - Weather and Climate,
  - Aerodynamics,
  - The resistance of the materials,
  - Acoustics (e.g., ISEN Labo Samba),
  - Nuclear (military),
  - Biology (evaluation of complex models, e.g., animals, COVID-19),
  - At the movies (e.g .; battles in the Rings Of Power, GoT etc.),
  - Video games,
  - Simulated Quantum machines,
  - In IT (testing real-time algorithms),
  - In Optimization .... [etc.],
  - ... and even more and more in geopolitical!

Rank	System	Cores	Rmax (PFlop/s)	Rpeak (PFlop/s)	Power (kW)
1	**Frontier** - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE DOE/SC/Oak Ridge National Laboratory United States	8,730,112	1,102.00	1,685.65	21,100
2	**Supercomputer Fugaku** - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan	7,630,848	442.01	537.21	29,899
3	**LUMI** - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE EuroHPC/CSC Finland	1,110,144	151.90	214.35	2,942
4	**Summit** - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM DOE/SC/Oak Ridge National Laboratory United States	2,414,592	148.60	200.79	10,096
5	**Sierra** - IBM Power System AC922, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM / NVIDIA / Mellanox DOE/NNSA/LLNL United States	1,572,480	94.64	125.71	7,438

Unité de performance des processeurs

Nom	FLOPS
yottaFLOPS	10^{24}
zettaFLOPS	10^{21}
exaFLOPS	10^{18}
pétaFLOPS	10^{15}
téraFLOPS	10^{12}
gigaFLOPS	10^{9}
mégaFLOPS	10^{6}
kiloFLOPS	10^{3}

1 FLOPS : 1 floating point operation per second.

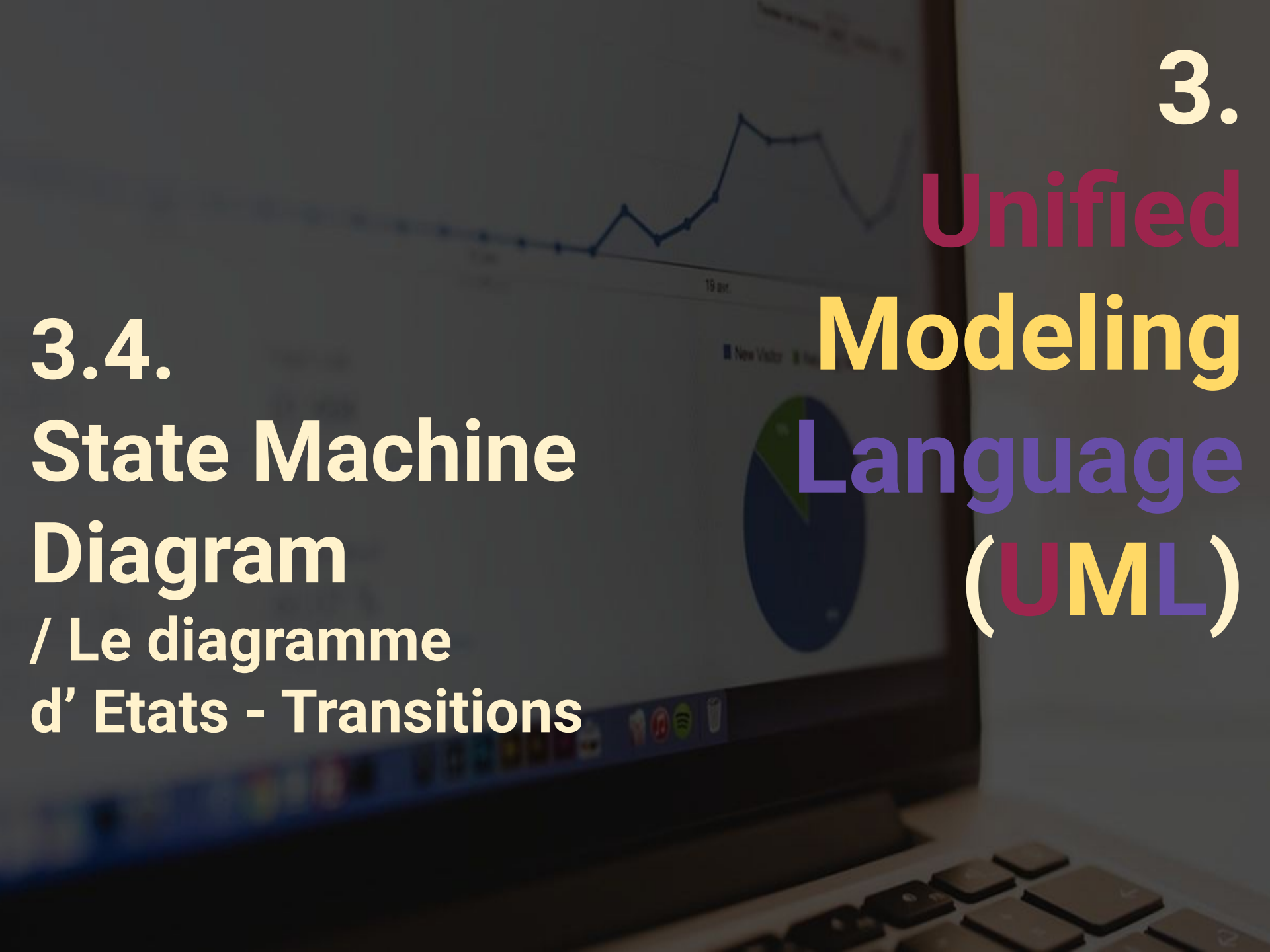
10	**Adastra** - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE Grand Equipement National de Calcul Intensif - Centre Informatique National de l'Enseignement Suprieur (GENCI-CINES) France	319,072	46.10	61.61	921

SIMULATION & Computing Power *the téra FLOPS race!* Ref: https://www.top500.org/lists/top500/list/2020/06/.

Fugaku

(**n°2** TOP500 au 06/2022)

More than 7 Millions of cores (ARM architecture)



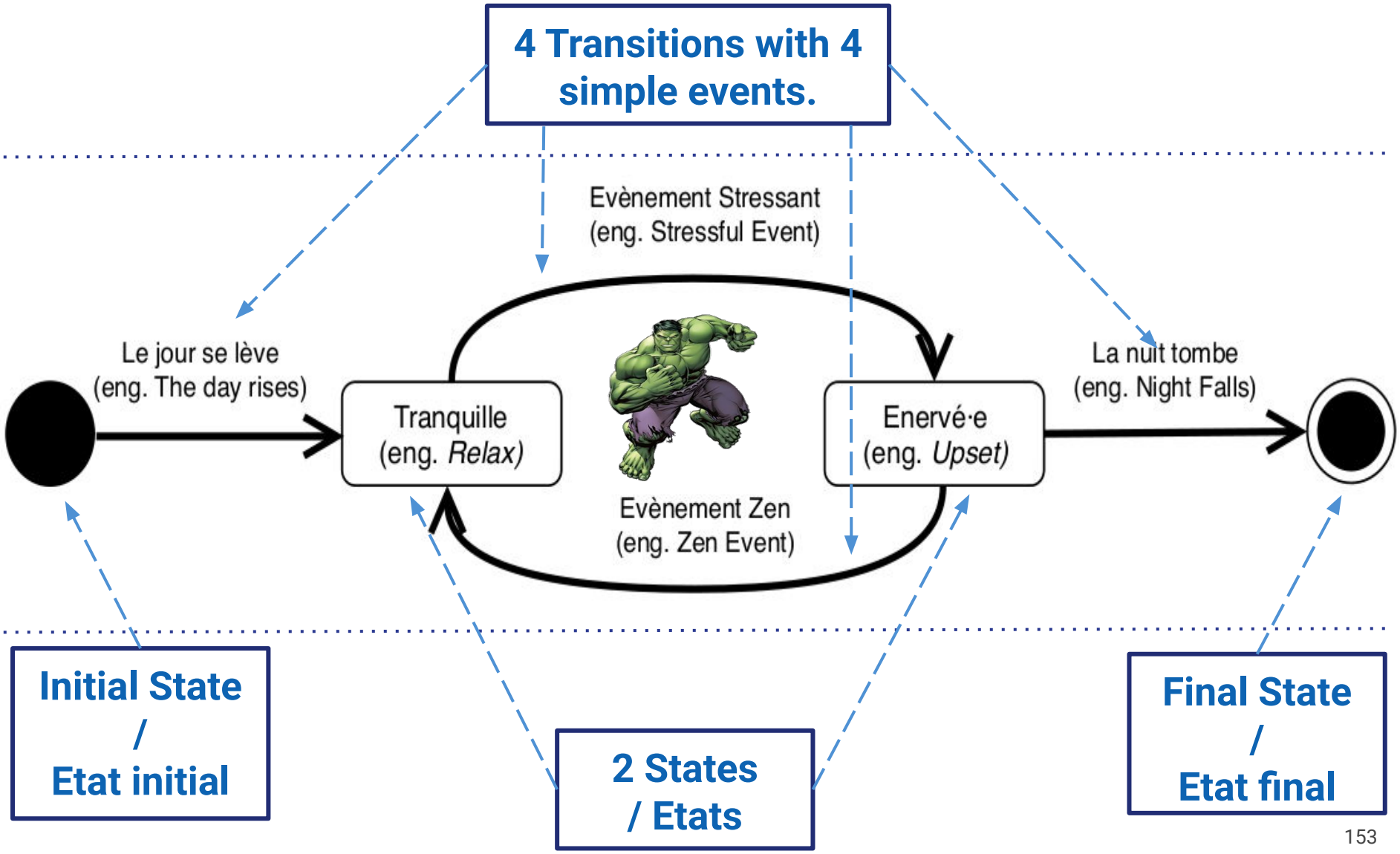
3. Unified Modeling Language (UML)

3.4. State Machine Diagram / Le diagramme d’ Etats - Transitions

State Machine Diagram
/ Diagramme d'états - transitions

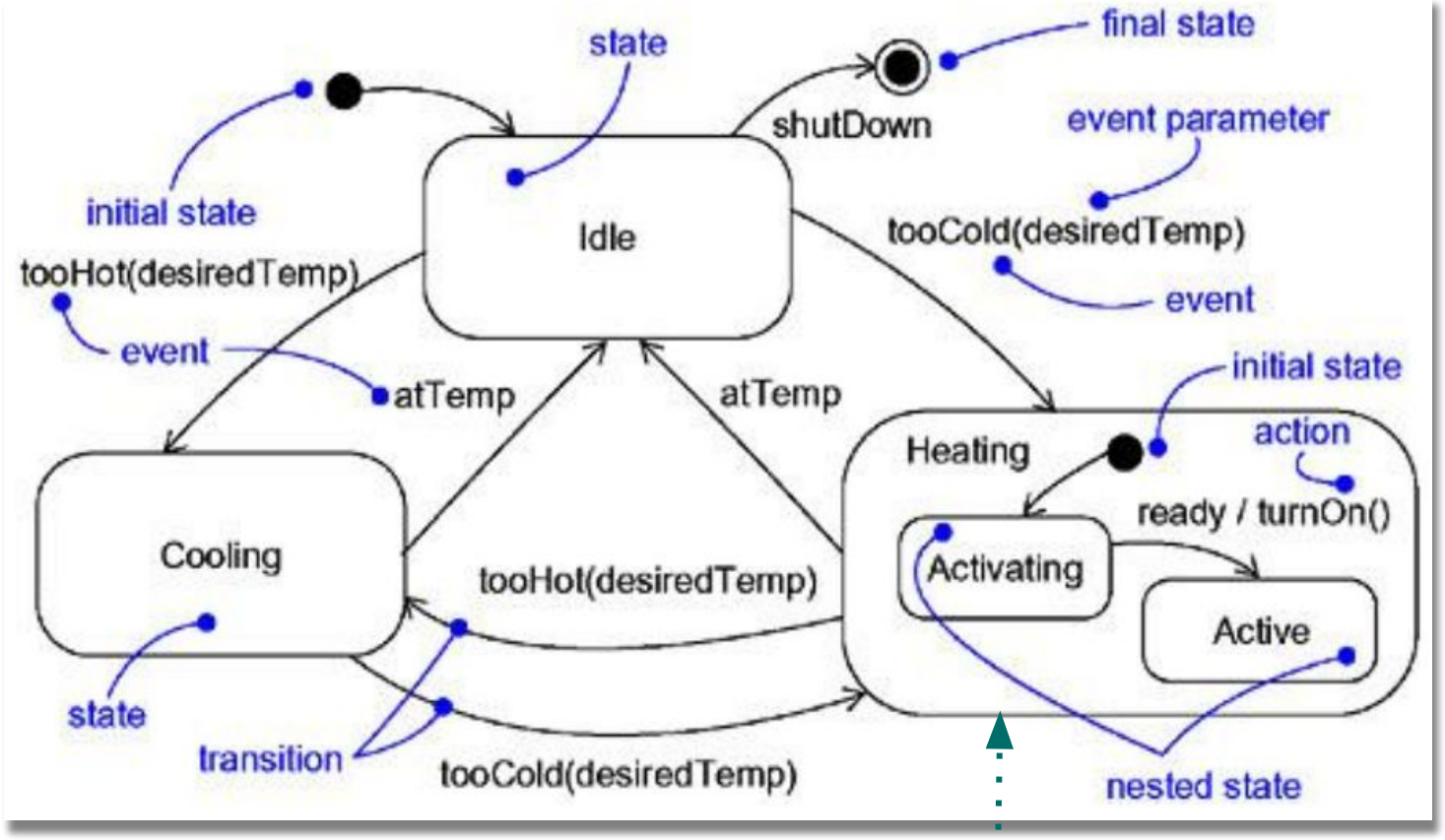
- **Objective**: **Model the behavior of objects based on events**;
- **States** / Etats : condition or situation of an object during which:
  - it satisfies a certain condition, or
  - it performs a certain activity, or
  - it is waiting for a certain event;
- **Transitions** (from one state to another):
  - **Event**
  - **[Condition(s)]**
  - **(Parameter)**
  - **/Actions**

A first example



A second example

Air Conditioning

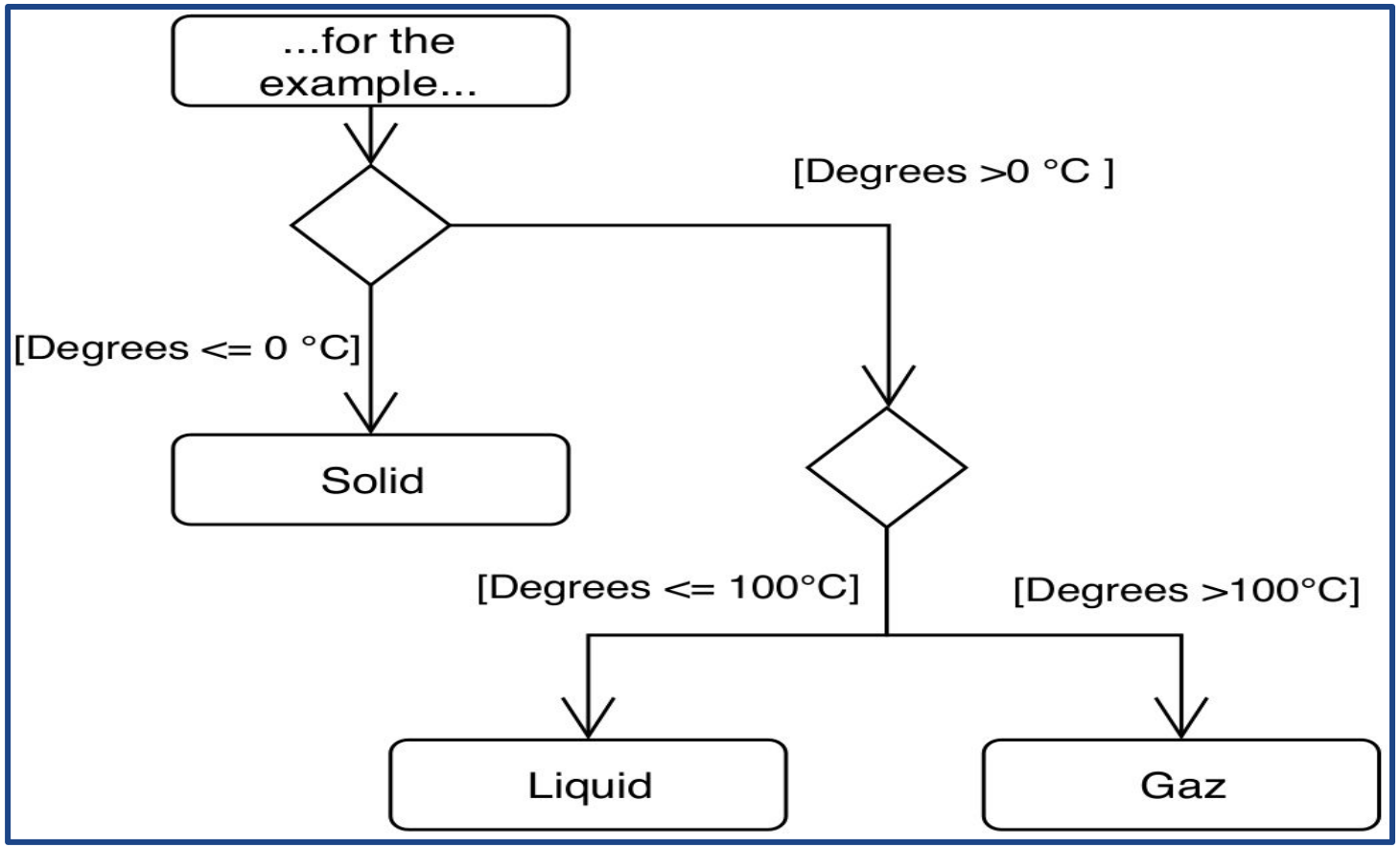


Ref: Addison Wesley - "the UML user guide".

We will see later how to model such factoring "**composite state**" (i.e. super state).

(diamond-shaped) **dynamic [condition]**

water state example



How to write a transition

From one state to another

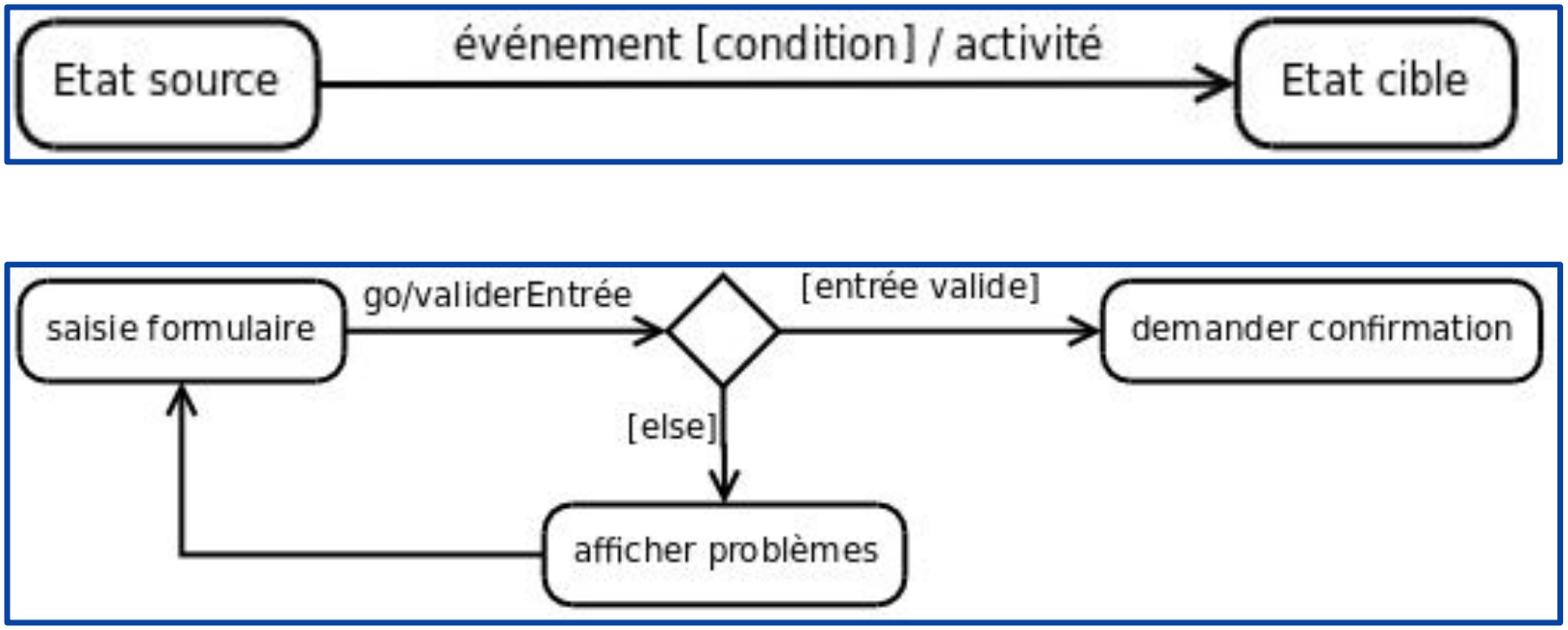
Event [condition] (parameter) / action

Événement [condition] (paramètres) / action

How to write a transition

Event [condition] (parameter) / action

Examples



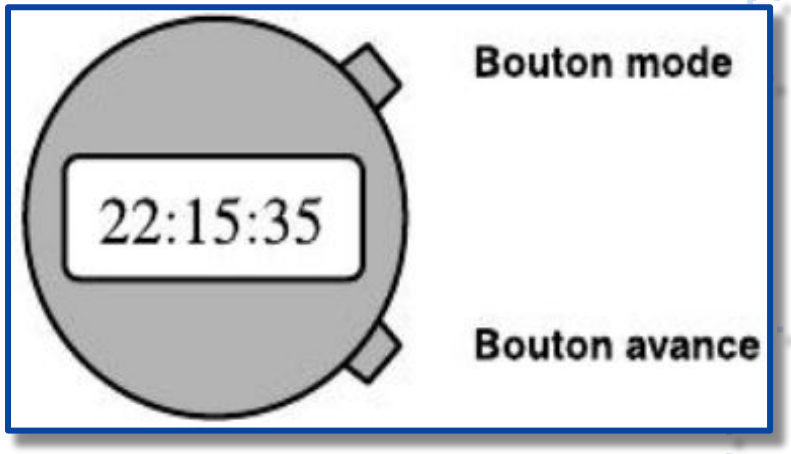
Ref: Laurent Audibert UML course

Fill a form

Display Problem

Request for confirmation

State Machine Diagram / Diagramme d'états - transitions
Example "Watch"



"mode" button

"add" button (forward)

Press "add" mode / hours++

appui bouton avance / heure++

Display

Press "mode" button

appui bouton mode

Affichage

Modification heure

Changing hours

Press "add" mode / minutes++

appui bouton avance / minute ++

Changing minutes

Modification minute

appui bouton mode

Press "mode" button

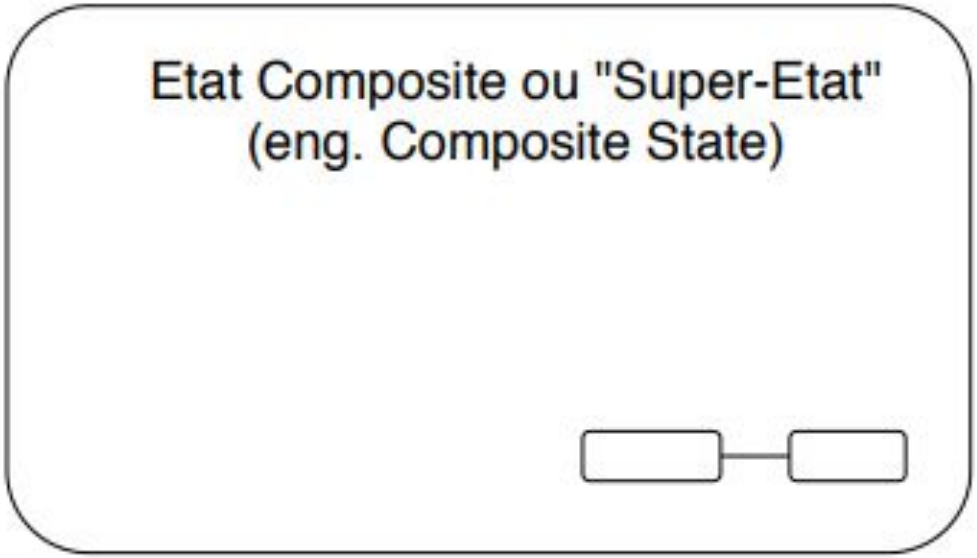
appui bouton mode

Press "mode" button

Ref: "UML 2.5 par la pratique, Roques."

Composite States

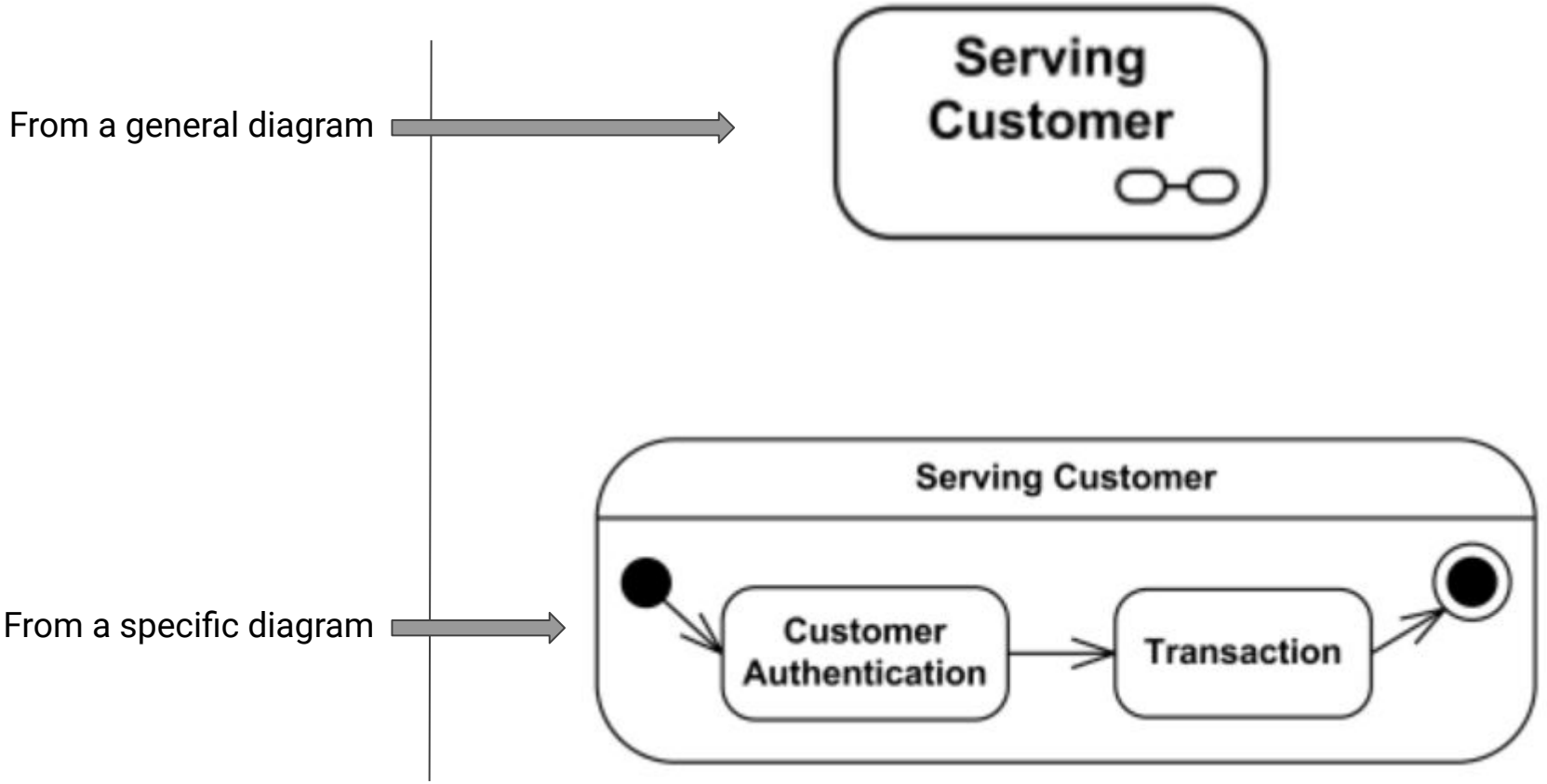
(also called **Super State**)



State Machine Diagram

Composites States

Examples

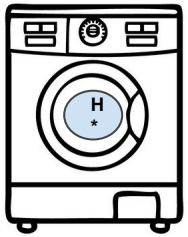


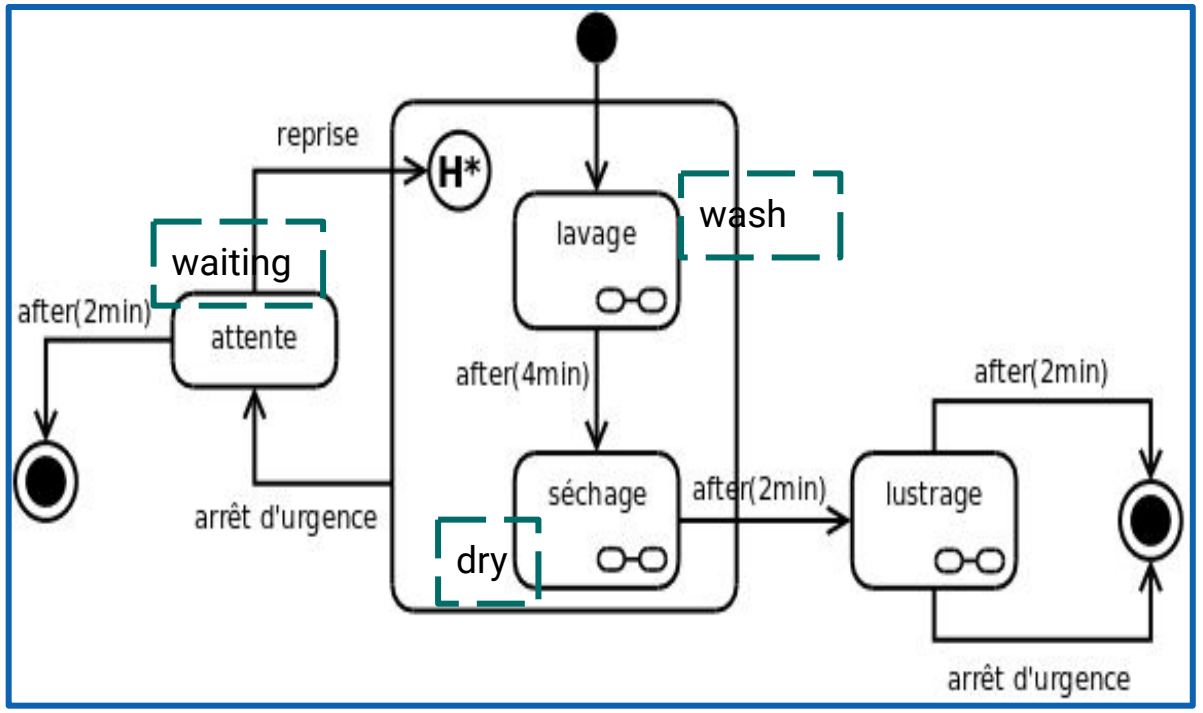
Advanced State Machine Diagram

the History pseudostate

H*

From an **external** transition, it saves the current state to resume the process from where it stopped.



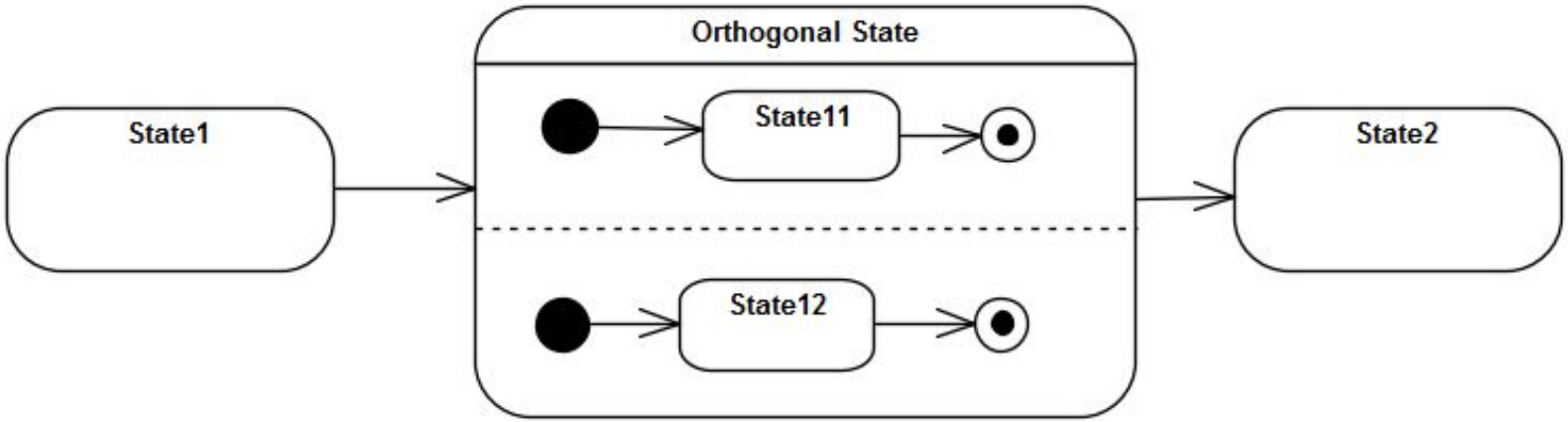


On the example above: allows you to resume washing (or drying) where it was before the interruption.

Pic ref: Cours Laurent Audibert

Advanced State Machine Diagram

The Orthogonal State

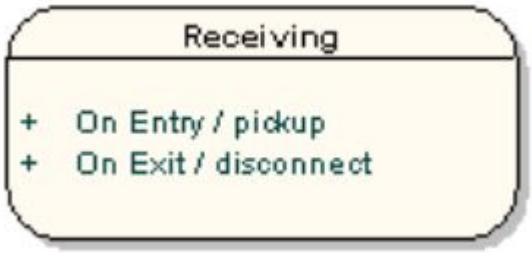


For concurrent mechanisms. **They must all reach their final state for the composite state to be considered complete.**

Advanced State Machine Diagram

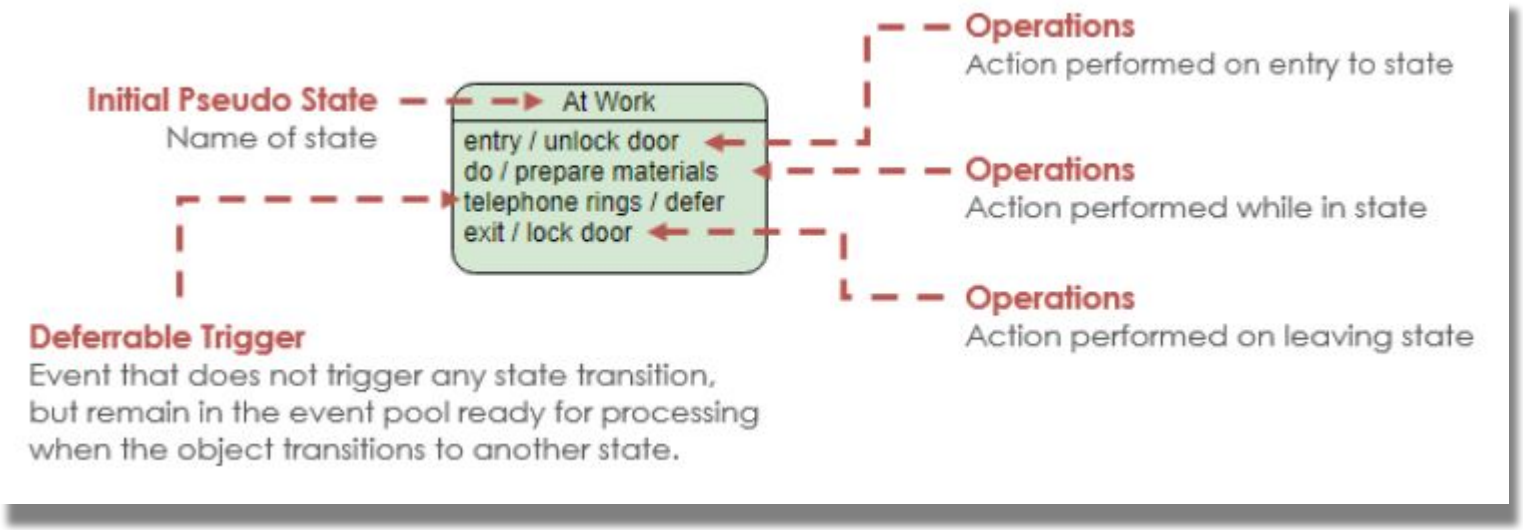
State Actions

Example 1



+ On Entry (or directly “Entry”)
+ On Exit (or directly “Exit”)

Example 2



Ref: https://online.visual-paradigm.com/diagrams/tutorials/state-machine-diagram-tutorial/

State Machine Diagram
- EXERCICE *SHOP* -

A simplified cash drawer has 3 modes: **Waiting for the next Customer**, **Item Registration** and **Waiting for Payment**. They can alternate with the following events:

- the entry of an item by the seller (e.g., barcode scan),
- when the seller has registered all the items,
  - (there can indeed be several...);
- Entering payment.

Goal: Draw the related state machine diagram.

Diagramme d'états-transitions
- EXERCICE *SHOP* -

Un tiroir-caisse simplifié a 3 modes : Attente de client, Enregistrement des articles et Attente de paiement. Ils peuvent alterner suite à :

- la saisie d'un article par le vendeur (e.g., scan code-barres),
- le moment où le vendeur a enregistré tous les articles,
  - (il peut en effet y en avoir plusieurs...) ;
- la saisie du paiement.

But : Dessiner le diagramme d'états-transitions du tiroir-caisse.

State Machine diagram
- Library -

In order to manage a library, you start to model everything that happens in it, in particular, by the representation of a state machine diagram on the 3 states of a book (**Available**, **Borrowed** and **Non-Returned**) knowing that the events that concern it are as follows:

- **Restitution**,
- **Borrow** (for one month),
- **Robbery**,
- **OneMonthIsPassed**.

Events may link to more than a couple of states.

Source image : https://www.planetminecraft.com/

No final state, but you need to locate the initial one.

Diagramme d'états-transitions
- EXERCICE *BIBLIOTHÈQUE* -

Afin de gérer une bibliothèque, vous vous mettez à modéliser tout ce qui s'y passe, notamment, par la représentation d'un diagramme d'états-transitions sur les 3 états d'un livre (**Disponible**, **Emprunté** et **NonRendu**) sachant que les événements qui le concernent sont les suivants :

- **Restitution**,
- **Emprunt** (pour un mois),
- **Vol**,
- **UnMoisEstPassé**.

Il se peut que des évènements se retrouvent liés à plus d'un couple d'états.

Source image : https://www.planetminecraft.com/

Pas d'état final, mais vous devez placer l'état initial.

Diag Etats-Transitions - EXERCICE telephoneBooth -

Dessinez le diag. d'états-transitions d'une cabine téléphonique. Vous pouvez mutualiser le décrochage par un "super-état".

Les états du téléphone sont les suivants :

- Raccroché
- AttentePièce
- AtteteNuméro
- AttenteDécrochageAuBoutDeLaLigne
- EnCommunication
- FinDeCommunication

Rappel sur les transitions :

Créer les transitions en combinant les éléments suivants :

Evènements :

- **raccrocherCombiné**
- **décrocherCombiné**
- **nouveauNuméro**
- **débuterCommunication**
- **nouvellePièce**
- **vérifierArgentRestant**

Conditions :

- **crédits>0.2€** (Minimum attendu)
- **crédits<0.21€**
- **numéroFaux - numéroValide**
- **créditSuffisant - créditInsuffisant**

Actions :

- **rendrePièces**
- **initCrédits=0**
- **taxer**

Diag State Machine - EXERCICE telephoneBooth -

Draw the state machine diagram according to the states and transitions below. Try to factor through a superstate.

The states of the phone are the following:

- HangUp
- WaitingCoin
- WaitingNumber
- WaitingPhonePickUpAt TheEndOfTheLine
- InCommunication
- EndOfCommunication

Help on transitions :

Create the transitions by combining the following:

Events :

- **hangUp**
- **pickUpPhone**
- **newNumber**
- **startCommunication**
- **newCoin**
- **checkRemainingMoney**

Conditions:

- **credits>0.2€** (minimum required)
- **credits<0.21€**
- **falseNumber - validNumber**
- **sufficentCredits - insufficentCredits**

Actions:

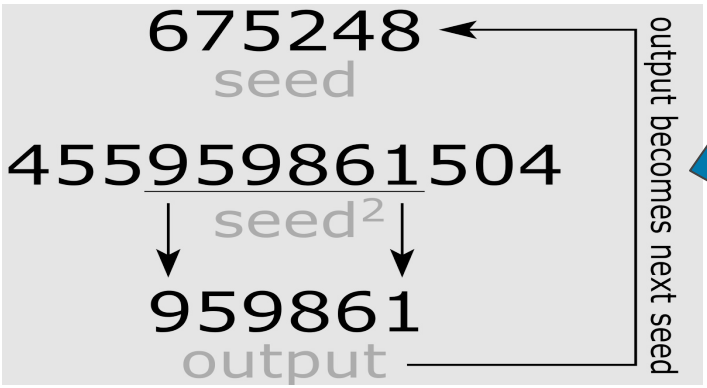
- **givingChange**
- **initCredits=0**
- **tax**

“Break n°2”

SIMULATION
&
Pseudo-random numbers

Pseudorandom number generators

- There is a r**eal competition on who will have the best pseudo-random number generator**.
- A good generator is **important for simulations** that require a lot of numbers.
- First pseudo-random number generation algorithm by **John Von Neumann** (**1940**): the **mid-square method**.
- Later:
  - Methods based on the rest of the **euclidean division**,
  - Methods with **binary operations** (e.g., shift loop etc.),
  - **Merging of generators**;
- Their quality is determined by statistical tests (e.g., chi-square test),
- Example of a good generator:
  - *Mersenne Twister.*
  - *Future: **quantum machines**?*



Monte Carlo

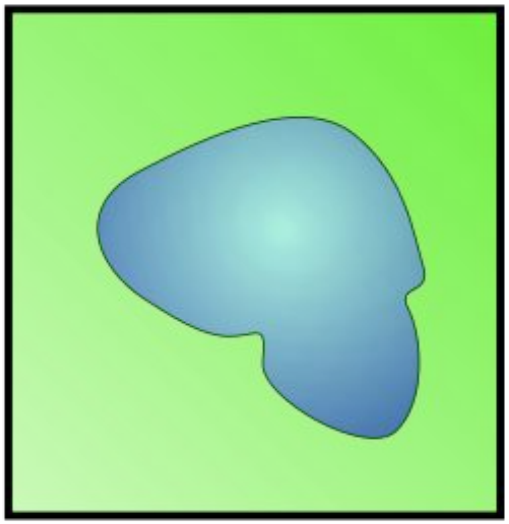
Method and Simulation
(Static and Dynamic)

- Invented by **John Von Neumann** and **Stanislaw Ulman**,
- 1st simulation of the **name of the Casino**
- Focused on the generation of pseudo-random numbers:
    - **stochastic process**.

… examples in the practical work.

Lake approximation with the Monte Carlo method

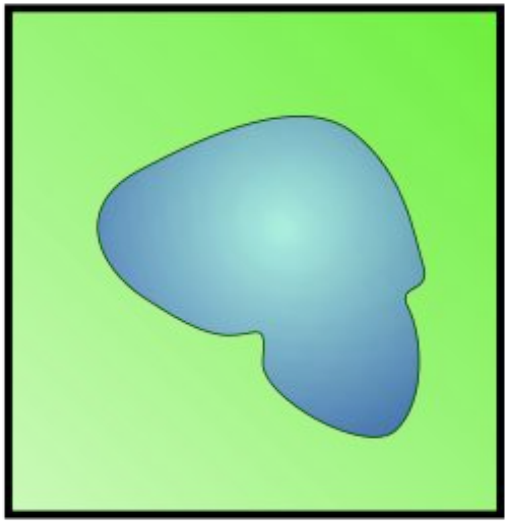
To **find the area of a lake**, an army is asked to **fire cannonballs** (just that!).



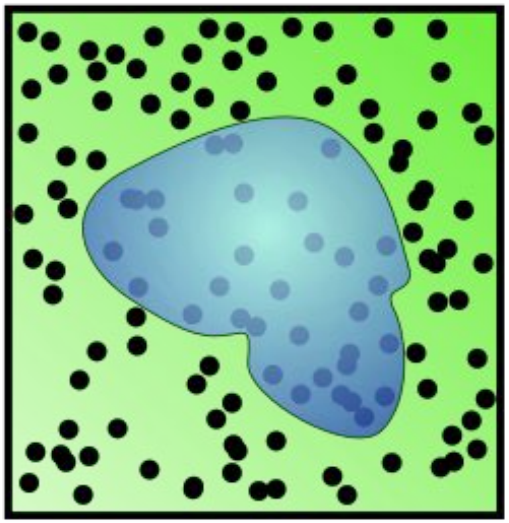
Lake approximation with the Monte Carlo method

To **find the area of a lake**, an army is asked to **fire cannonballs** (just that!). We have:

- ***X*** *cannon shots fired* ***randomly*** *on the area,*
- ***N*** *is the number of balls that did* ***NOT*** *make a "****splash****! / plouf!",*
- ***X − N*** *is therefore the number of balls which made "Splash! Plouf!".*



We can deduce an approximation of the area of the lake.



(area == superficie; lake = lac; terrain = (here) 'land": all the square area)

$$\frac{\text{superficie}_{\text{terrain}}}{\text{superficie}_{\text{lac}}} = \frac{X}{X-N}$$

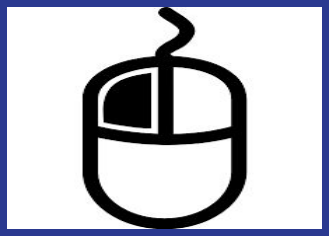
$$\Longrightarrow \quad \text{superficie}_{\text{lac}} = \frac{(X-N)}{X} \times \text{superficie}_{\text{terrain}}$$

The land area (superficie terrain) is of course known here.

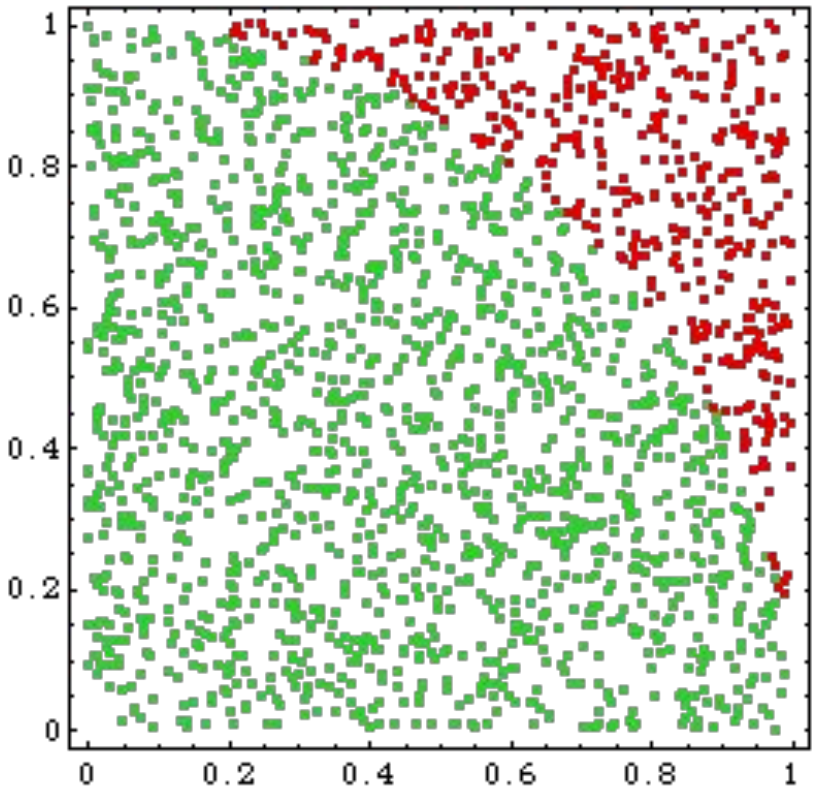
Practical Work

Practical Work 7

Monte Carlo Method



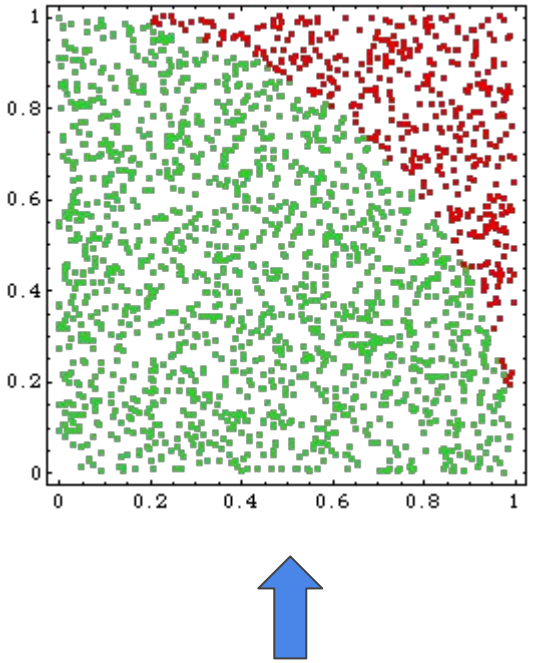
π approximation with the Monte Carlo method



π approximation with the Monte Carlo method

- Main idea: we generate points at random in a domain of known area. When the number of points placed tends to infinity, the proportion of points "fallen" in a subdomain gives its area. Here, we will take the opportunity to calculate **π**.
- Goal: Get a value close to one **hundredth of π** by developing the following algorithm with n very large:

```
quarterOfTheDiscArea = 0 ;
For i from 1 to n Do
    x <= randomly chosen in [0;1] ;
    y <= randomly chosen in [0;1] ;
    If x² + y² <= 1 Do
        quarterOfTheDiscArea
            = quarterOfTheDiscArea + 1 ;
    End If
End For
approxPi = (4 * quarterOfTheDiscArea) / (n) ;
```

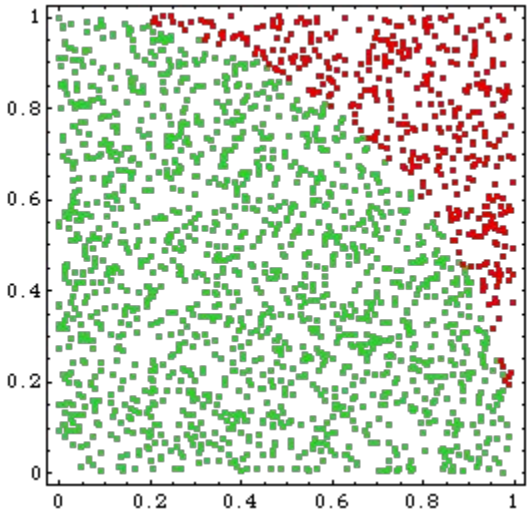


BONUS 1: Be more precise!
BONUS 2 : use a graphic API to represent the process as in the pic above.

Approximation de π par la méthode de Monte Carlo

- Idée de méthode de Monte Carlo : On génère des points au hasard dans un domaine dont l'aire est connue. Lorsque le nombre de points placés tend vers l'infini, la proportion des points « tombés » dans un sous-domaine permet d'obtenir son aire. Ici, on va en profiter pour calculer **π**.
- Votre but : arriver à une valeur proche du centième de **π** en développant l'algorithme suivant avec n très grand :

```
quartDisque = 0 ;
Pour i de 1 à n Faire
    x tirée aléatoirement dans [0;1] ;
    y tirée aléatoirement dans [0;1] ;
    Si x² + y² <= 1 Faire
        quartDisque = quartDisque + 1 ;
    Fin Si
Fin Pour
approxPi = (4*quartDisque)/(n) ;
```

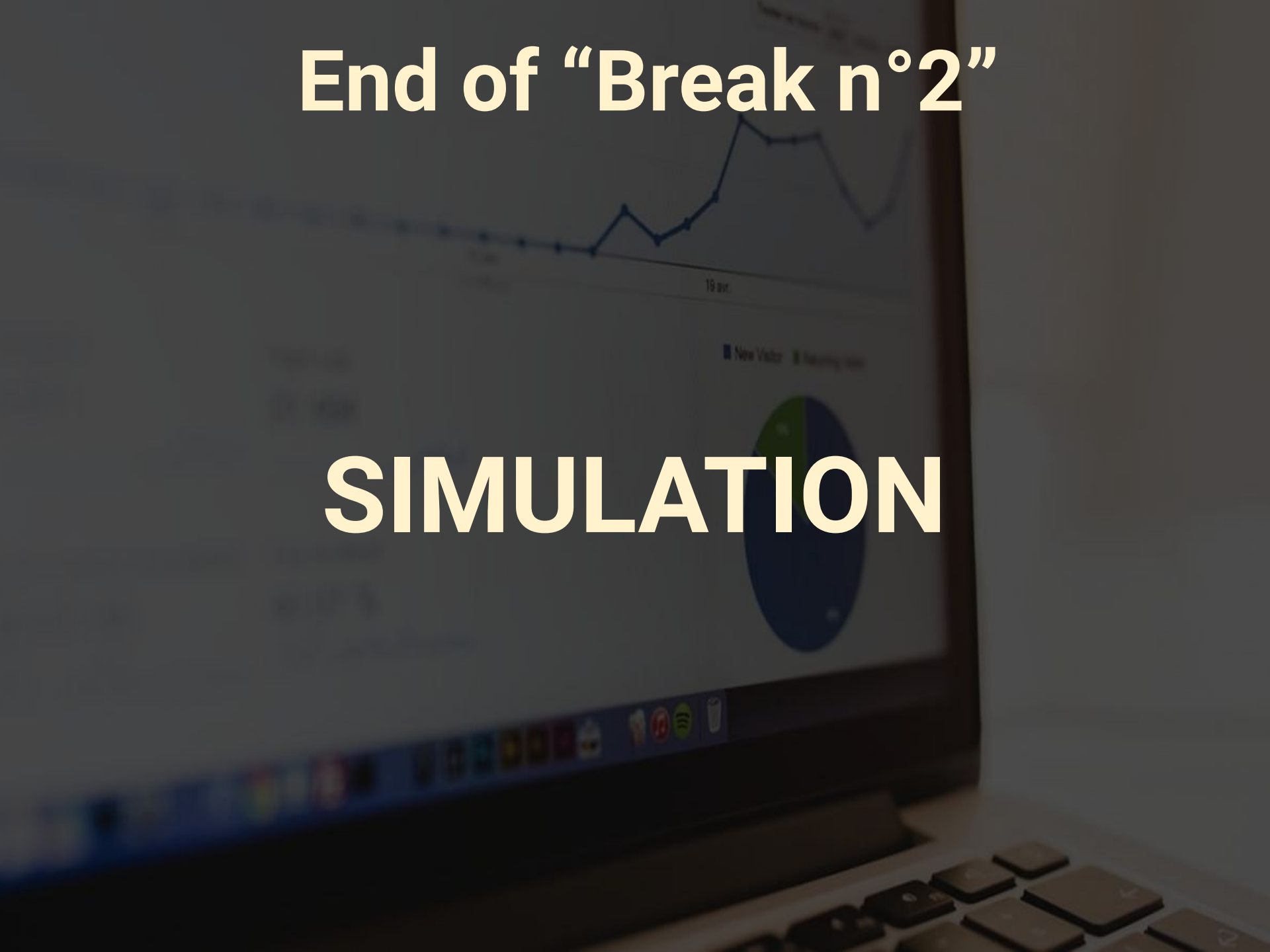


BONUS 1 : Cherchez à affiner **π** en fonction de n.

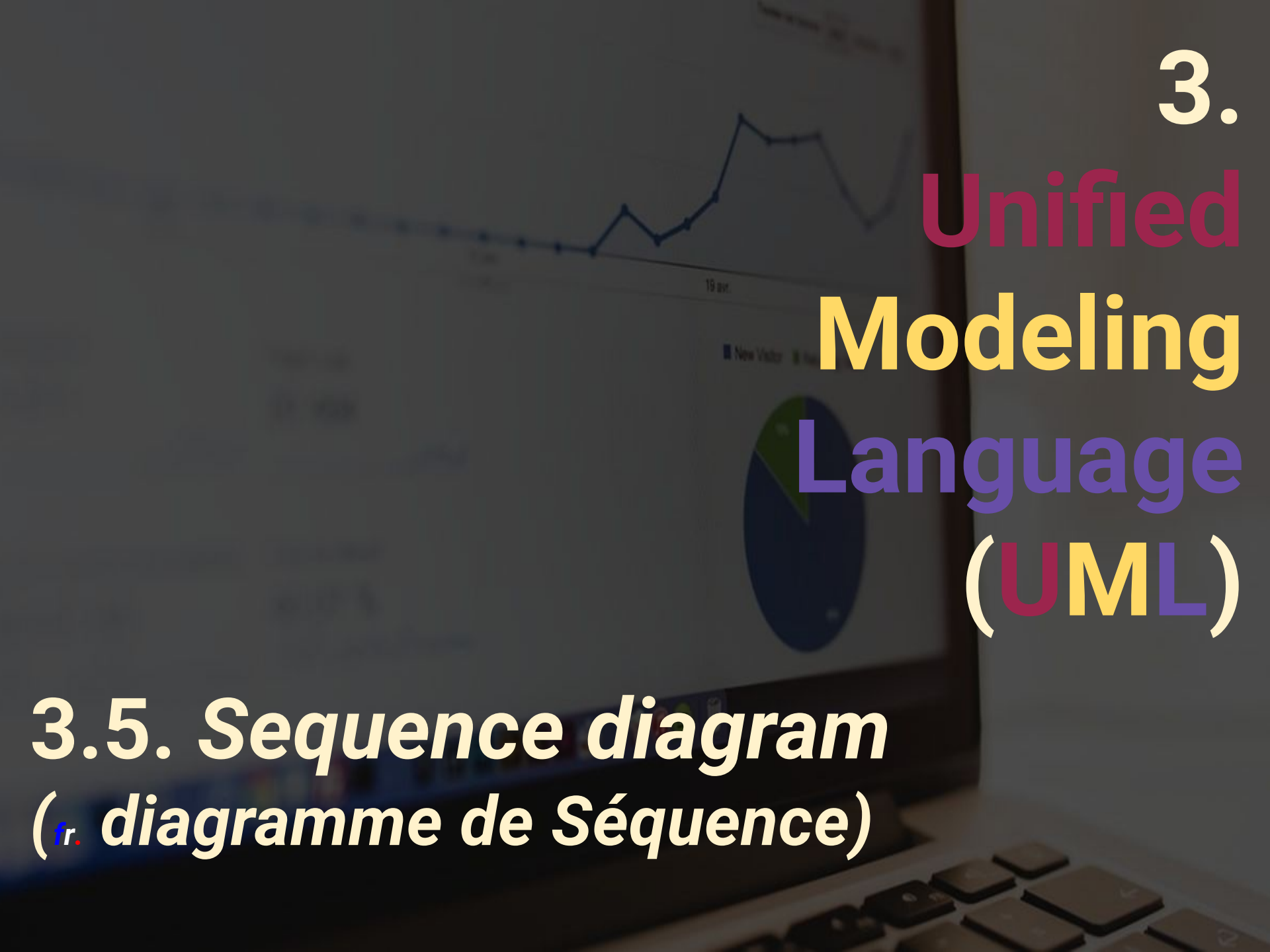
BONUS 2 : Avec une interface graphique, affichez différemment les points du cercle et de l'extérieur du cercle.

Π approximation

Practical Work 7


End of “Break n°2”
SIMULATION

Back to the lecture / Retour au cours



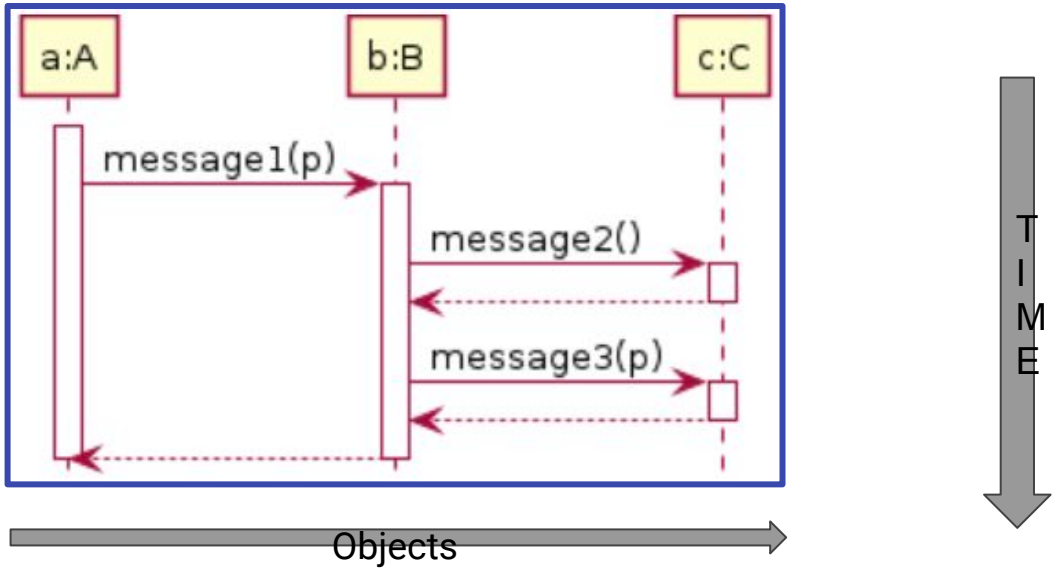
3. Unified Modeling Language (UML)

3.5. *Sequence diagram*

(fr. *diagramme de Séquence*)

Sequence Diagram

- Centered on the (line of) life of **objects**,
  - Creation and destruction sometimes specified;
- Show the **interactions between objects**,
- **Vertical timeline** (from top to bottom),
- Importance of objects sorted on the horizontal axis (from left to right)
  - The starting element to the right,
  - from the most important to the - important,

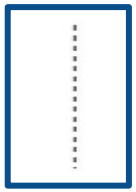


Sequence Diagram

BASIC ELEMENTS

Dashed line:

= Object lifeline.



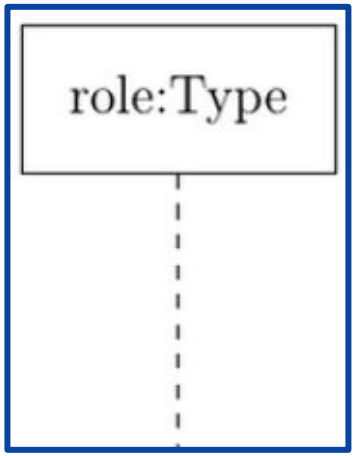
```
class myRandomClass
{
    void myRandomFunction()
    {
        ClassBlabla myObjectOfBlabla = new ClassBlabla();

        / [...]
        // end of object life
    }
}
```

> A role and / or a type s **required**.

> The ':' is **systematic**.

> The **role** identifies the object, it is often the name of the instance / **object**.

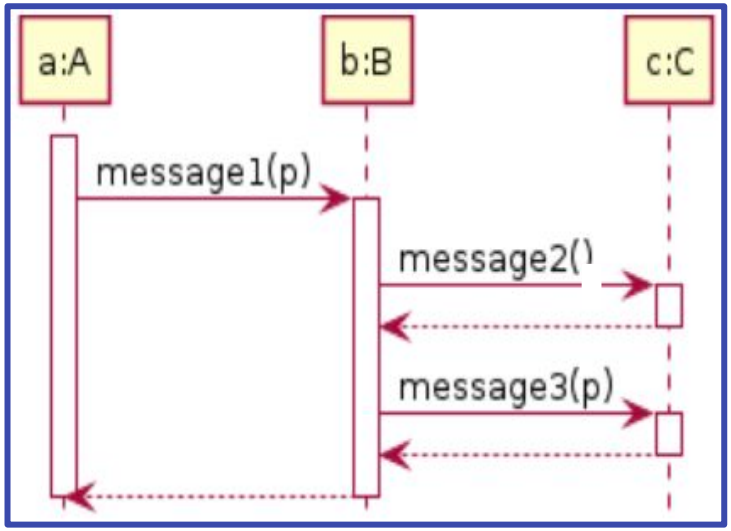
> The **Type** is often the **name of the class**.



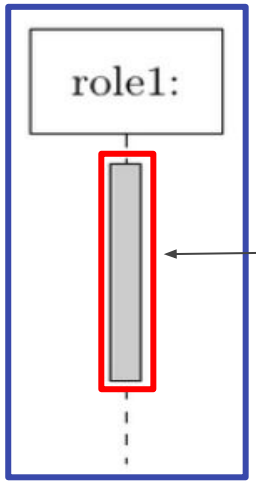
myObjectOfBlabla:**ClassBlabla**

Sequence Diagram

EXAMPLE



BASIC ELEMENTS



Rectangle representing the **amount of time taken by an action**. *(not always given)*

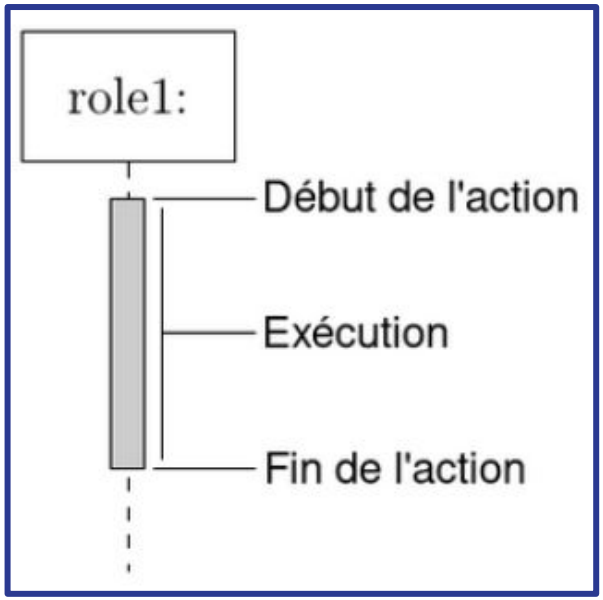
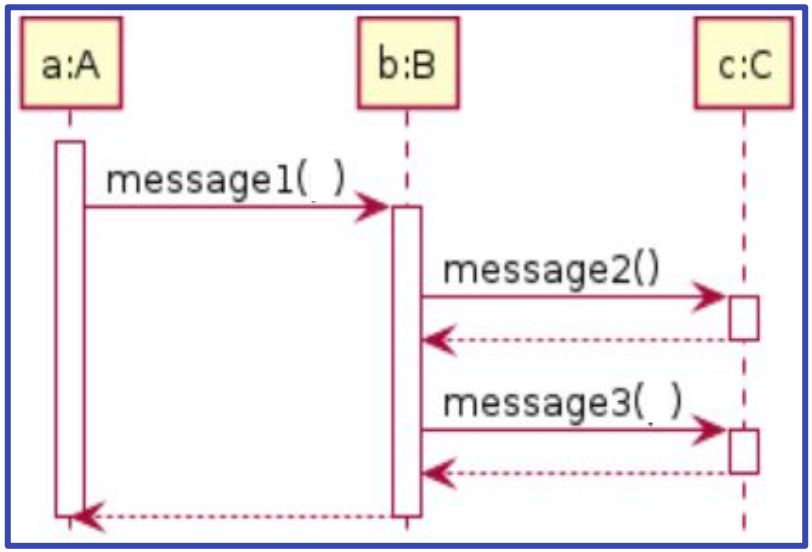


Diagram source: Pierre Gérard

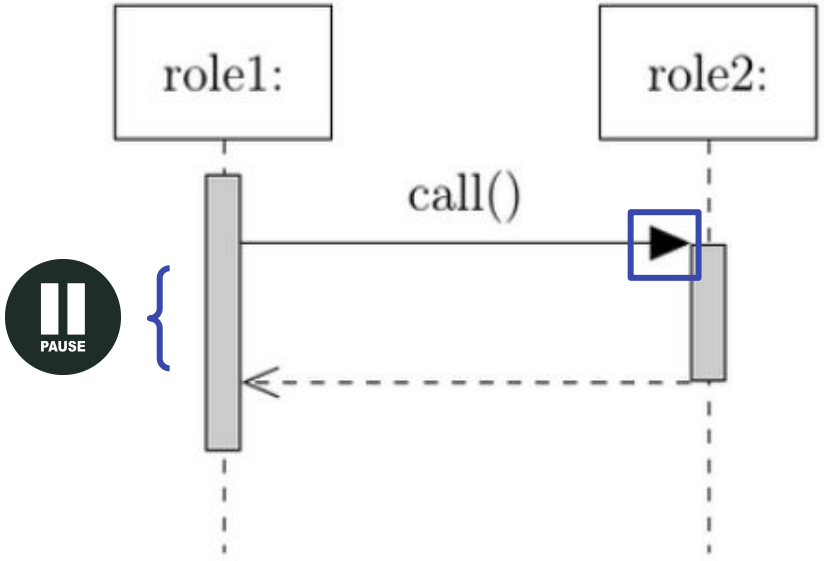
Pic ref: http://www.ferdinandpiette.com/isen/concept_objet/

Sequence Diagram

EXAMPLE



BASIC ELEMENTS
Synchronous messages



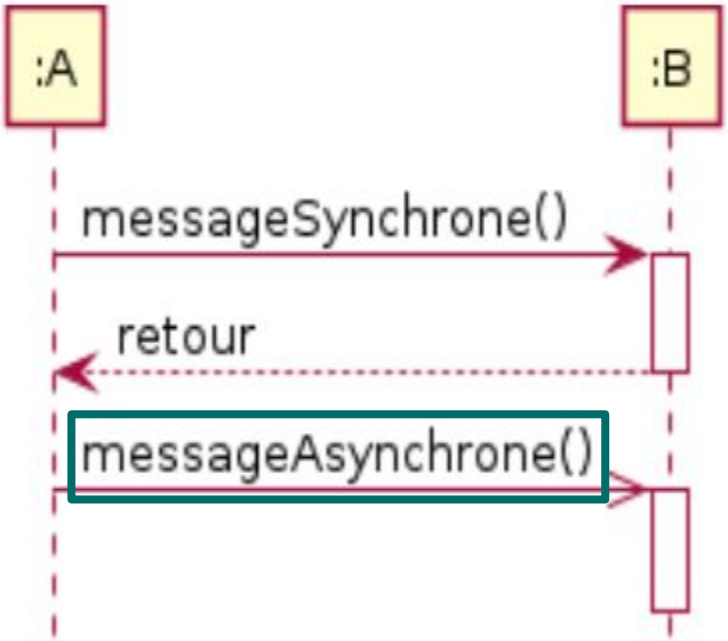
- The call **locks** role1 while role2 works 
- **Synchronous** message is the most common.
- 

Diagram source: Pierre Gérard

Ref: http://www.ferdinandpiette.com/isen/concept_objet/

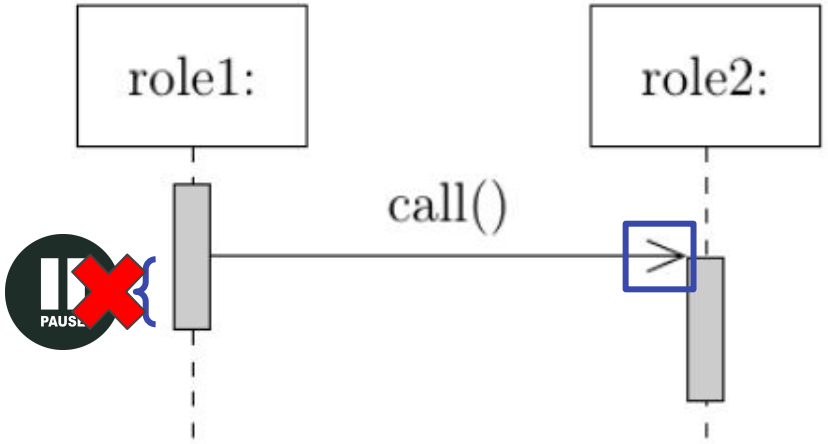
Sequence Diagram

EXAMPLE



Pic ref: cours Pierre Gérard

BASIC ELEMENTS
Asynchronous messages

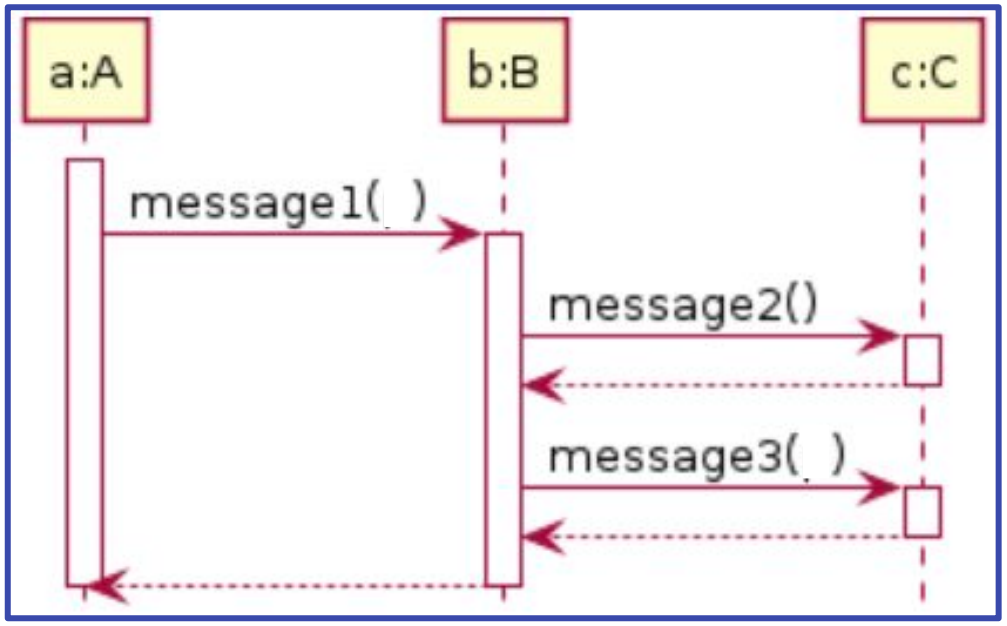


- The call **does NOT lock** role1,
- Role1 can **continue** to execute its code without a role2 return.
- **Asynchronous** message is rare.

Pic ref: http://www.ferdinandpiette.com/isen/concept_objet/

Sequence diagram

Synchronous messages JAVA example




```
public class A {
        protected B b;

        public void firstMethodLaunchInTheMain()
        {
            b.message1();
        }
}
```

```
public class B {
    protected C c;
    public void message1()
    {
        c.message2();
        c.message3();
    }
}
```

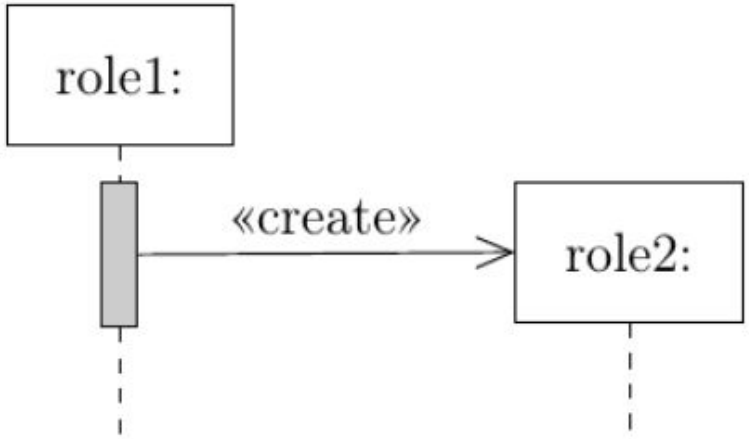
```
public class C {
    public void message2()
    {   }
    public void message3()
    {   }
}
```

Sequence diagram

EXAMPLE

Pic ref: cours Pierre Gérard

BASIC ELEMENTS
Object instantiation

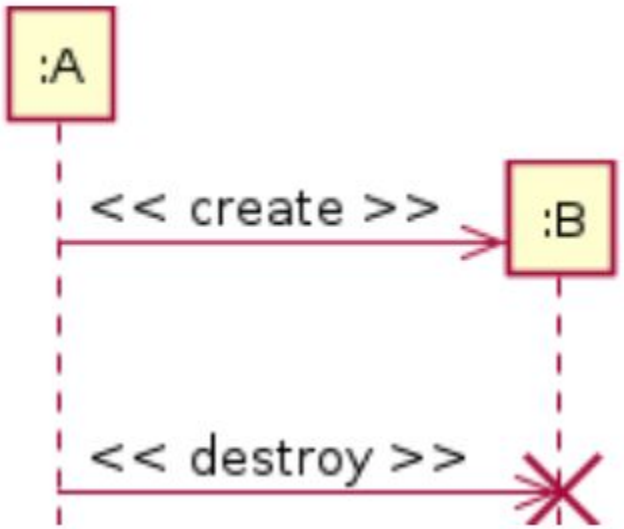


- The instantiation of one object by another is realised by:
  - A message targeting directly the “rectangle” of the new object,
  - Arrow name: **<<create>>**.

Pic ref: http://www.ferdinandpiette.com/isen/concept_objet/

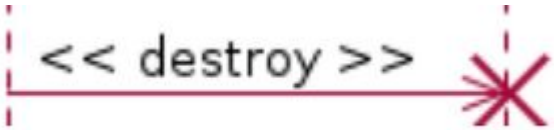
Sequence diagram

EXAMPLE

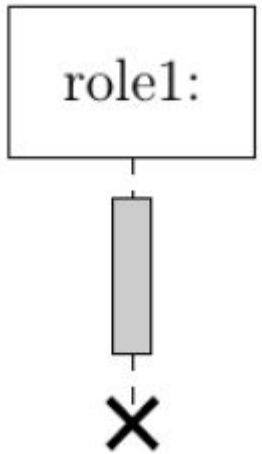


Pic ref: cours Pierre Gérard

BASIC ELEMENTS
Object destruction



- **Explicit** destruction by another object.

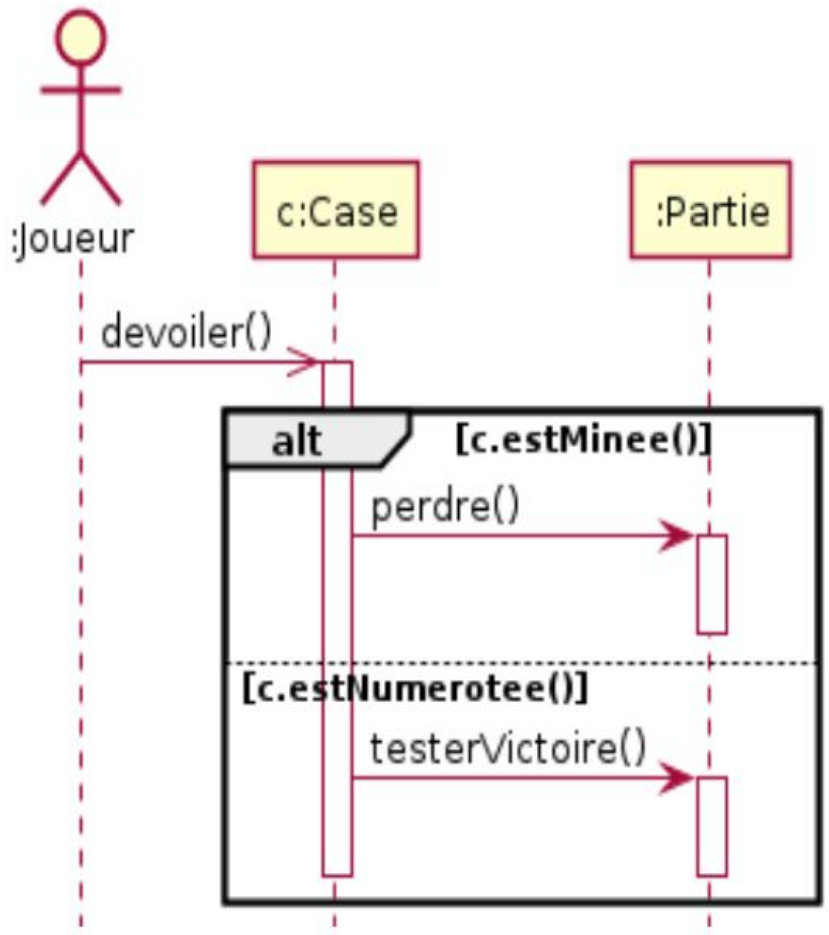


- **Implicit** destruction of the object.

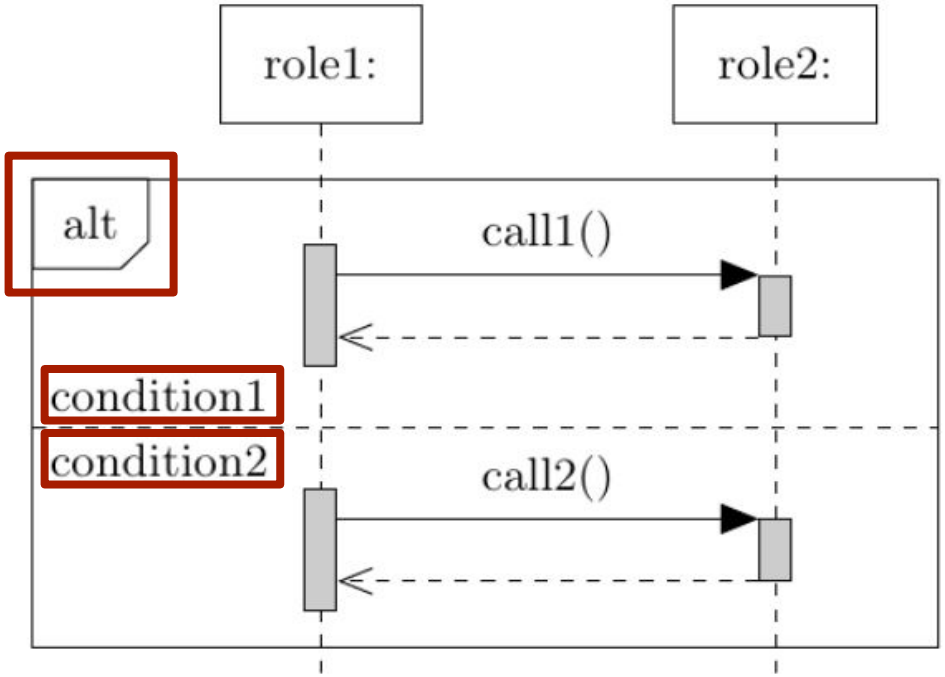
Pic ref: http://www.ferdinandpiette.com/isen/concept_objet/

Sequence diagram

EXAMPLE



BASIC ELEMENTS "Switch-Case"



- **IF** *condition1* is TRUE
  - *call1()* is called,
- **ELSE IF** *condition2* is TRUE

Pic ref: cours Pierre Gérard

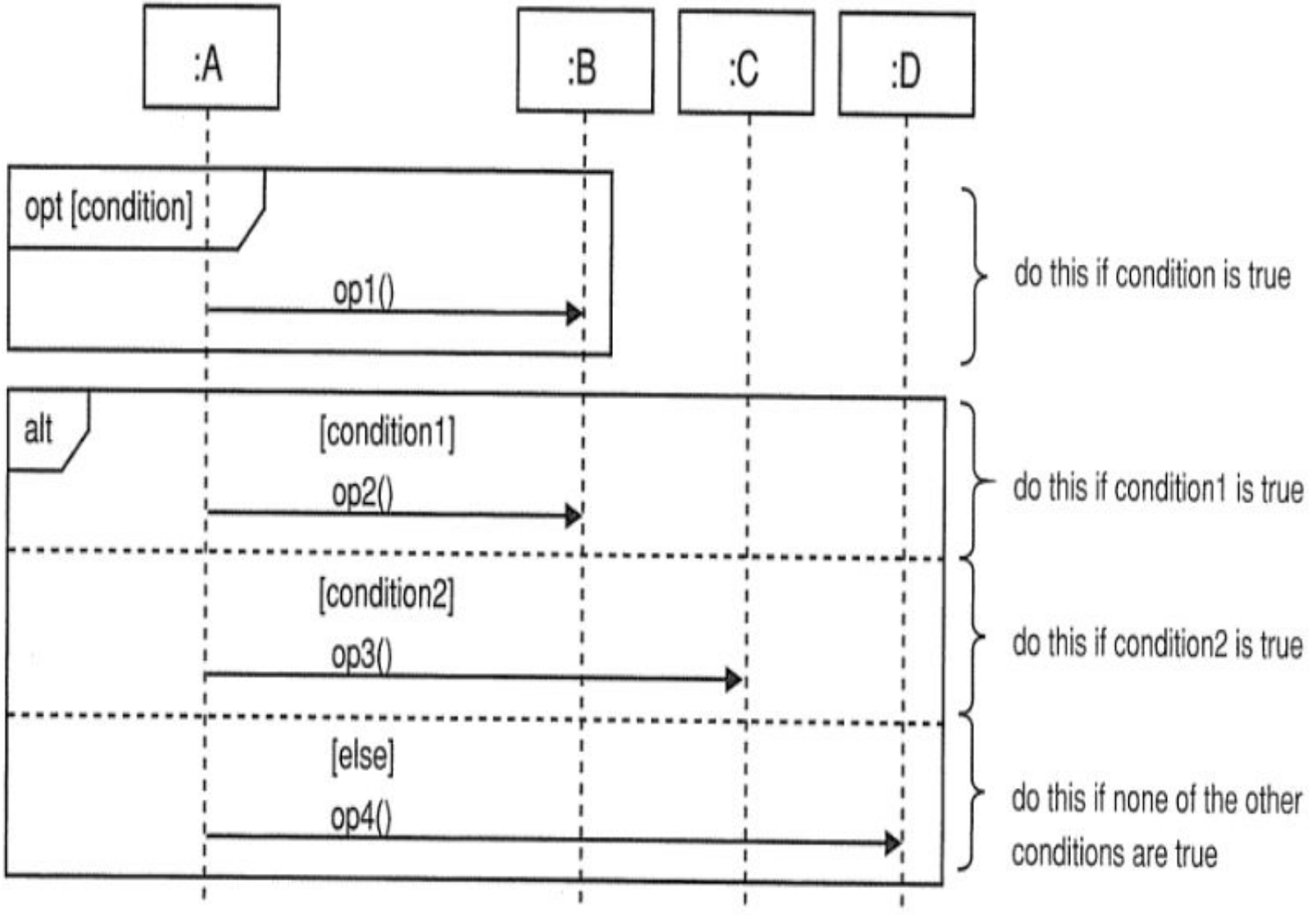
Pic ref: http://www.ferdinandpiette.com/isen/concept_objet/

Sequence diagram

"If-Then" & "Switch-Case"

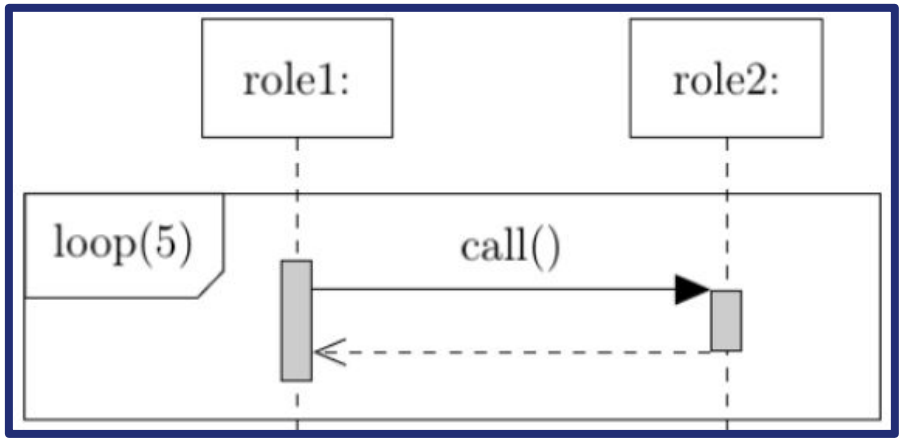
IF ... Then.

Switch ... Case



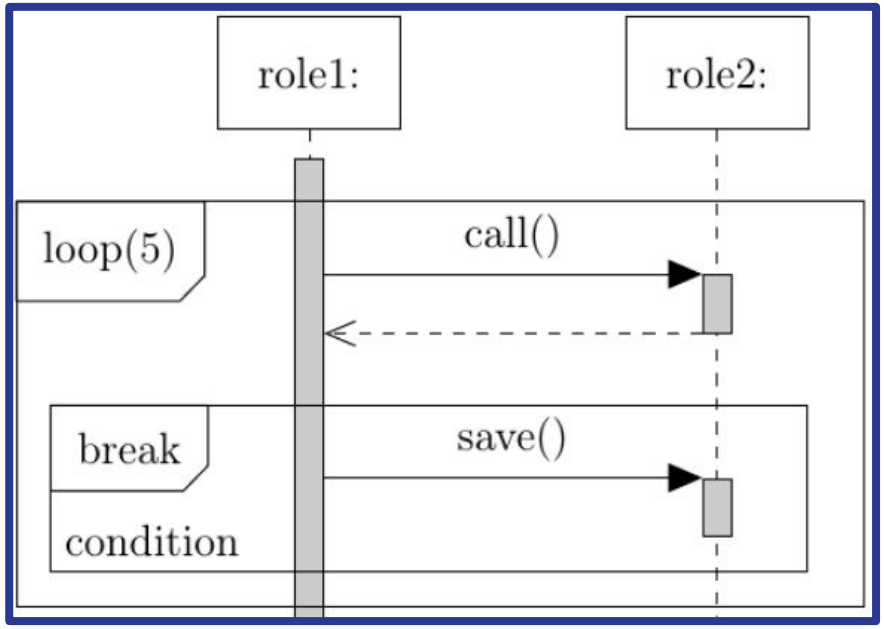
Sequence diagram

FOR



- **loop(n)** case:
  - We give the number of iterations.
  - We run all the instructions for each iteration.

FOR & WHILE

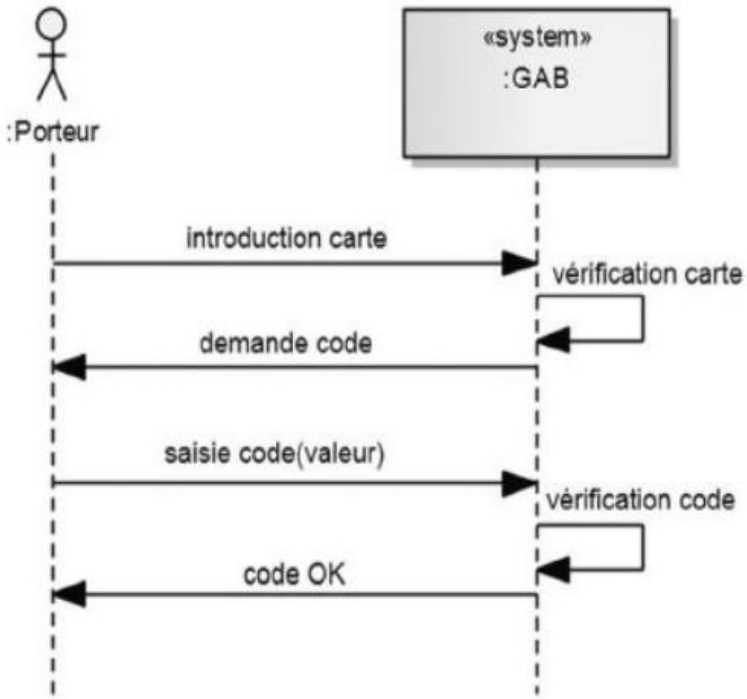


- **loop(n) + break** case:
  - Stop the loop **IF** condition **is TRUE.**
- **loop + break** case:
  - typical while loop

Ref pic: http://www.ferdinandpiette.com/isen/concept_objet/

Sequence diagram

EXAMPLE

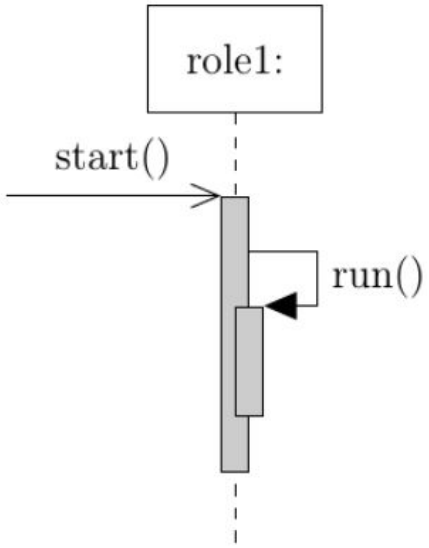


Pic ref: UML 2.5 par la pratique, Roques.

SPECIAL ELEMENTS

Actor **outside the system** (not integrated into the class diagram).

For example, it can represent the user of the software of the architecture you are building.



Several executions can overlap on the same lifeline.

(e.g., a role1 makes a change on its own state)

Pic ref: http://www.ferdinandpiette.com/isen/concept_objet/

Sequence diagram
- EXERCISE: SERVER&CLIENT -

- Model a sequence diagram such as:
  - A **Server** instance creates threads (**Thread** class),
  - A **User** named *geek* wakes up the server via a call to a *wakeOnLan* method. Once the server responds, *geek* executes the server's *Get* method with the name of a file as parameter.
  - *Threads* also have a *Get* method.
  - *driveZ*, an **HDD** instance, contains the data which is read with *read(File)* method called by the *thread*. And the data is then returned.
- Draw the sequence diagram by correctly ordering the classes according to the series of method calls.

Sequence diagram
- EXERCICE SERVEUR&CLIENT -

- Modéliser un diagramme de séquences tel que :
  - Une instance de **Serveur** crée des *threads* (classe *Thread*),
  - Un ***User*** nommé *geek* réveille le serveur via un appel à une méthode *wakeOnLan*. Une fois que le serveur lui répond, *geek* exécute la méthode *Get* du serveur paramétrée du nom d'un fichier.
  - Les *threads* ont également une méthode *Get*.
  - *driveZ*, instance de **HDD**, contient les données qui sont lues grâce à leur méthode *read(File)* appelée par le *thread*. Et les données (*data*) sont alors renvoyées.
- Tracer le diagramme de séquence en ordonnant correctement les classes selon la séquence d'appels aux méthodes.

Class & Sequence diagrams
- EXERCISE: BASKETMANAGEMENT 1/2 -

You need to develop a management software for e-commerce. You simply start with the basket management with:

- 1 class diagram with **attributes** and **methods** (to be deduced) respecting the encapsulation of the data. Deduce the **classes** (written in bold) and their content from the points below:
  - An ***Item*** corresponds to an item in the shopping cart and is defined by a product (*Product*) and its quantity (*quantity*). We add an item to the basket by the *addItem()* method.
  - ***ShoppingBasket*** is a class that contains the list of the *Items* of the buyer (*Buyer*) Items. A buyer is identifiable by an integer idBuyer.
  - **Product**, which lives up to its name, has:
    - A *productId*, a *price*,
    - A *name* and a *description*.

Class & Sequence diagrams

- EXERCICE BASKETMANAGEMENT *1/2* -

Vous avez besoin de développer un logiciel de gestion pour du *e*-commerce. Vous commencez simplement par la gestion de panier avec :

- 1 diagramme de classe avec **attributs** et **méthodes** (à déduire) respectant l'encapsulation des données. Déduire les classes (écrites en gras) et leur contenu des points ci-dessous :
  - Un ***Item*** correspond à un élément du panier d'achat et est défini par un produit (*Product*) et sa quantité (*quantity)*. On ajoute un *item* au panier par la méthode *addItem*().
  - ***ShoppingBasket*** est une classe qui contient la liste des *Items* de l'acheteur (*Buyer*) et un acheteur identifiable par un *idBuyer* entier.
  - ***Product***, qui porte bien son nom, a :
    - Un *productId*, un *price*,
    - Un *name* et une *description*.

- EXERCISE: BASKETMANAGEMENT 2/2 -

The class diagram is accompanied by a sequence diagram involving:

- 1 Customer (the actor) who uses the software,
- An instance of the *ShoppingBasket* and Item classes.

This sequence diagram represents a process of basketing an Item by the Customer (use an *addItem()* method which will create the *Item* object) then the following management:

- If the user changes the quantity of the Item (*ChangeQuantity*), the appropriate method is called.
  - If this quantity becomes zero, the Item is destroyed.
- If the user chooses to delete the Item (*deleteItem*), it is deleted.

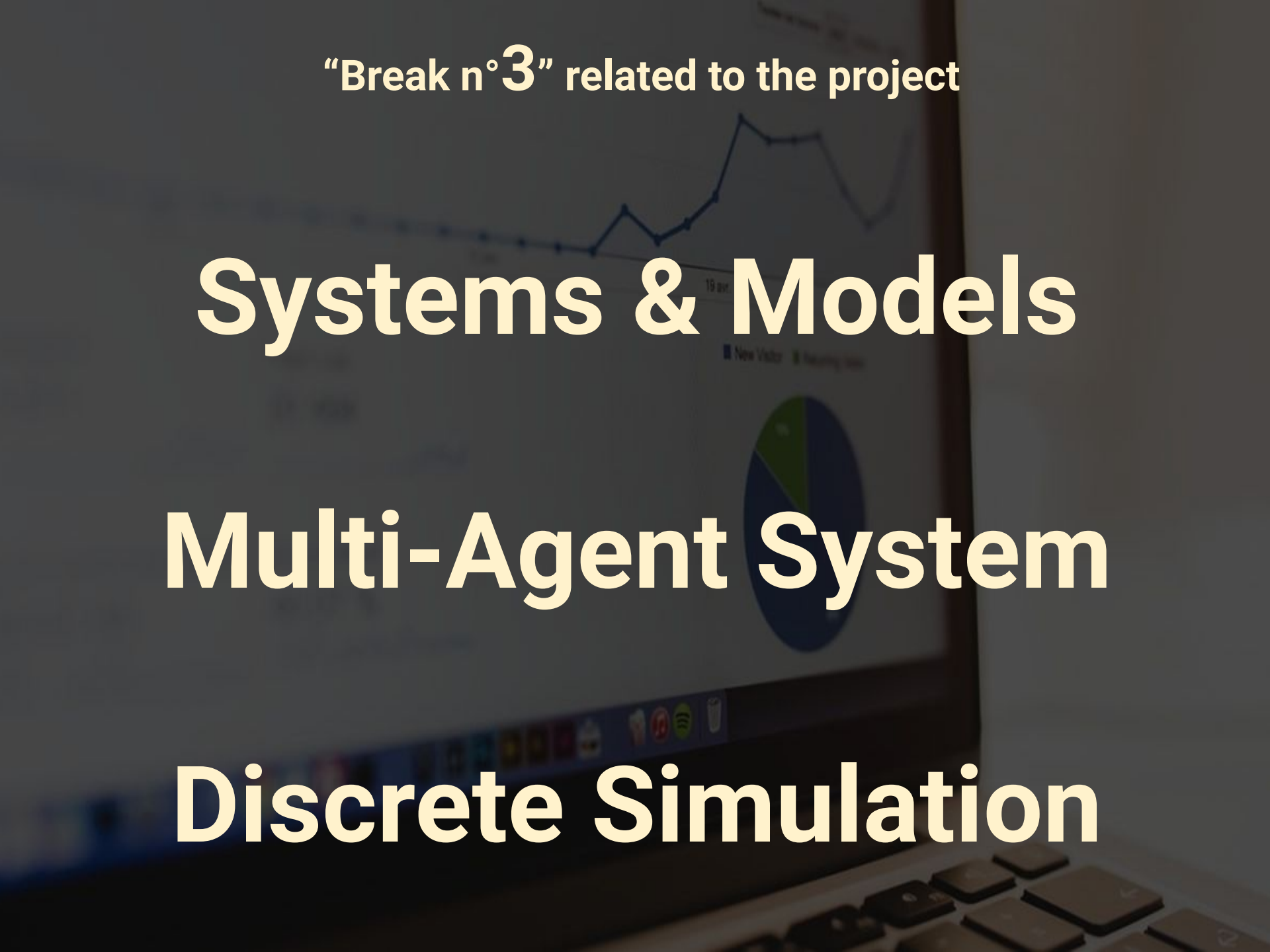
- EXERCICE BASKETMANAGEMENT 2/2 -

Le diagramme de classe est accompagné d'un diagramme de séquences mettant en jeu :

- 1 acteur qui utilise le logiciel, i.e., un *Custumer*,
- Une instance des classes *ShoppingBasket* et *Item*.

Ce diagramme de séquence représente un processus de mise en panier d'un *Item* par l'acteur (utilisez une méthode *addItem()* qui va créer l'objet *Item*) puis la gestion suivante :

- Si l'utilisateur change la quantité de l'*Item* (*ChangeQuantity*), la méthode adéquate est appelée.
  - Si cette quantité devient nulle, l'*Item* est supprimée.
- Si l'utilisateur choisi de supprimer l'*Item* (*deleteItem*), il est supprimé.



"Break n°3" related to the project

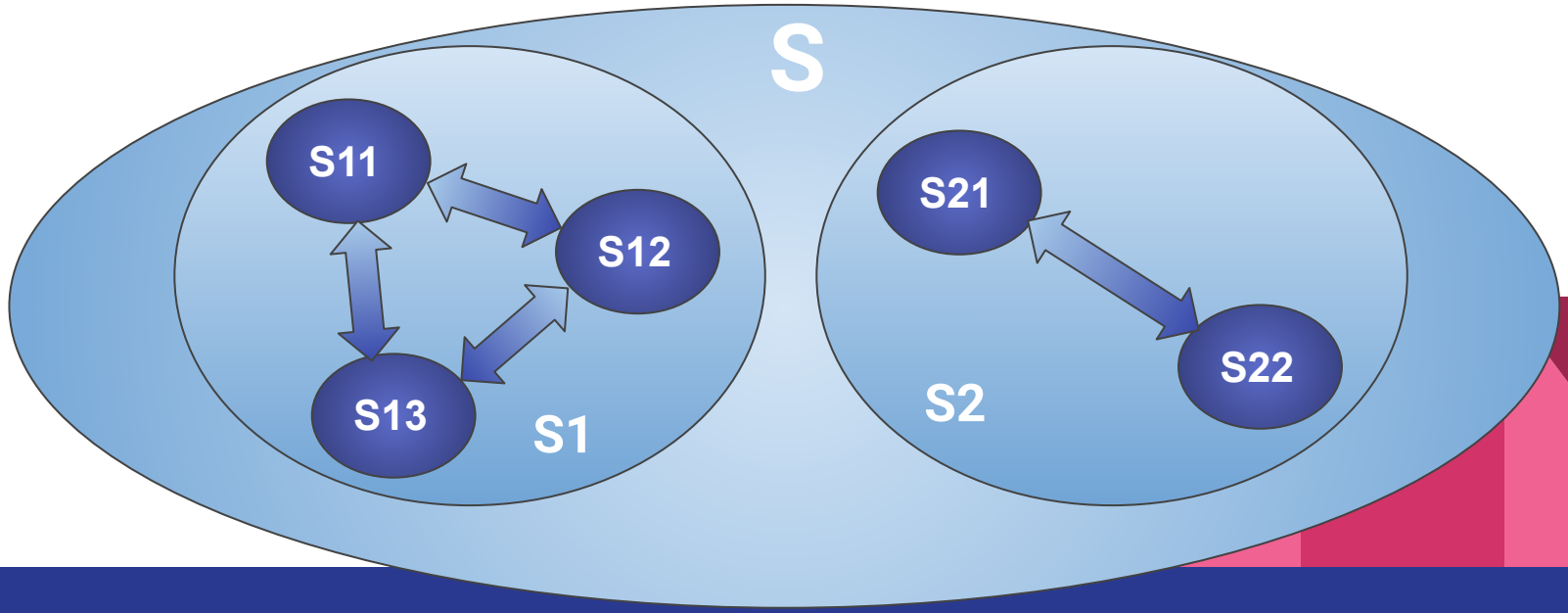
Systems & Models

Multi-Agent System

Discrete Simulation

A System... in 1 slide...

- (Very) simple definition of system:
  - **A collection of interacting objects.**
- There are **static** and **dynamic** systems. These mean that **interactions can change the state of objects**.
- There is a whole **encapsulation of systems**. For example, an open subsystem will evolve according to the environment in which it is located, this environment is also a system.



A Model... in 1 slide...

- (Very) simple definition of a model:
  - **Abstraction simplifying the real system studied.**
- An **old notion** like... the heliocentric model of Copernicus!
- Minsky, 1965:
  - “To an observer B, an object A* is a model of an object A to the extent that B can use A* to answer questions that interest him about A.”
- Popper, 1973, 3 characteristics common to all models:
  - **A model must have a character of resemblance to the real system,**
  - **A model must constitute a simplification of the real system,**
  - **A model is an idealization of the real system.**

Discrete Simulation... in 1 slide...

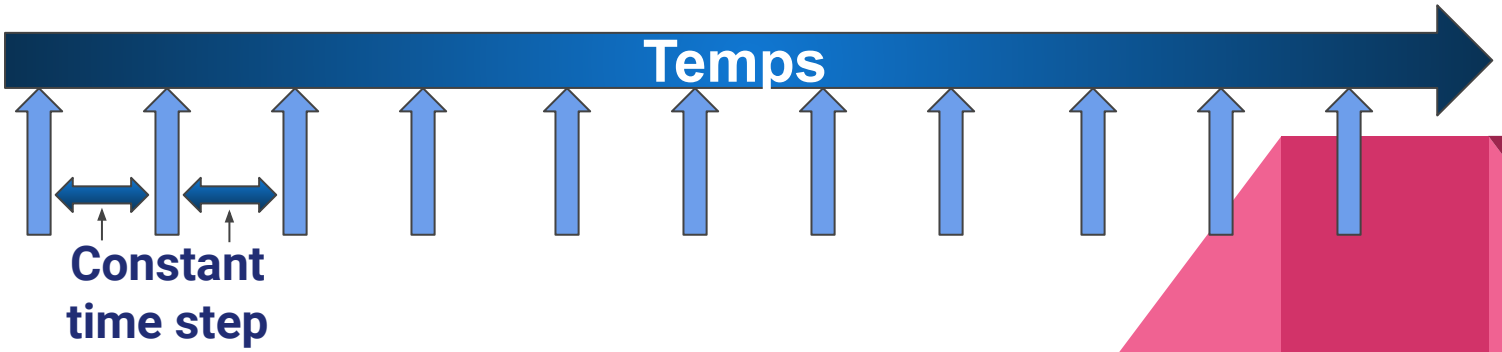
- We immerse a **model in the time dimension**…
  - / On plonge un modèle dans le temps…

- Simulation definition (Hill, 1993) :
  - "**Simulation** is the process of changing an **abstraction** of a **system over time to help understand how that system works and behaves**, and to understand some of its dynamic characteristics in order to evaluate different decisions."

- **Discrete** Simulation:
  - Set of possible values of variables of **finite size**
    - => Set of states of the finite size system;

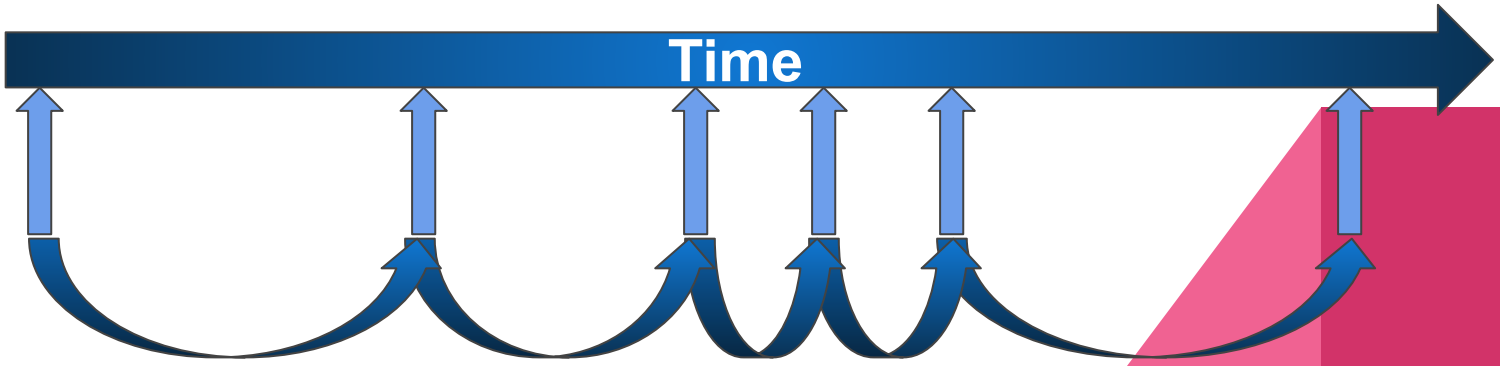
Time management in Simulations (1/2)

- **Clock driven / constant time step simulation**
  - **/ Simulation dirigée par horloge / à pas de temps constant**
  - Technically **simple**,
  - Duration of the simulation discretized into a number of **intervals of identical size** (i.e., the time step),
    - / Durée de la simulation discrétisée en un certain nombre d'intervalles de taille identique (i.e., le pas de temps),
  - **At each time step: search for events that must be triggered in this period,**
  - **Main difficulty: finding the adequate time step.**



Time management in Simulations (2/2)

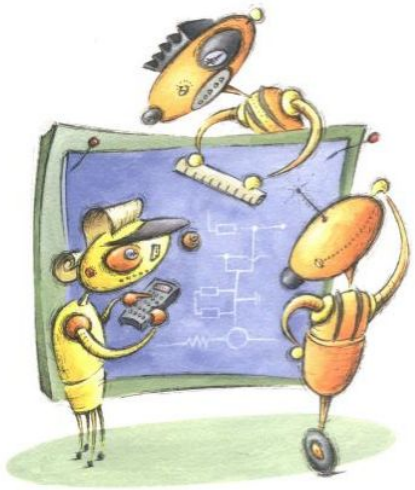
- **Event driven / timeline simulation**
  - **/ Simulation dirigée par les évènements / à échéancier**
  - Technically **complicated**,
  - Virtual time progresses **from one date of occurrence of events to another**,
    - **Le temps virtuel progresse d'une date d'occurrence d'évènements à une autre,**
  - **No event search to process**,
  - **Skipping unnecessary periods of time**,
  - Main difficulty: **managing a schedule storing events ordered chronologically**.



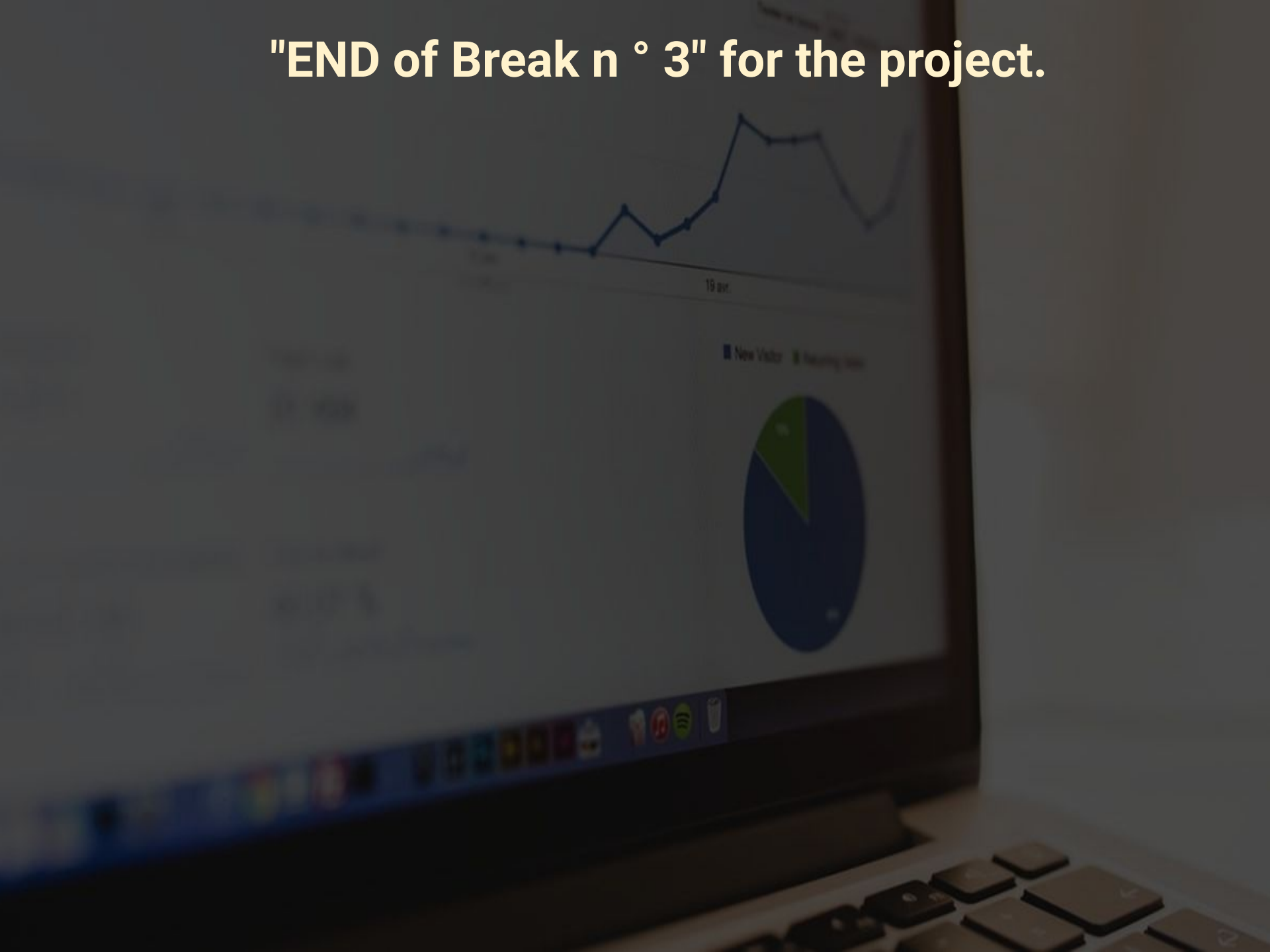
Multi-Agent Systems (**MAS**) ... in 1 slide …

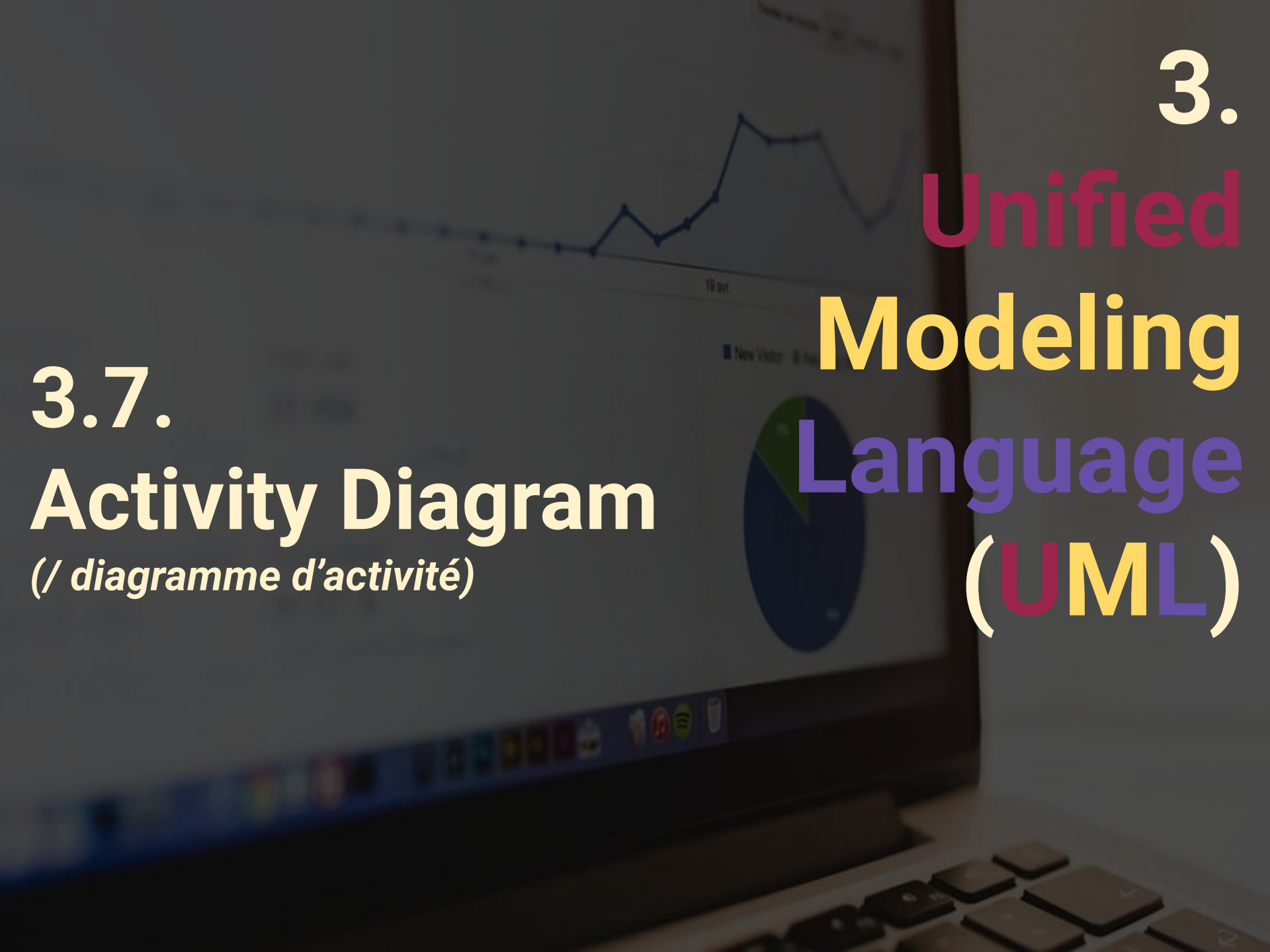
/ Systèmes Multi-Agents (**SMA**)...en 1 *slide*...

- 2 types of **multi-agent systems (MAS)**:
  - **Reactive MAS:**
    - Large number of agents,
    - Without memory,
    - Local vision of their environment;
  - **Cognitive MAS**:
    - Few agents,
    - With memory,
    - Good knowledge of the environment,
    - Based on communication protocols between agents,
    - Knowledge of agents among themselves;



"END of Break n ° 3" for the project.





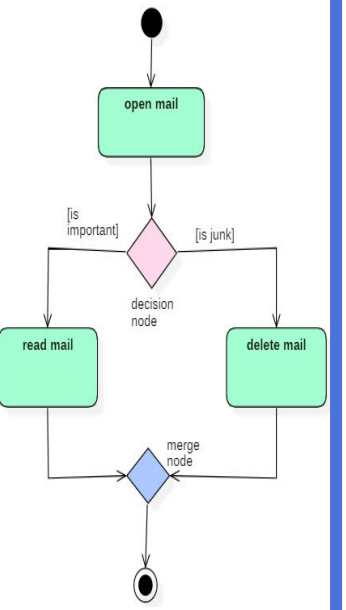
3. Unified Modeling Language (UML)

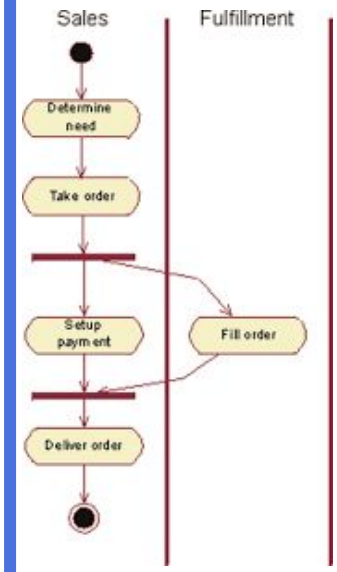
3.7. Activity Diagram

(/ diagramme d'activité)

Activity Diagram

- **Goal**:
  - Represent the **sequential or parallel actions** within one of the processes of the system studied.
    - / Représenter l'enchaînement séquentiel ou parallèle d'actions au sein d'un des processus du système étudié.
- **Structure**:
  - Use **objects** and **control flows**,
  - Similar to an algorithmic scheme,
  - Can partition actions according to object type like columns in sequence diagrams.
- **When?** From the start of a project (informal "high level" vision) and complete until its end ("low level" vision close to algorithms).

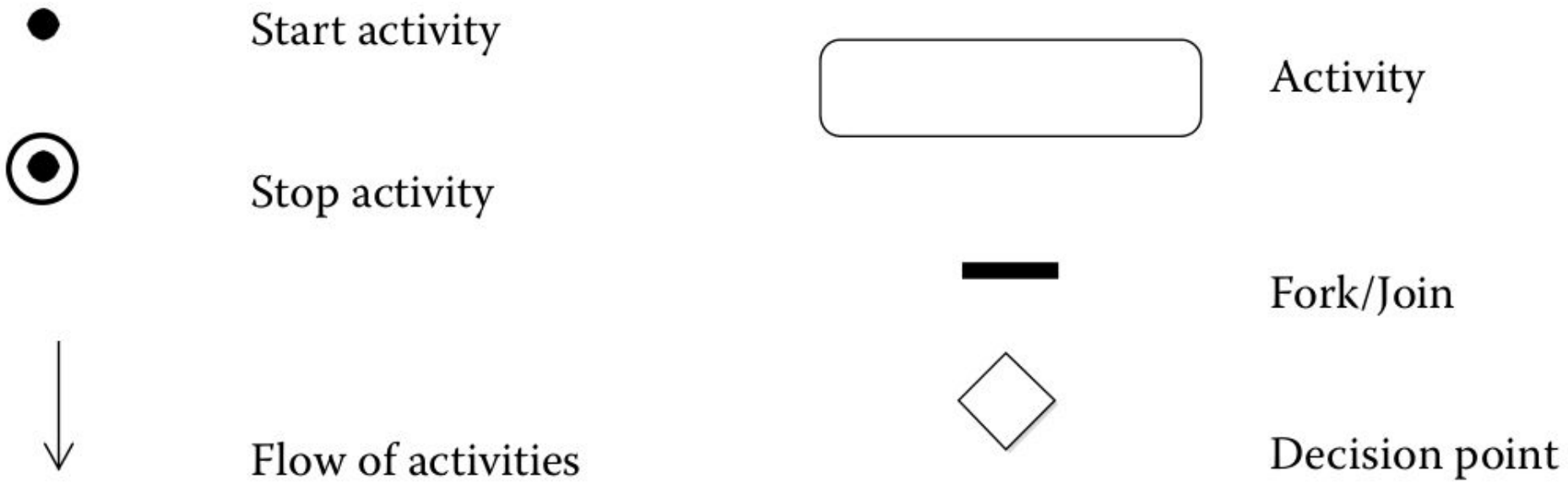




Activity Diagram

Notations

(eng. / fr.)



Respectivement en français :

- Départ d'activité
- Fin d'activité
- Flot
- Activité / Action
- Débranchement
- Décision

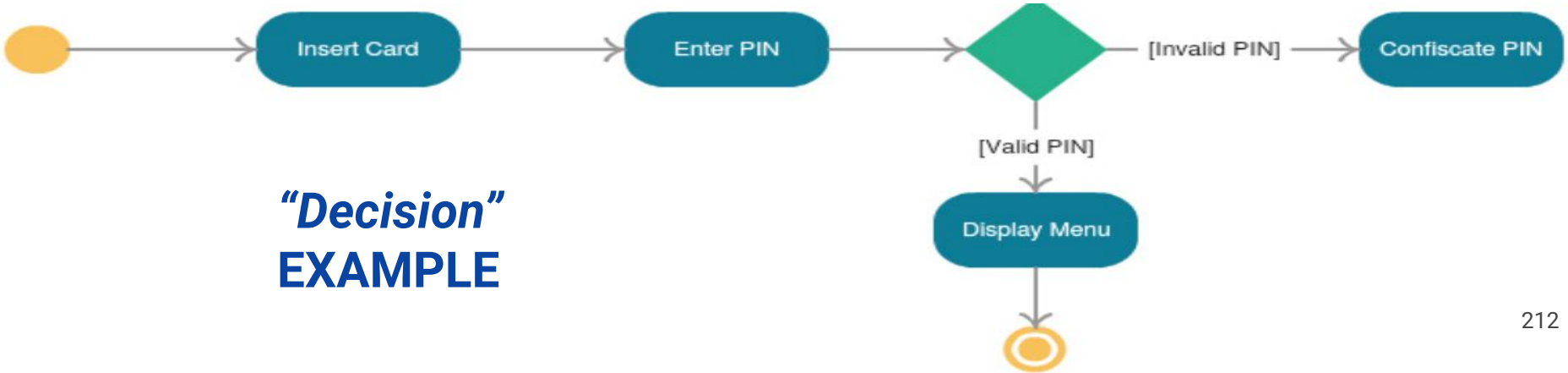
Activity Diagram
BASIC ELEMENTS

Activity/Action : represents treatment or transformation. An activity can contain several actions, the latter are the basic unit of these diagrams.

Flow : "sequencing control" arrow connecting the different elements of the activity diagram.

2 types for a single "diamond" ("decision and merge" nodes):

- ***decision*** : control node with 1 incoming flow and/or several outgoing **[**under conditions**]**,
- ***merge*** : Control node with several inbound and 1 outbound.



"Decision"
EXAMPLE

Activity Diagram

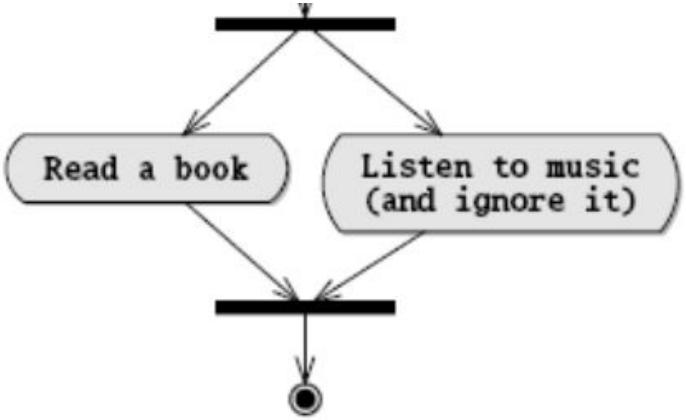
BASIC ELEMENTS

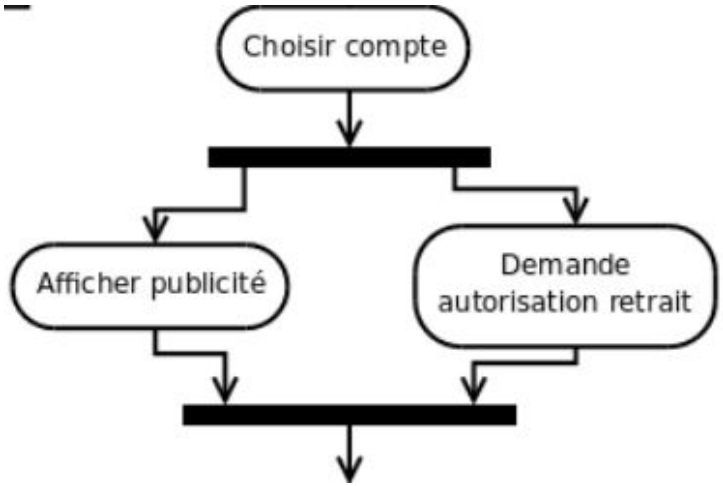
Fork **(/ Débranchement)** & ***Join*** **(/ Rebranchement).**

- Allows the start of **concurrent actions** (in parallel) (i.e., bifurcation node) then their **synch**ronization (i.e., union node).

Fork has an incoming flow leading to several outgoing flows; the reverse is true for ***Join***.

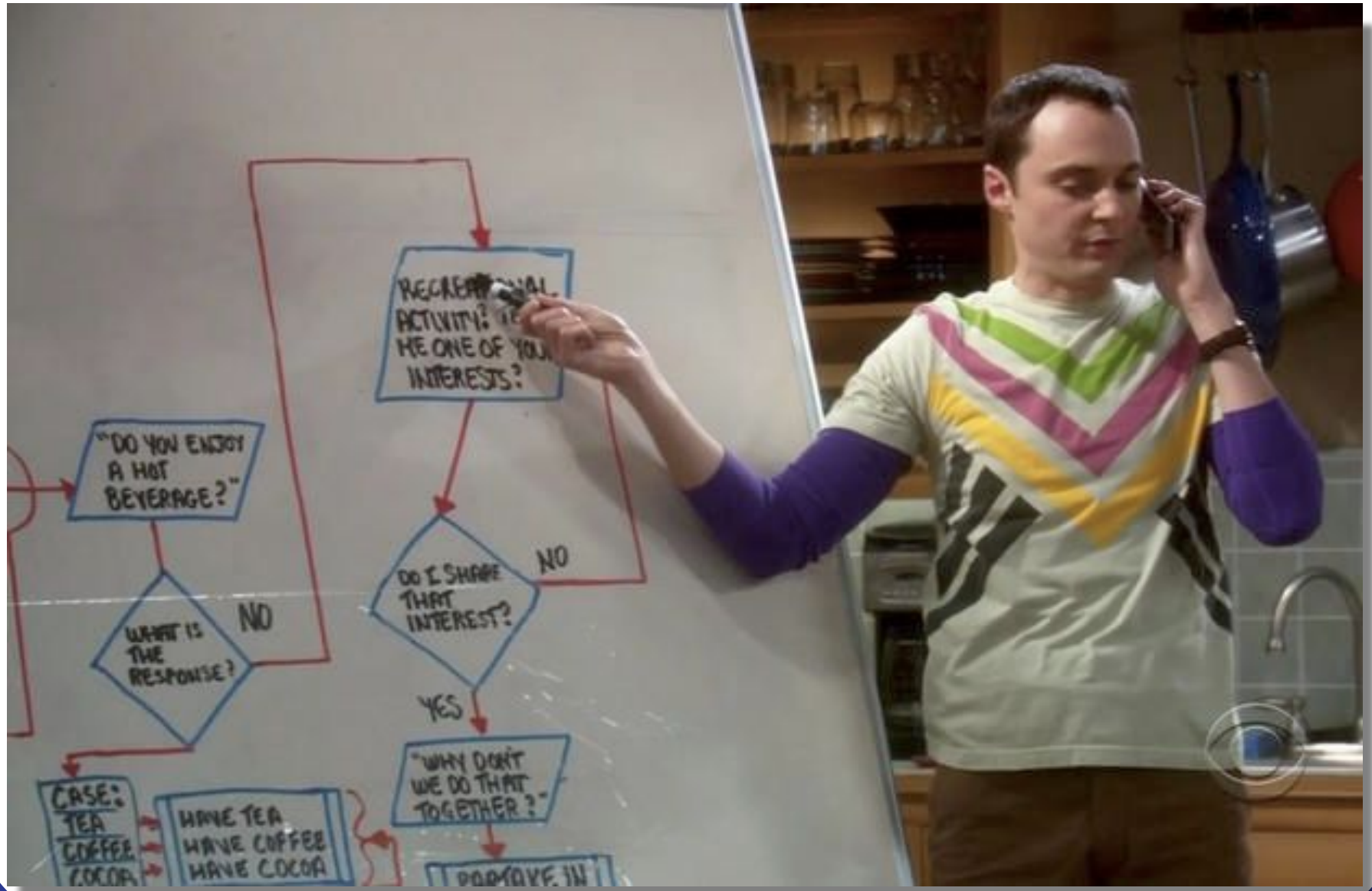
EXAMPLE





Activity Diagram

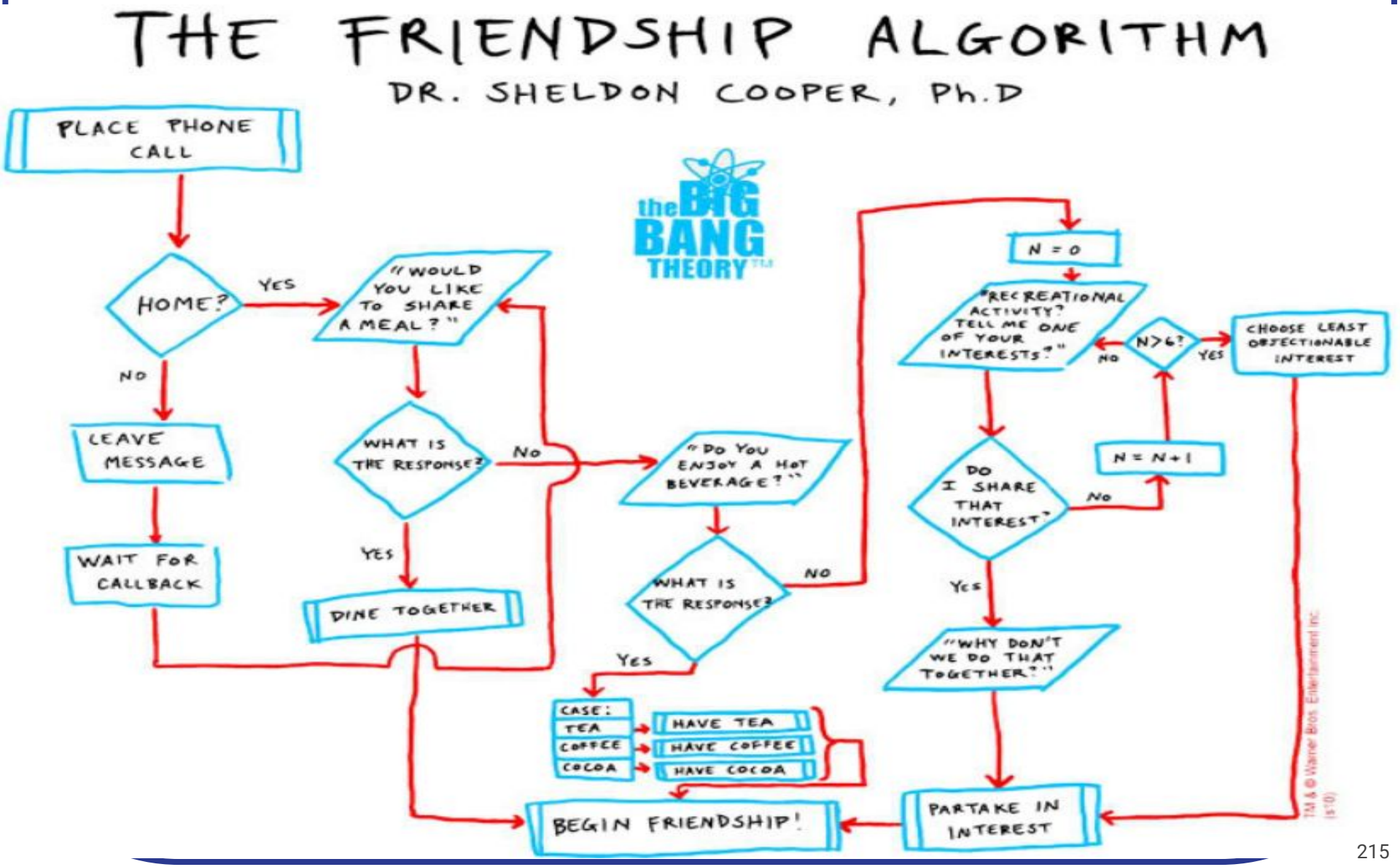
- Easy EXERCISE diagOfSheldon -



Activity Diagram

- EXERCISE diagDeSheldon - (S02E13)

Transform the Sheldon diagram into a **UML activity diagram**



Activity Diagram

Advanced Elements

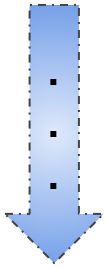
Rep. **Stop Flow** and **Stop Activity**. The 1st (more rare) only terminates one stream (and does not terminate the other streams in parallel). The 2nd (more frequent) ends all activities.

"**Super**" **Action** calling another activity (here given in place of "Calling an Activity"), the small fork ⑃ being the distinctive sign. Once the call for the new activity is over, the flow starts again from the Super Action.

Hourglass (/sablier) blocking a flow for a certain time announced (here "End of Month Occurred"). Once the time is up, the flow starts again. An activity can also start on this element.

Activity Diagram
Advanced Elements

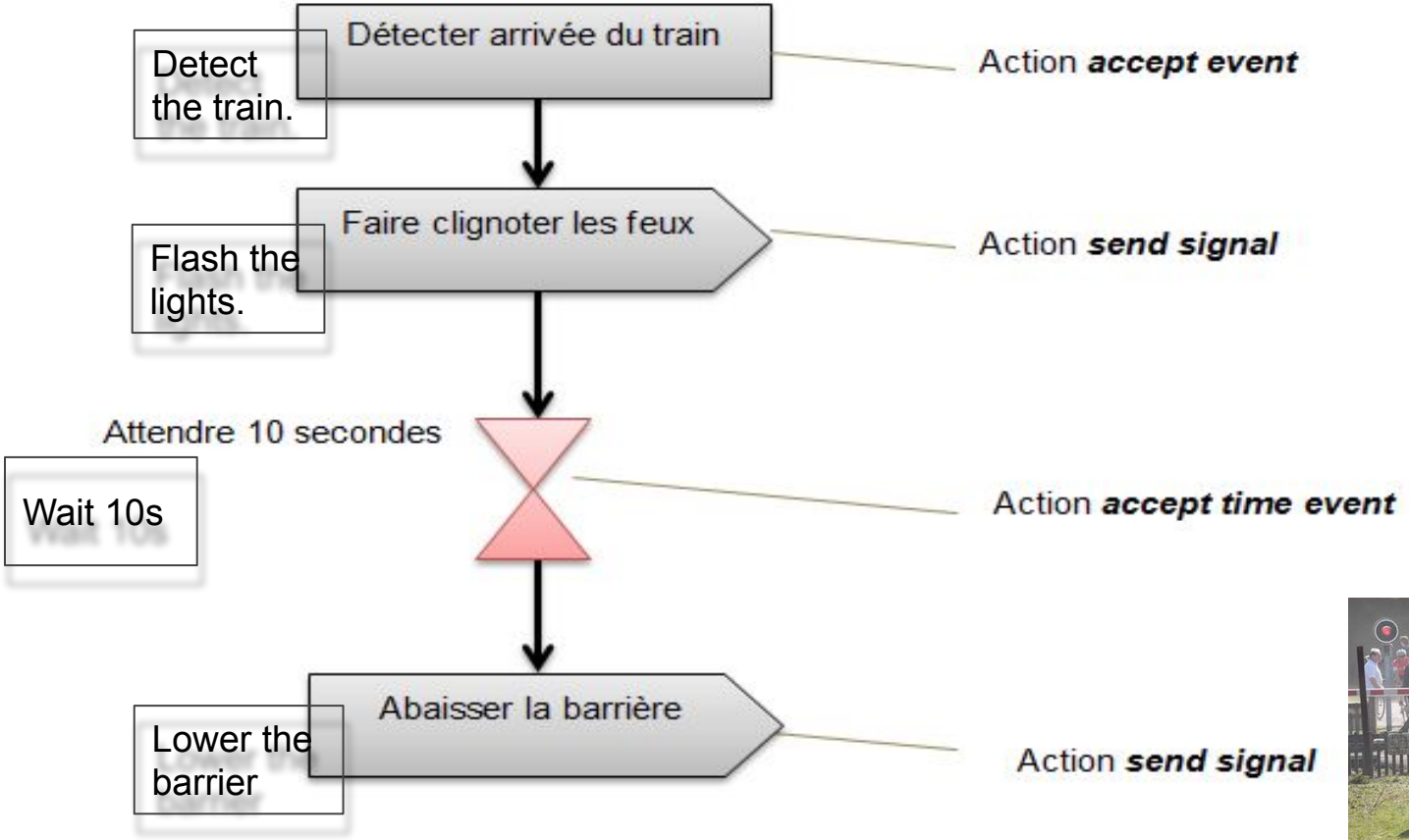
Sends a signal to activate a flow on an “Accepting an Event” type action.



Action waiting to be executed. Once the event is "accepted", a flood starts from this action.

Activity Diagram

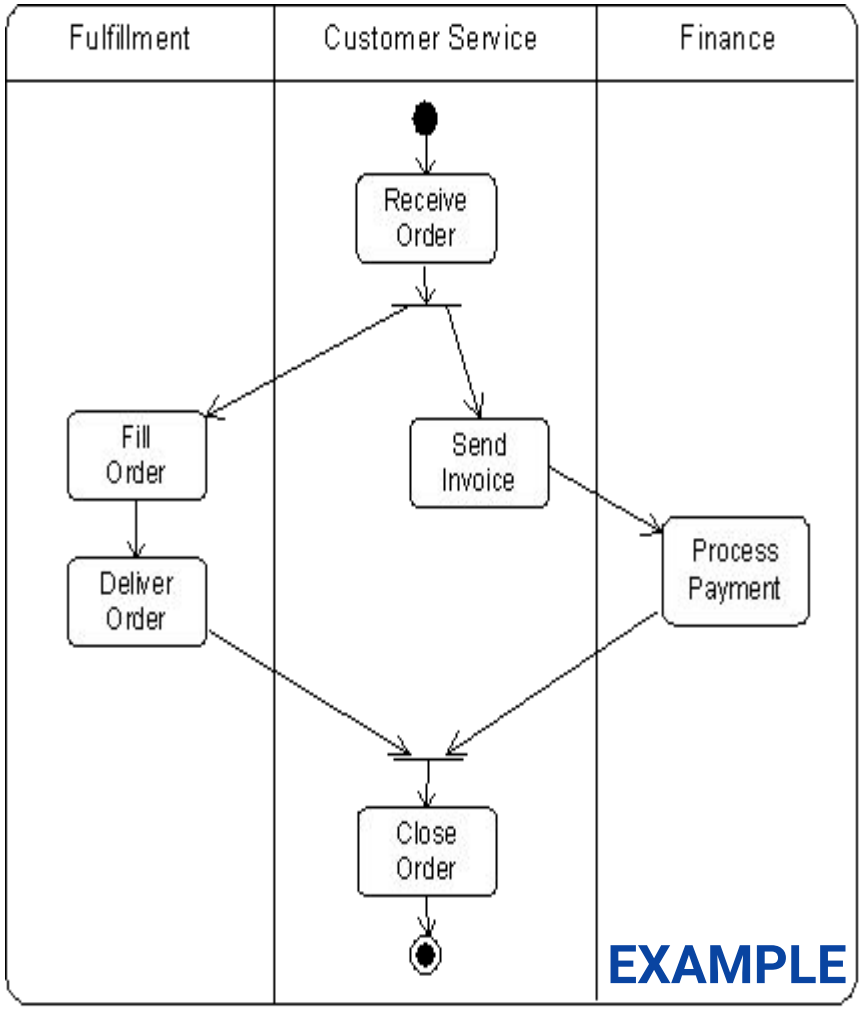
SPECIAL ACTIONS - EXAMPLE “Railroad Crossing”

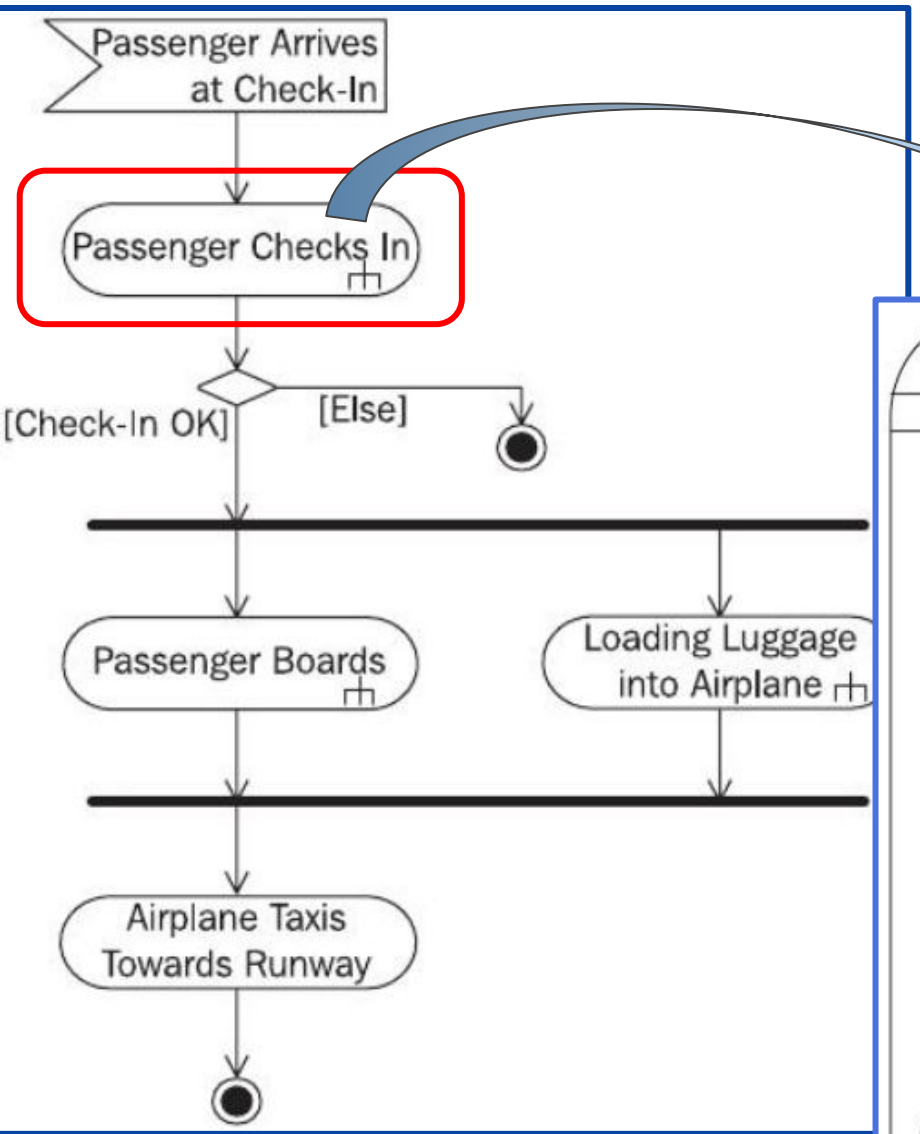


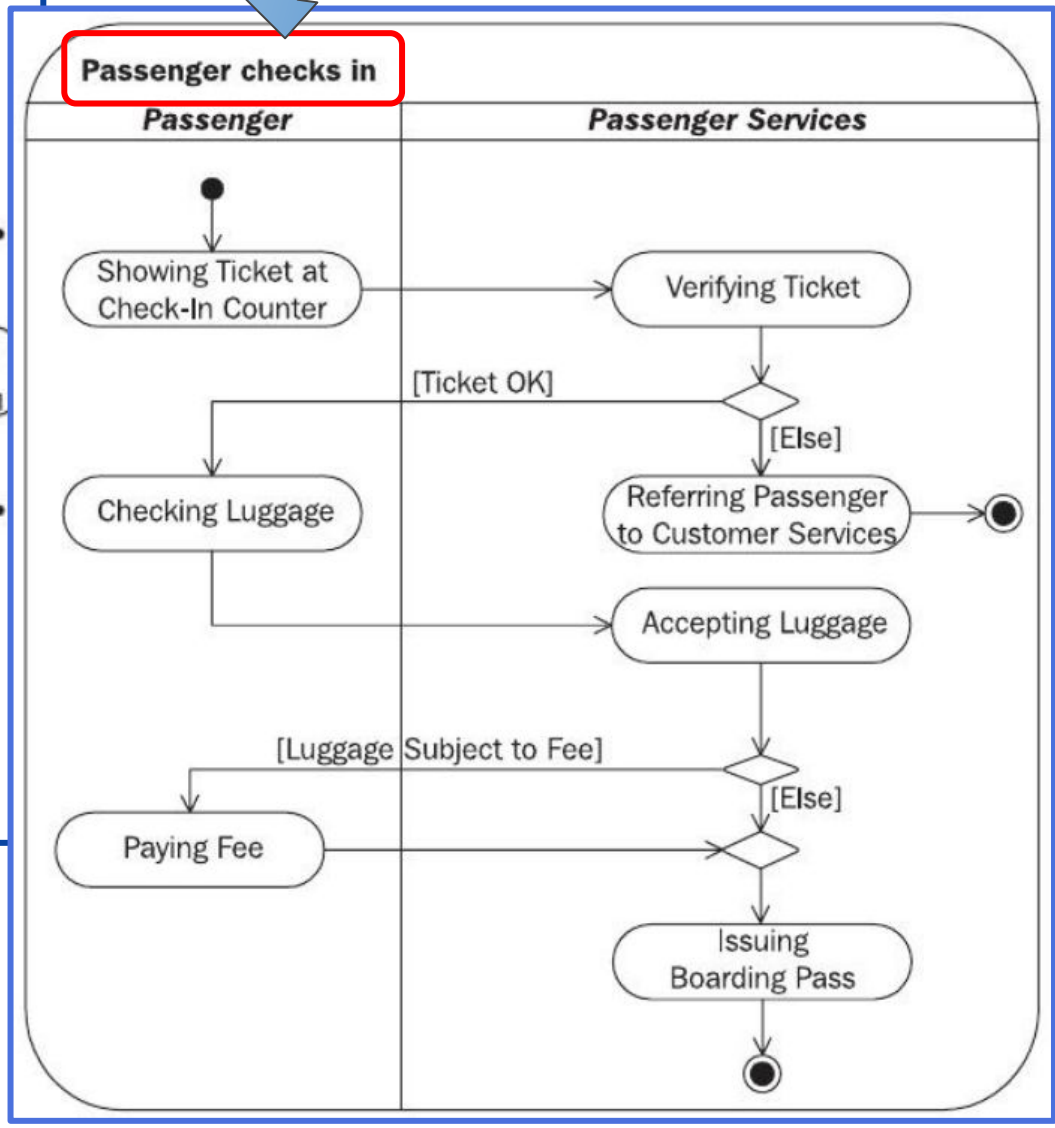
Activity Diagram
PARTITION

All the actions of an activity diagram can be partitioned into parts representing classes responsible for those actions. For example, we can find classes.

This partition is often vertical but can be horizontal.







Example

“Airport Arrivals”

Activity Diagram
- Prepare dinner -
Short exercise on Fork & Join

Tonight, you have to make dinner…

In your TO DO LIST you have to:

(1) - Cook spaghetti,

(2) - Mix Carbonara Sauce,

(3) - Combine 1 & 2,

(4) - Open Red Wine during (1), (2) and (3) if one is in mood for it.

Draw an activity diagram (think about which actions can be made in the same time)?

Activity Diagram

EXERCISE Multithreaded Chocolate Mousse

In order to prepare for 100% autonomous kitchen machines, a chef wants to put his recipes in the form of an activity diagram. He · She tries chocolate mousse first.

He · She knows he · she can chop chocolate before it melts, and, at the same time, that he · she can crack the eggs and then separate the whites from the yolks. This then allows him to add the egg yolks to the chocolate regardless of whipping the whites to stiff peaks.

Finally, he · she can mix the egg whites with the chocolate preparation before pouring everything into ramekins. These end up in the refrigerator. The recipe is complete (and can be considered successful) after 3 hours.

Note: A difficulty of this exercise is to separate sequential actions from parallel actions.

Activity Diagram

- EXERCICE mousseChocoM*ultithreadée* -

Afin de se préparer aux robots de cuisine 100% autonomes, un·e chef veut passer ses recettes sous la forme d'un diagramme d'activité. Il·Elle s'essaye d'abord à la mousse au chocolat.

Il·Elle sait qu'il·elle peut casser le chocolat avant de le faire fondre, et, en parallèle, qu'il·elle peut casser les oeufs puis séparer les blancs des jaunes. Cela lui permet ensuite d'ajouter les jaunes d'oeuf au chocolat indépendamment de battre les blancs en neige.

Enfin, il·elle peut mélanger les blancs en neige avec la préparation chocolat avant de verser le tout dans des ramequins. Ces derniers finissent au réfrigérateur. La recette est terminée (et peut être considérée comme réussie) au bout de 3 heures.

Note : Une difficulté de cette exercice est de bien séparer des actions séquentielles des actions parallèles.

Activity Diagram

- EXERCISE Multithreaded Chocolate Mousse (1 year later) -

After multiple unsuccessful attempts, the chef renames his 100% autonomous robot as “Assistant”. Indeed, the robot is not skillful enough neither to break the eggs, nor to separate the whites from the yolks, nor to beat the whites to snow (a shame!). And, finally, nor to mix the whites and the chocolate preparation.

Thus, he wants us to modify his activity diagram using a score in order to clearly mark what the assistant is doing and what he is obliged to do.

Activity Diagram

- EXERCICE mousseChoco*Multithreadée1AnAprès* -

Après de multiples tentatives infructeuses, le chef renomme son robot 100% autonome en “Assistant”. En effet, le robot n’est pas assez habile ni pour casser les oeufs, ni pour séparer les blancs des jaunes, ni pour battre les blancs en neige (un comble !) et, enfin, ni pour faire le mélange des blancs et de la préparation chocolat.

Ainsi, il veut que l’on modifie son diagramme d’activités en utilisant une partition afin de bien marquer ce que fait l’assistant et ce que lui est obligé de faire.

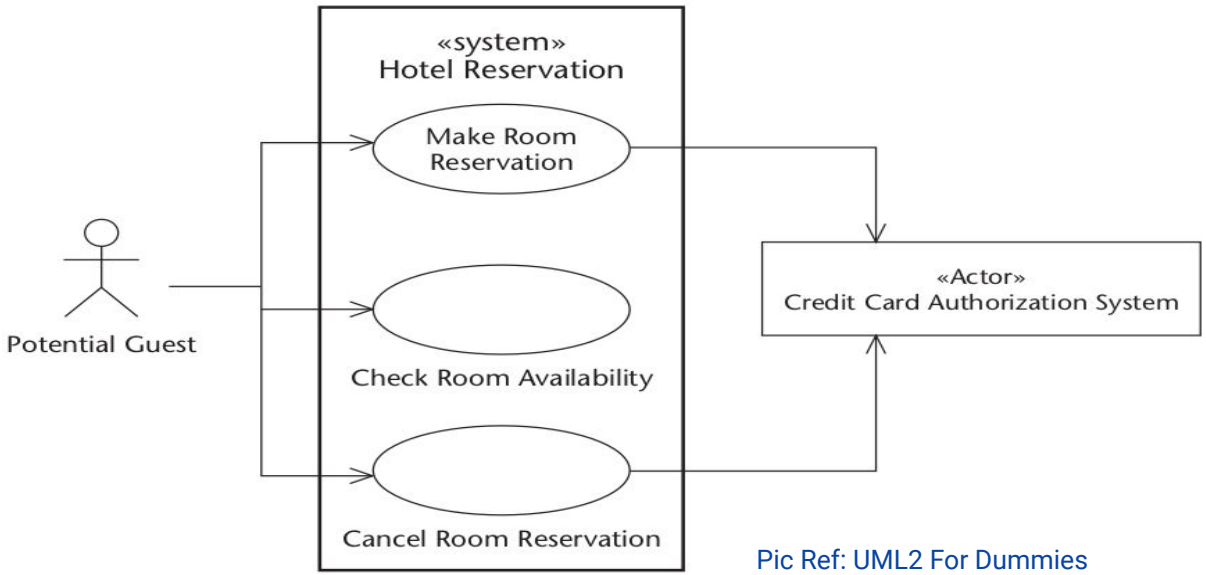
3. Unified Modeling Language (UML)

3.8. Use Case
(fr. Cas d'utilisation)

USE CASE DIAGRAMS

- **Determine the users**
- **Defining use scenarios**
- To **describe needs** from an external point of view
  - between customers and developers
- To keep you **focused on your users' goals**
- Help for accomplishing a task and/or communicate with your peers

Example >

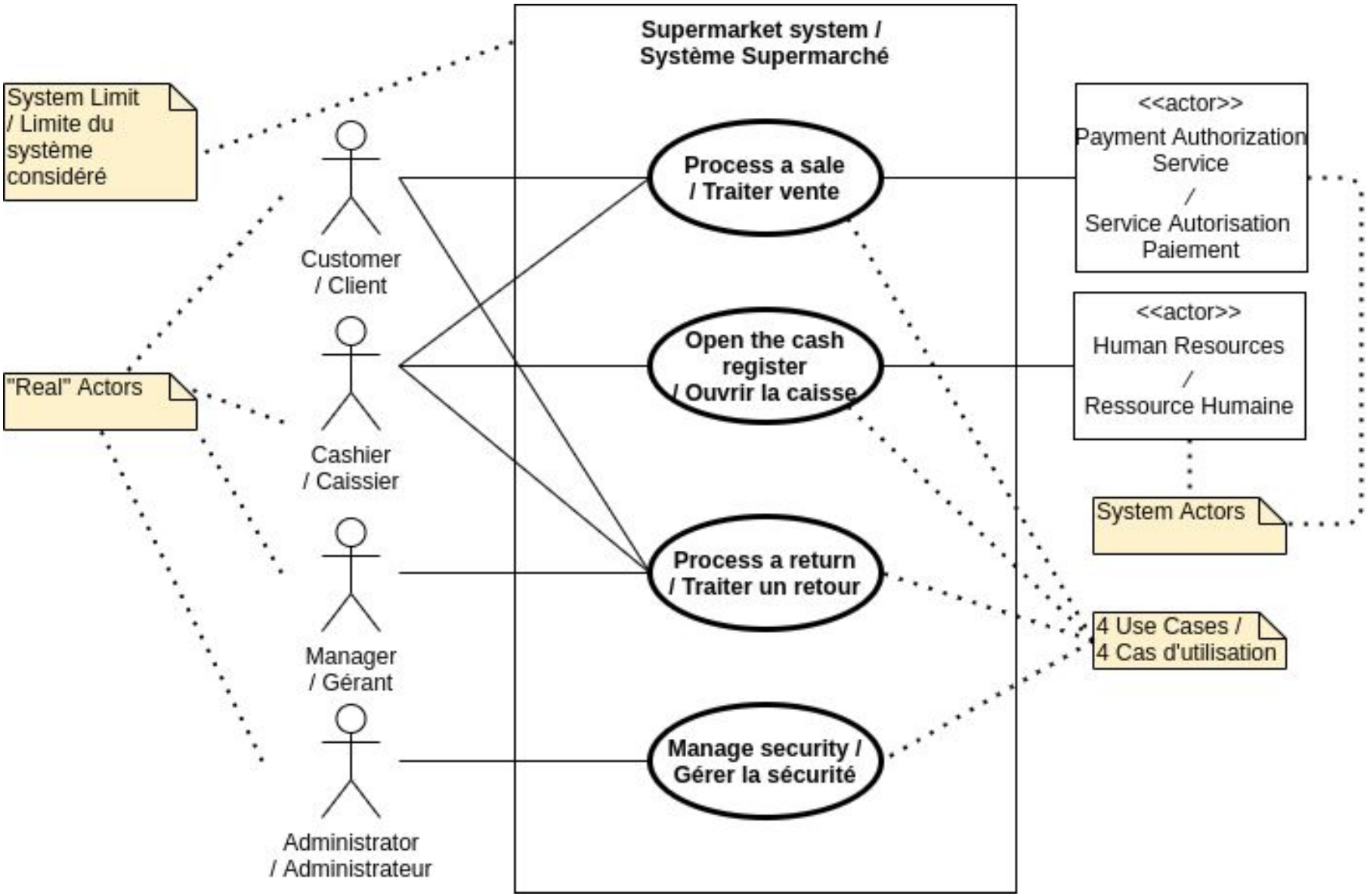


Pic Ref: UML2 For Dummies

USE CASE DIAGRAMS

(fr. Cas d'utilisation)

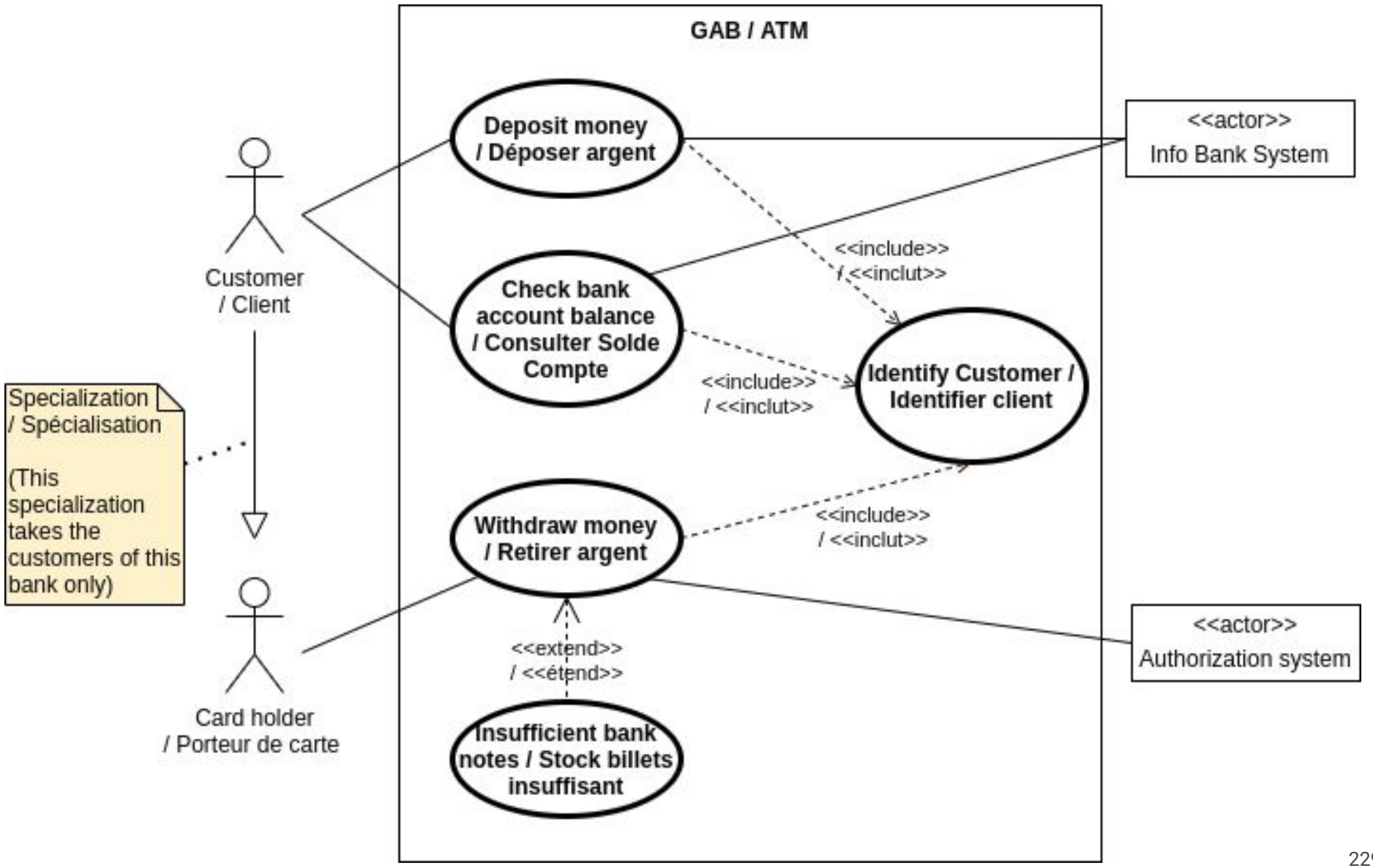
Example



USE CASE DIAGRAMS

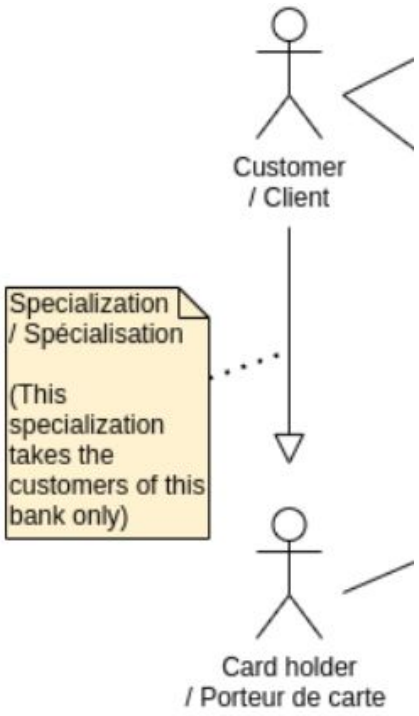
(fr. Cas d'utilisation)

Example



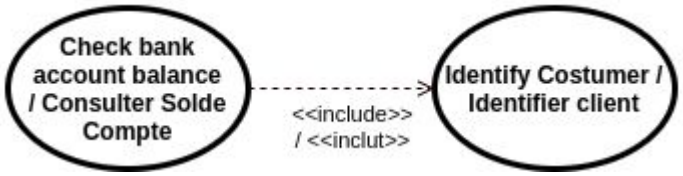
USE CASE DIAGRAMS
(fr. Cas d'utilisation)

Specialization / Spécialisation
Generalization / Généralisation

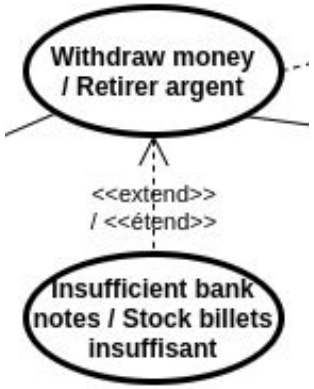


Example:

- only clients of the bank can deposit and check the bank account balance.
- Card Holder is a **generalization** of a Customer while Customer is a **specification** of a Card holder.



- Inclusion (**<<include>>**)
  - Precise the inclusion of a specific action in an use case.

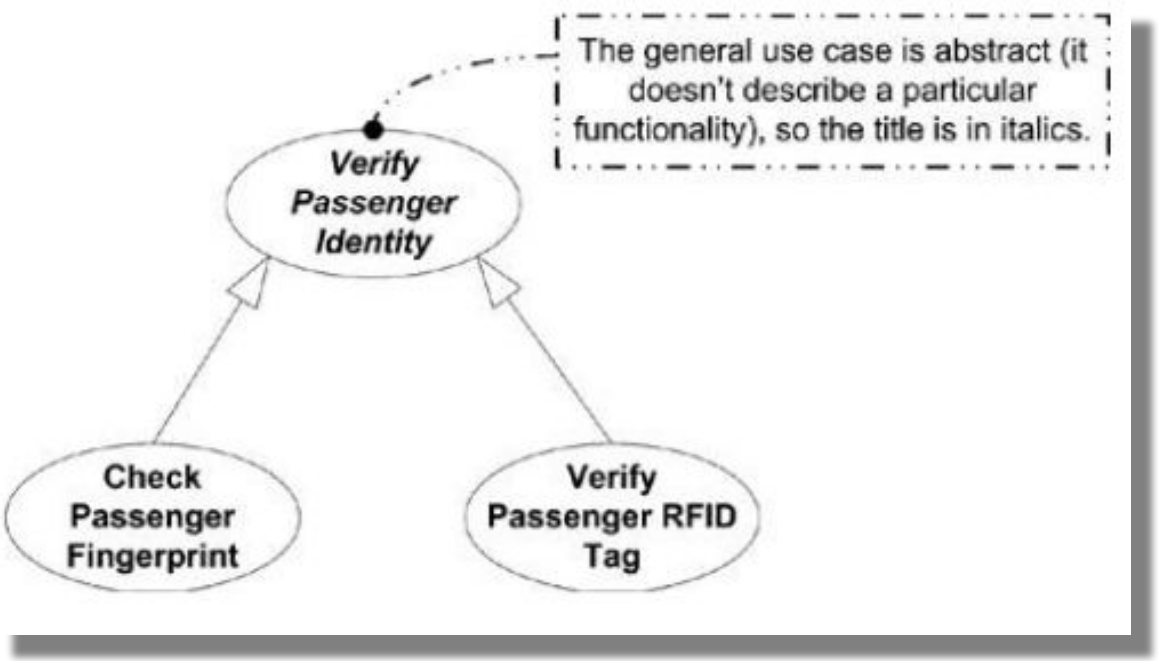


- Extension (**<<extend>>**)
  - Add actions, checks or upgrade in some use cases.

USE CASE DIAGRAMS

(fr. Cas d'utilisation)

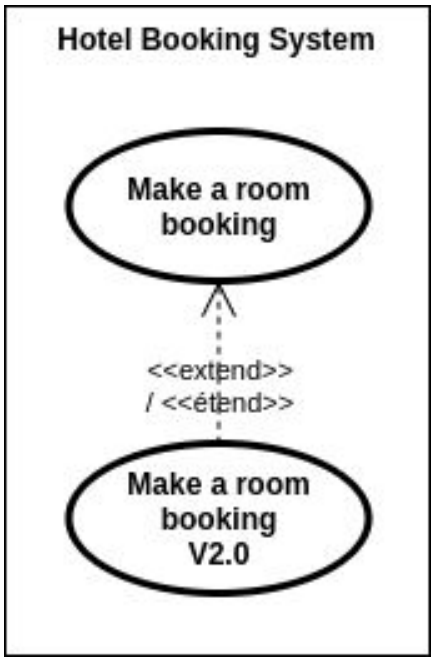
Generalization / Généralisation
(Specialization / Spécialisation**)**



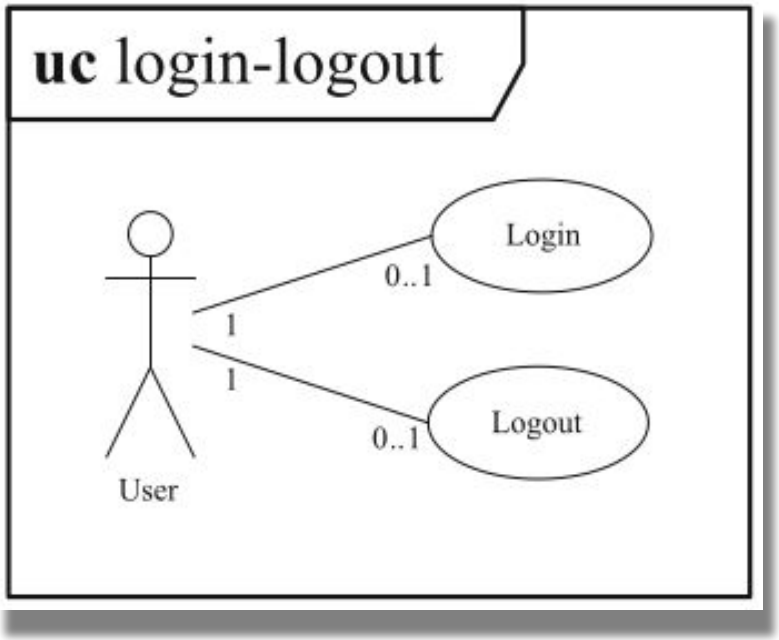
Pic Ref: UML2 In A Nutshell

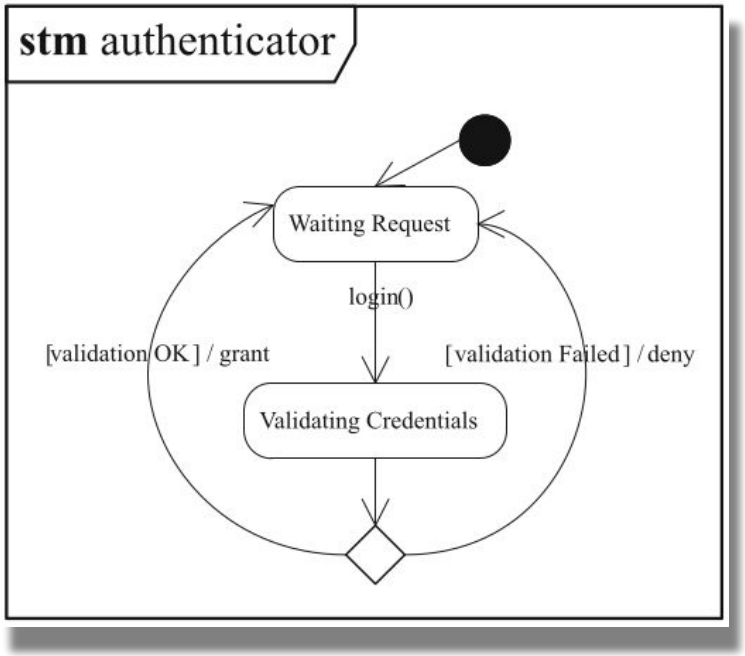
New release example
(in order to display an update)

Extending / Extension
(<<extend>> / <<étend>>)



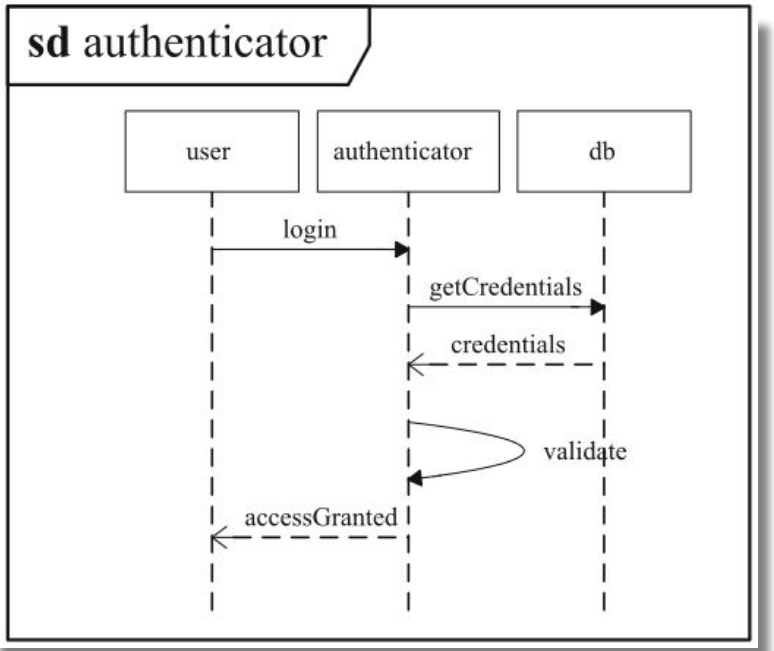
Few Remarks

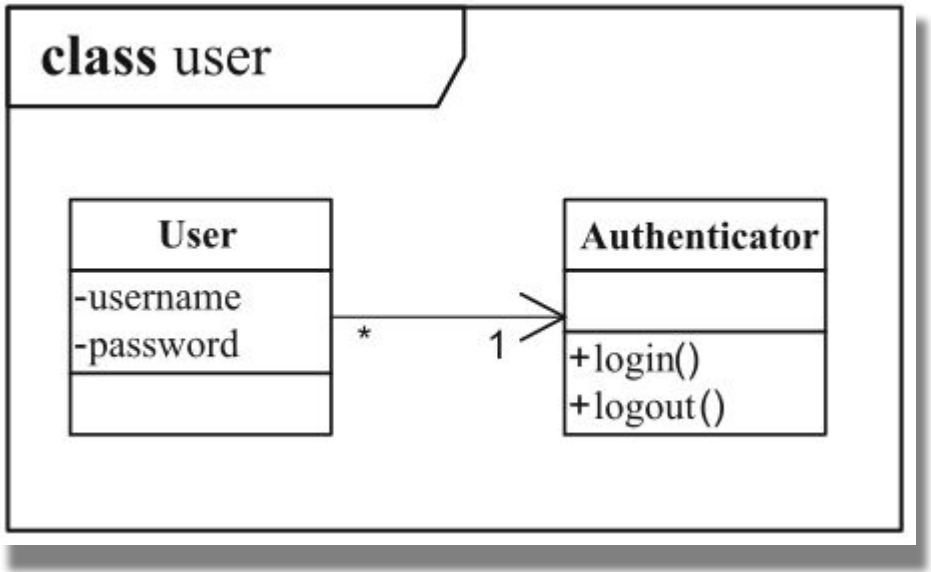




UML Generalities

Frames

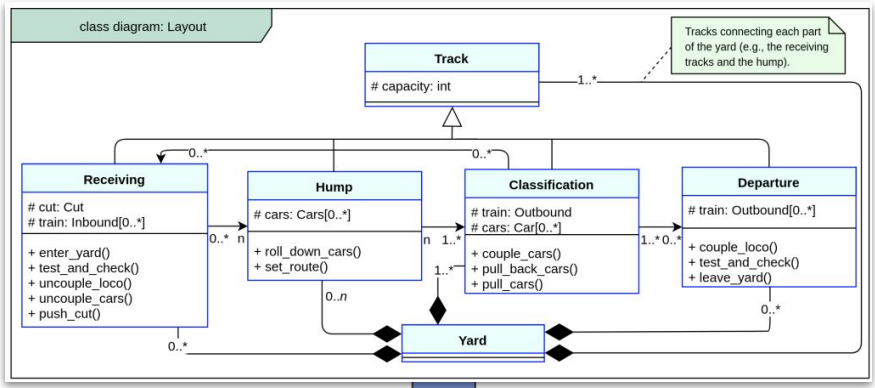




Before we are done with UML ...

Between code and UML diagrams ...

Generation of UML diagrams from code.
(reverse-engineering method)



Generate code from UML diagrams.

(The one you will use for the project)


GAME
OVER
...UML

4. Design Patterns / Patrons de conception

Design Patterns
/ Patrons de conception

- **Goal** :
  - Provide generic solutions for famous design problems
    - Do not reinvent the wheel!
  - Flexible and efficient code;
- **Structure** :
  - Objects and classes ;
- **Characteristics** :
  - Adaptability ; Validated by pairs ;
- **Difficulties** :
  - May increase code complexity.

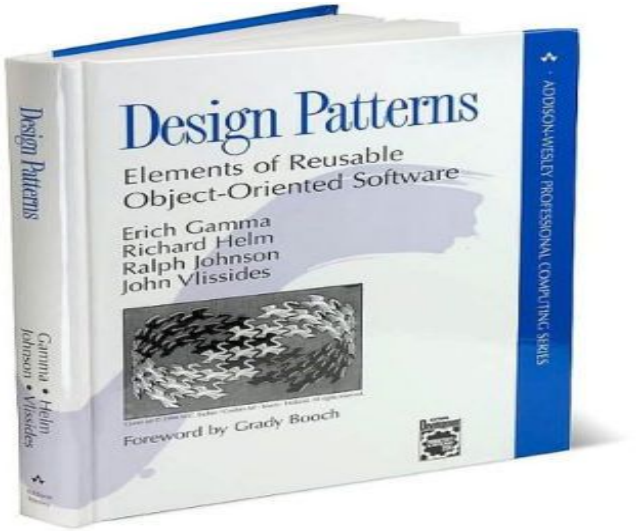
To resume: - You have a problem with the design of software mechanism?
=> All of the design patterns probably have the answer...

Il était une fois... **Les patrons de conception** (fr)

Once upon a time... **The design Patterns** (eng)

Secrets d'Histoire

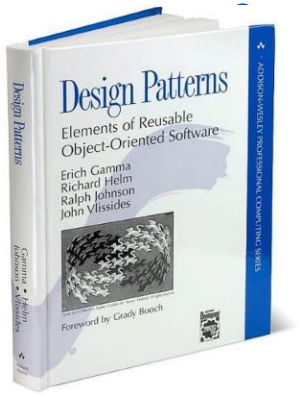
- Appearing in the literature in **1994** :
- “Design Patterns: Elements of reusable **object oriented** software”,
- authors: **Gamma**, **Helm**, **Johnson** et **Vlissides**
  - Know as the **Gang of Four**.



Il était une fois... Les patrons de conception

Once upon a time... The design Patterns

- The first **23** design patterns of the **gang of 4** are of three types:



Les patrons de création / Creational Patterns

- How to instantiate a class?
  - e.g., how to apply a single instance limit for a given class?
- How to configure an object?

Les patrons de structure / Structural Patterns

- How to interface?

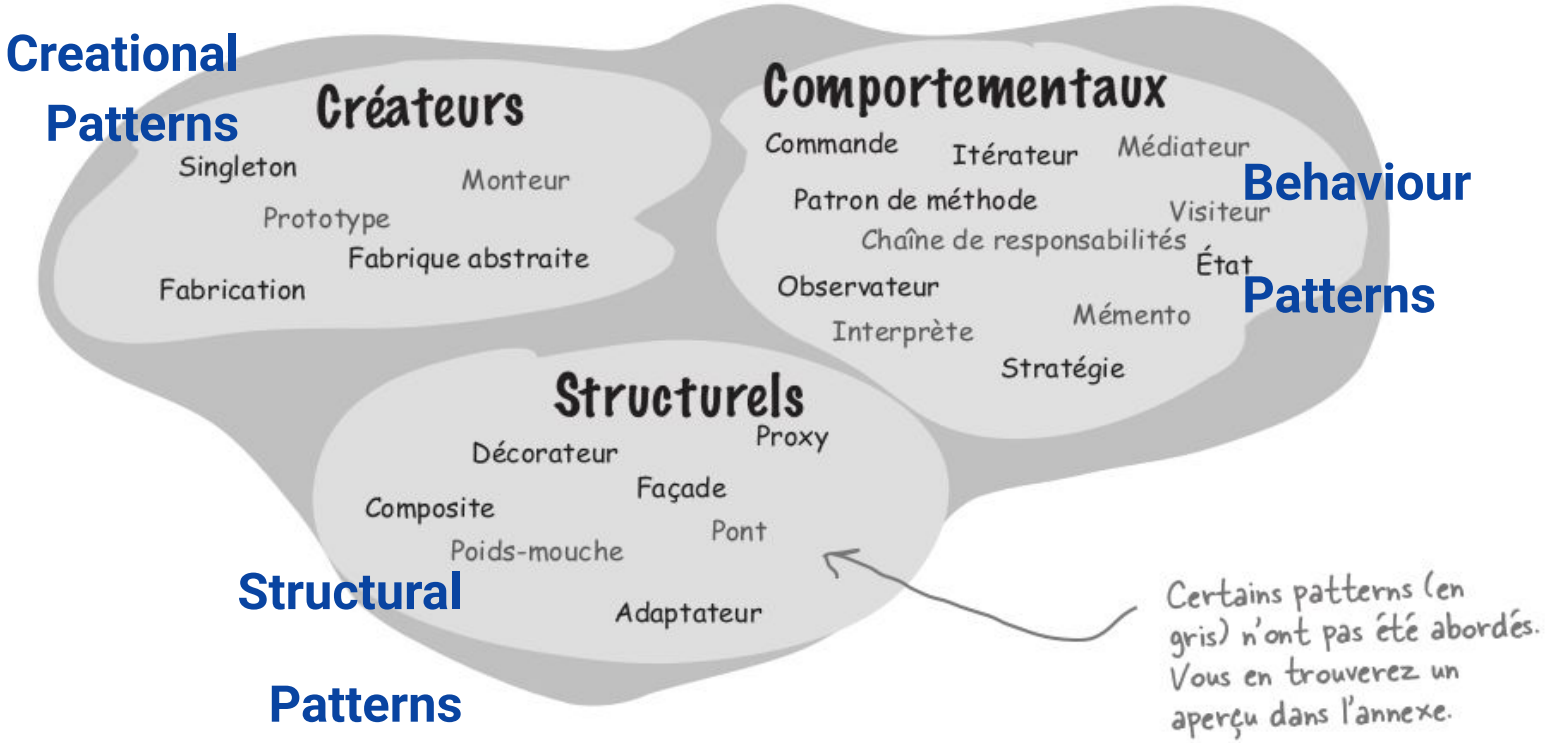
Les patrons de comportement / Behavioral Patterns

- How to properly manage the behavior of an application?

(sorry… for the french…
Catégorie de Patrons de Conception)

Les Patterns Créateurs concernent l'instanciation des objets et fournissent tous un moyen de découpler un client des objets qu'il a besoin d'instancier.

Tout pattern qui est un **Pattern Comportemental** est en rapport avec les interactions des classes et des objets et la distribution des responsabilités.



Les Patterns Structurels permettent de composer des classes ou des objets pour former des structures plus vastes.

Pic Ref: Cours de Stéphan Lardic

Design Pattern
SINGLETON

- **Goal**:
  - Limit the number of instantiation to only one object;
- **Particularities**:
  - It seems simple,
  - But (a bit) difficult to understand!
- **Examples**:
  - Limit the instantiation of one driver for each device,
  - 1 instance of a Buffer,
  - Etc.

Design Pattern
Singleton

Some questions...

- How to instantiate?
- How to limit the access of the instantiation process?

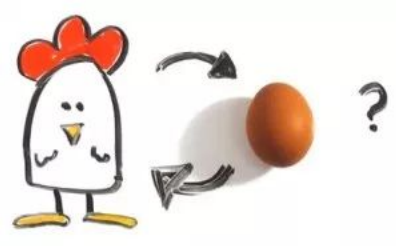
Design Pattern
Singleton

```
1
2  public class SingletonALaClasse {
3
4      private SingletonALaClasse() {};
5
6  }
7
```

Are you shocked by a private constructor?

How would you call this constructor?

Design Pattern
Singleton




```
1
2  public class SingletonALaClasse {
3
4      private SingletonALaClasse() {};
5
6  }
7
```

To call the **`private`** constructor for generating the first (and only) instance from a public method of the same class.

Why not...BUT..AT THE BEGINNING...:

How to call a method from a class which has no object/instance?

Design Pattern
Singleton

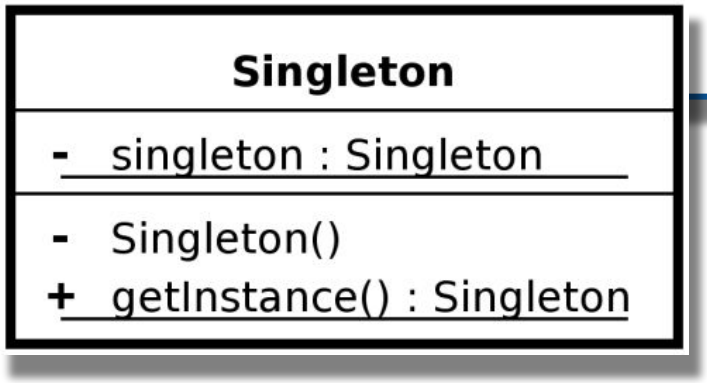
```
2  public class SingletonALaClasse {
3
4      private SingletonALaClasse() {};
5
6      public static SingletonALaClasse getInstance()
7      {
8          return new SingletonALaClasse();
9      }
10 }
```

```
public class Main {

    public static void main(String[] args) {

        SingletonALaClasse.getInstance();
    }
}
```

By modifying a little the code above while continuing to use the properties of "static" elements, **how do you limit the number of instances to 1?**

Design Pattern
Singleton

```java
public class SingletonALaClasse {

    private static SingletonALaClasse lUnique;

    private SingletonALaClasse() {};

    public static SingletonALaClasse getInstance()
    {
        if (lUnique==null)
        {
            lUnique = new SingletonALaClasse();
        }
        return lUnique;
```




```java
public class Main {

    public static void main(String[] args) {

        SingletonALaClasse.getInstance();
    }
}
```

Design Pattern

Iterator

Provide a way to access the elements of an aggregate object sequentially without exposing its underlying representation.

Examples:

- browsing the main data structures (List, Vector, Tree etc.),
- browsing the contents of a directory in a file system,
- browsing the results of a query to a database.

We're looking for an object browsing into a collection of other objects. This object must be isolated from the intern structure of the collection.

Design Pattern
Iterator

The Iterator class defines an interface for accessing the list's elements. An iterator object is responsible for keeping track of the current element;

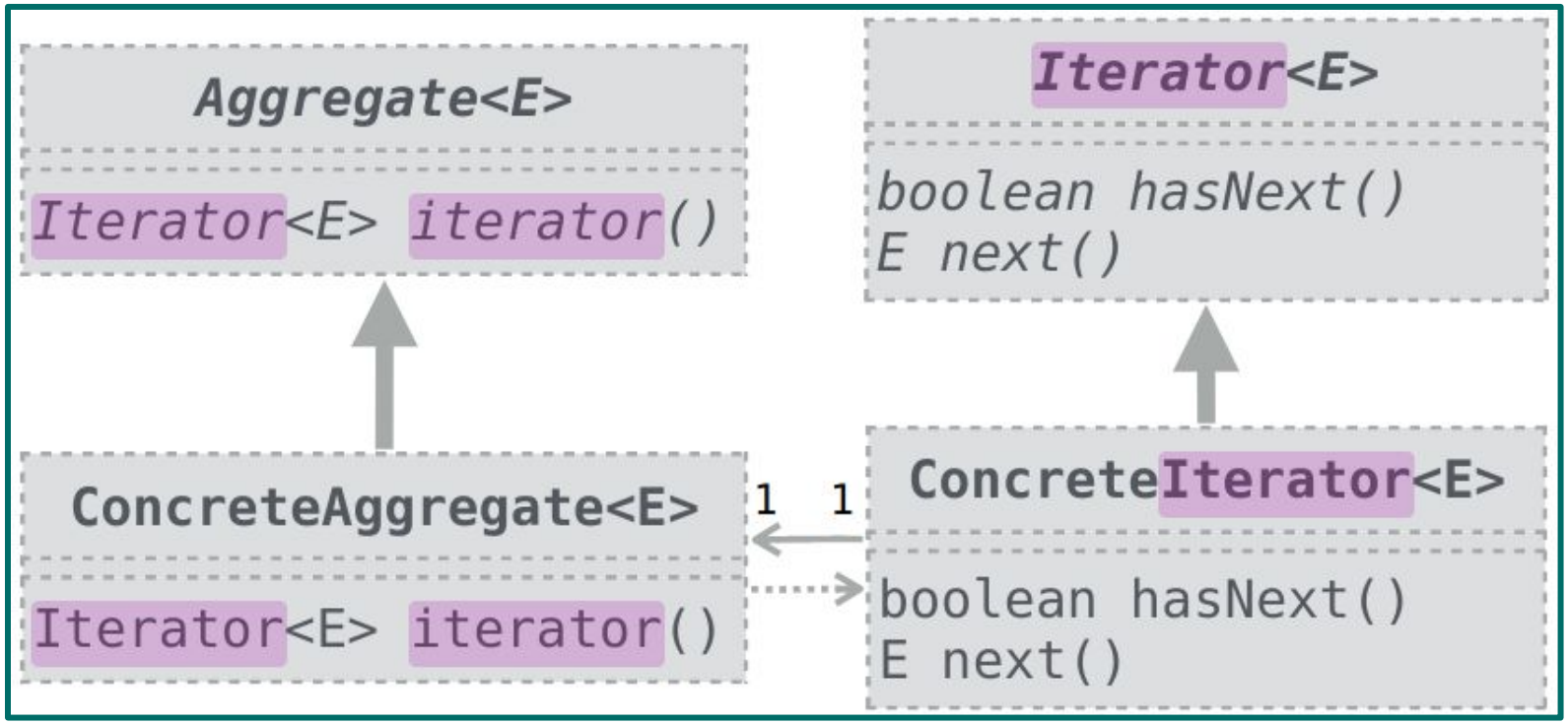
We can change the aggregate class without changing client code. We can do this by generalizing the iterator concept to support **polymorphic iteration**.

Design Pattern
Iterator

To summarize:

- to **access an aggregate object's contents** without exposing its internal representation.
- to support **multiple traversals** of aggregate objects.
- to **provide a uniform interface for traversing different aggregate structures** (that is, to support polymorphic iteration).

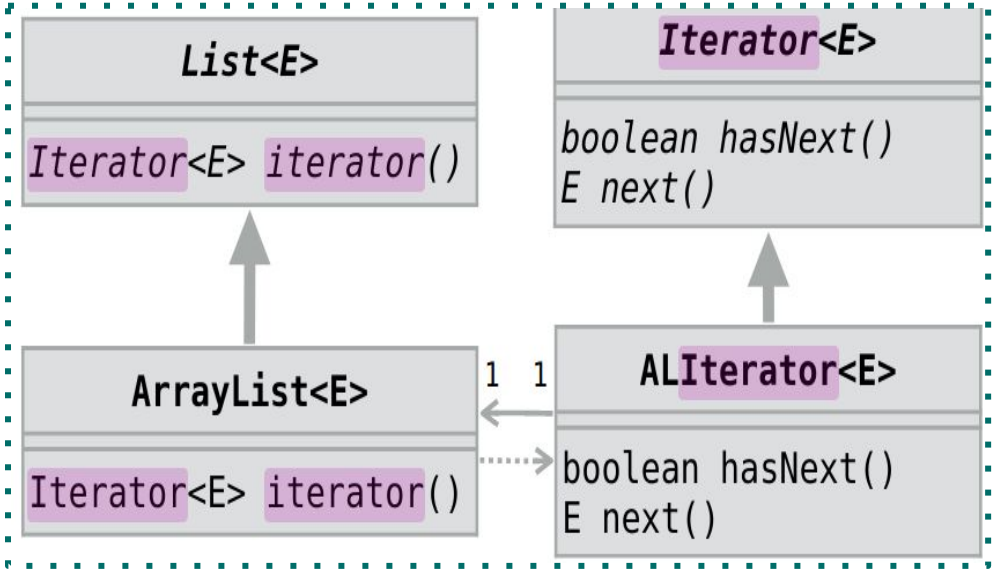
Design Pattern
Iterator: class diagram



Design Pattern

Iterator: class diagram

Example:

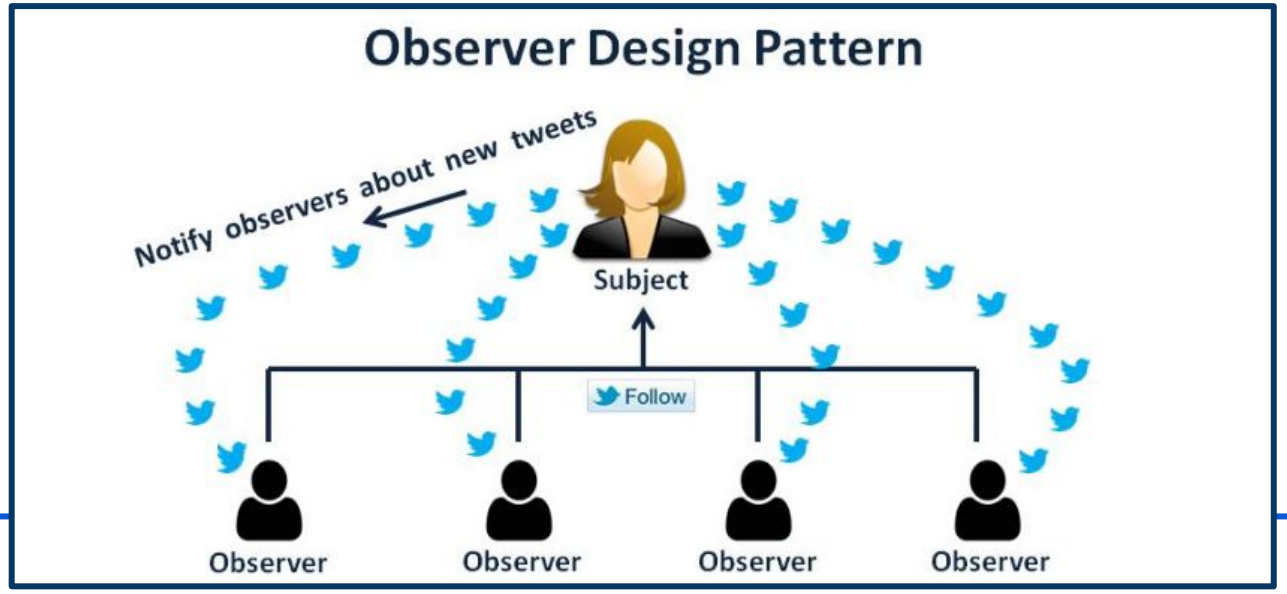



```
public interface Iterator<E> {
  // … methodes hasNext, next, etc.
}
public final class ArrayList<E>
    implements List<E> {
  // … autres méthodes de List
  public Iterator<E> iterator() {
    return new ALIterator(this);
  }
  private final static class ALIterator<E>
      implements Iterator<E> {
    // … methodes hasNext, next, etc.
  }
}
```

Behaviour Design Pattern

Design Pattern
Observer
/ Observateur

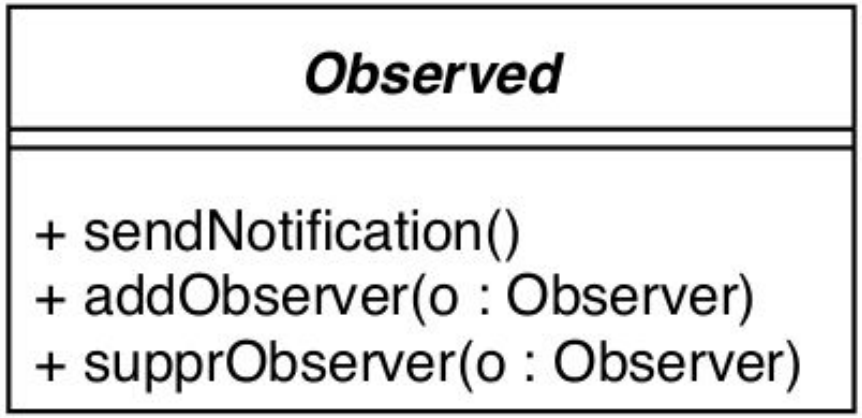
- Goal:
  - Allow an association 1..* between objects:
    - when an object changes state, all those who depend on it are notified and updated automatically;
- Goal reached without nightmare for implementing and maintaining,
- It is the most famous design pattern. You can find it in:
  - Videos games,
  - HIM,
  - etc.



2 roles:

- The **Subject** / Observed:
  a. can change state,
  b. notifies the **Observers** that he has changed,
  c. can furnish a new state;
- The **Observers**:
  a. can subscribe and unsubscribe to the **subject** state modifications,
  b. are notified if there are subscribers,
  c. can retrieve the state of the **subject**.

Design Pattern
Observateur / Observer

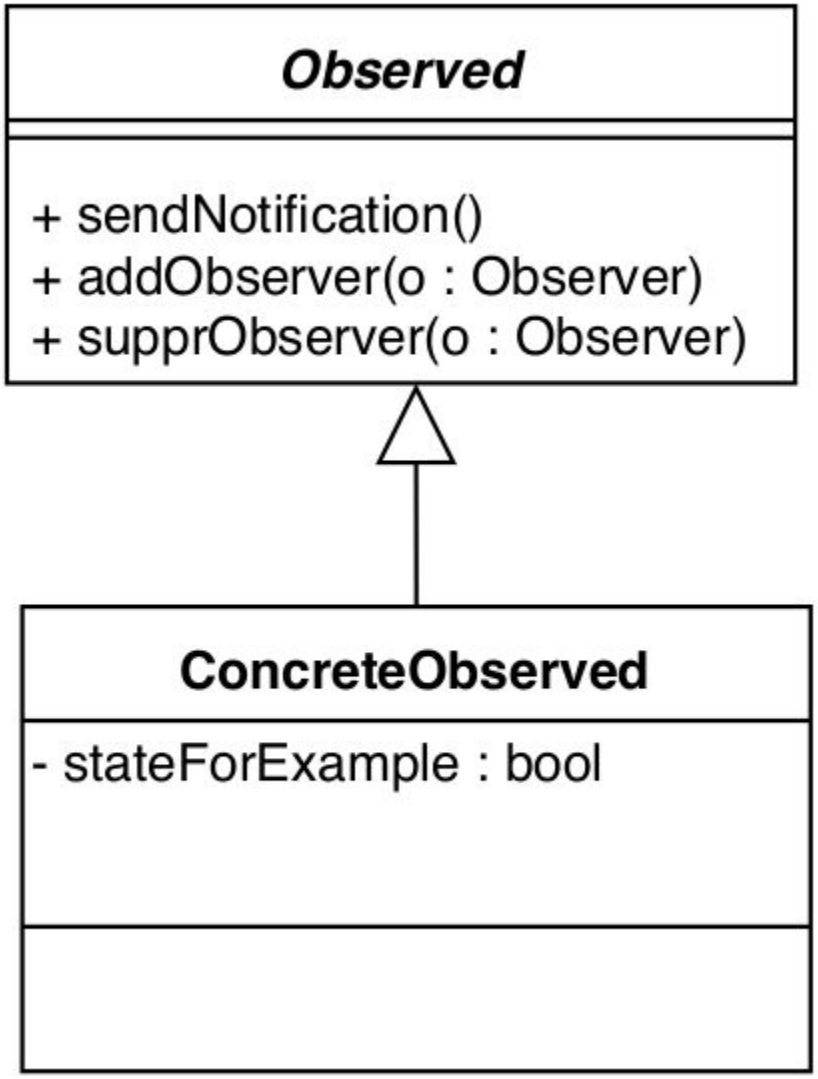


The **Subject** / *Observed*

Common methods:

- Can send notification,
- Can add an observer,
- Can delete an observer.

Design Pattern
Observateur / Observer



The **Subject** / *Observed*

Common methods:

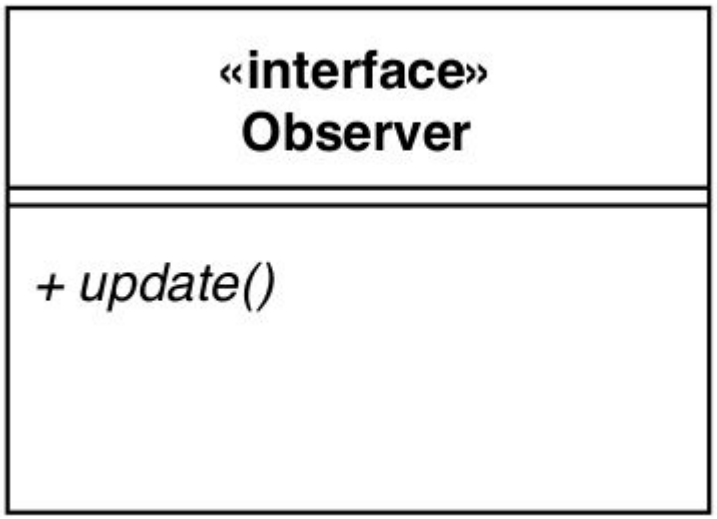
- Can send notification,
- Can add an observer,
- Can delete an observer.

Specified Attributes:

- Related to the state of the Subject object (Observed).

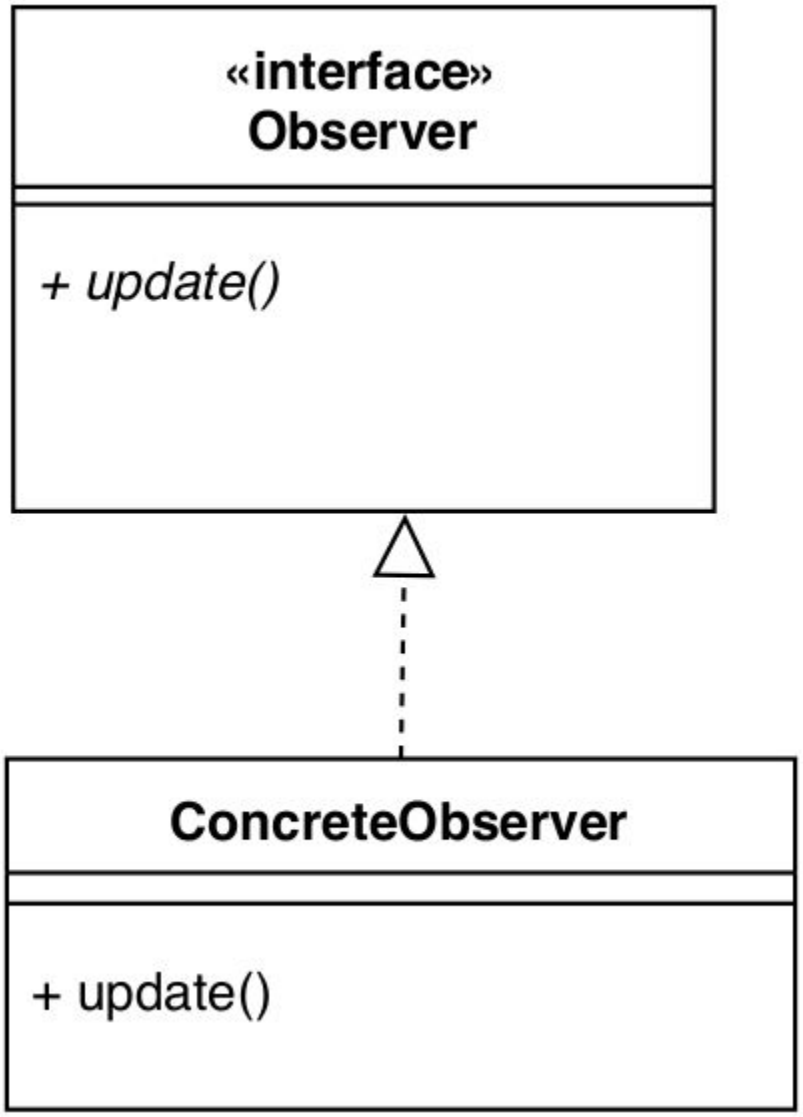
Design Pattern
Observateur / Observer

In Java: an <<interface>>.



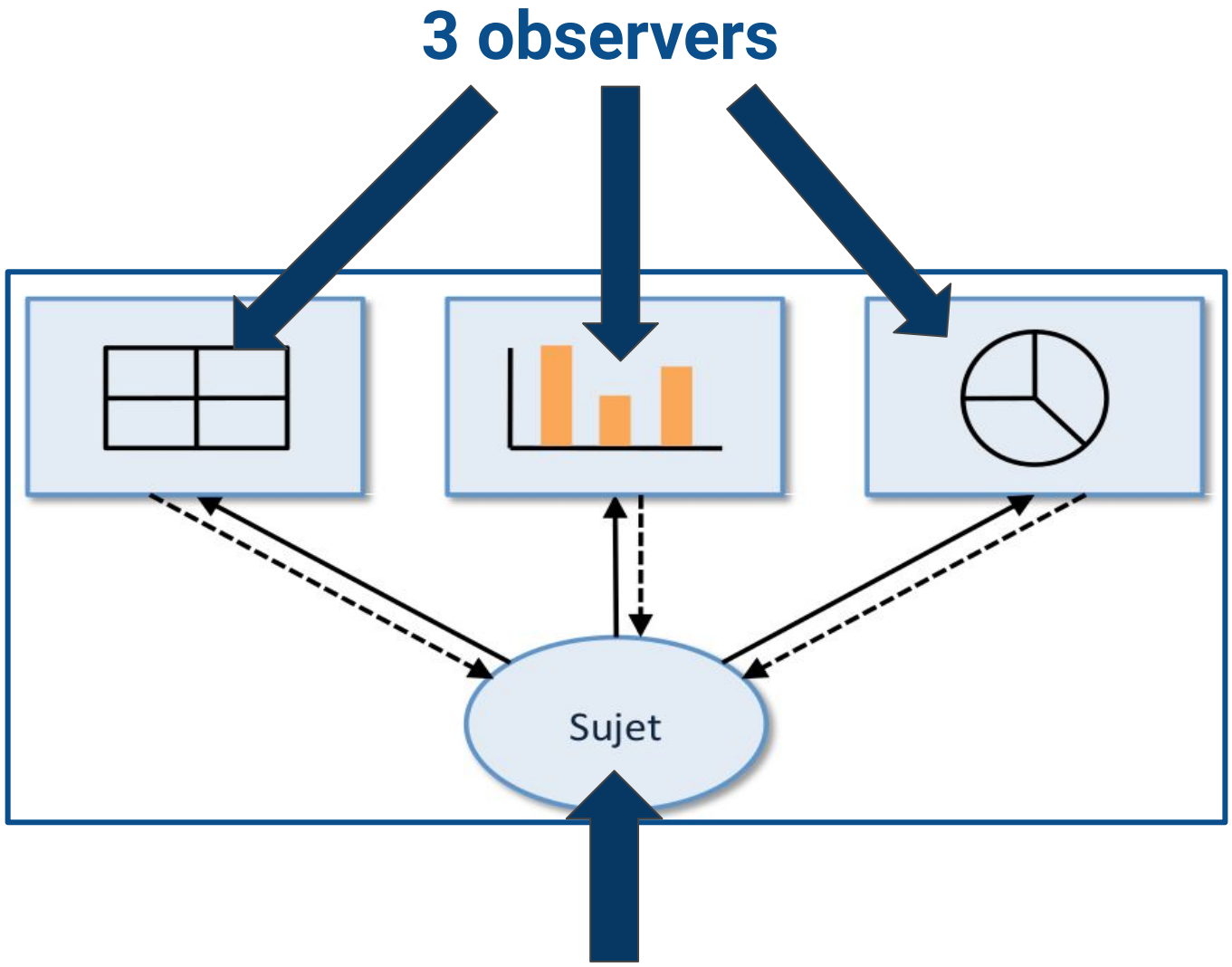
- The observer has an update method:
  - e.g., a graph whose data has changed,
  - the update () method must be re-implemented according to the specificities of the observer.

Design Pattern
Observateur / Observer



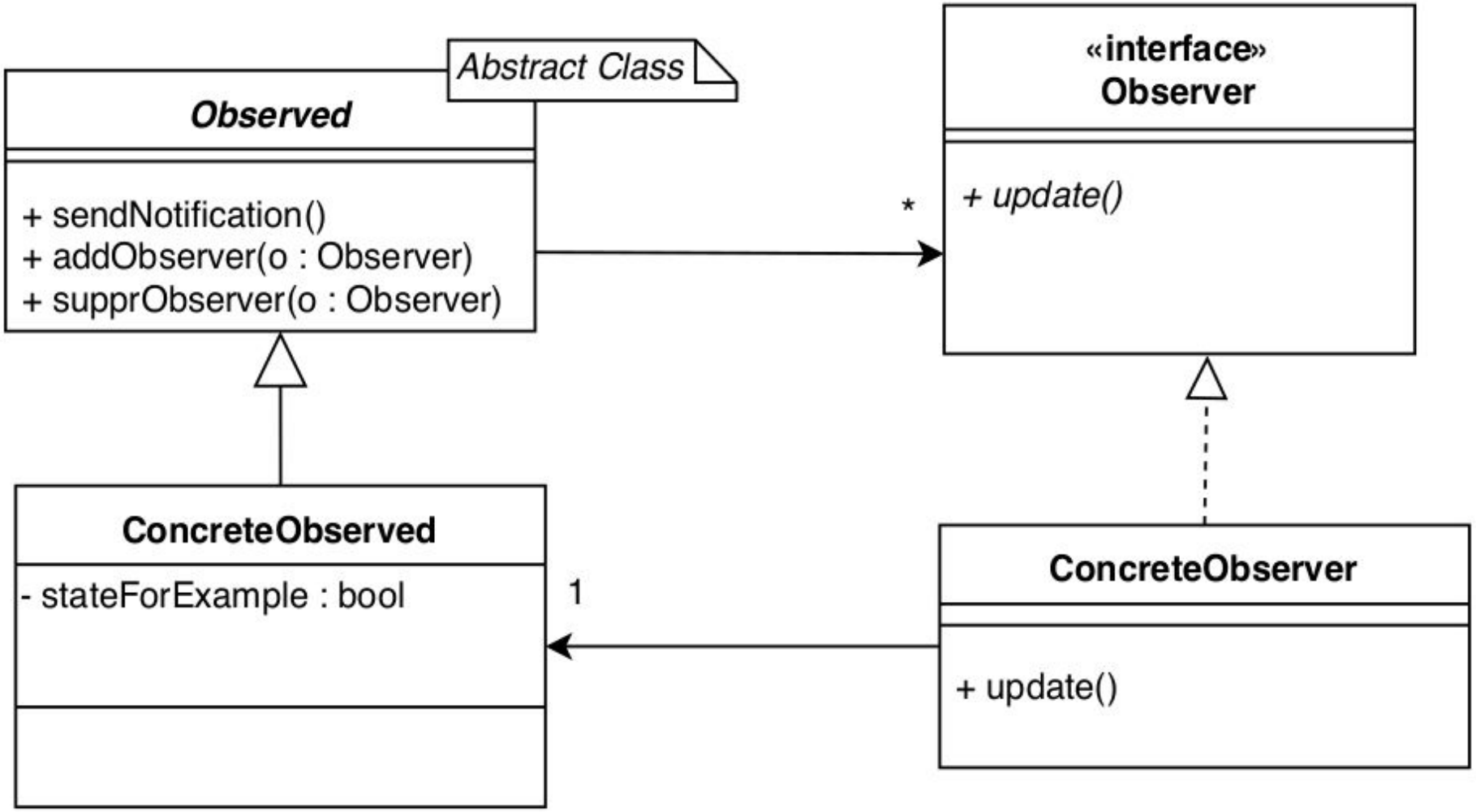
- The observer has an update method:
  - e.g., a graph whose data has changed,
  - the update () method must be re-implemented according to the specificities of the observer.

Design Pattern - Observateur / Observer



Design Pattern

Observer / Observateur



Design Pattern Observer ....
So well known that some of the work is done in java!

Inheritance of the *Observed*

```
import java.util.Observable;
public class ObservableValue extends Observable
{
   private int n = 0;
   public ObservableValue(int n)
   {
      this.n = n;
   }
   public void setValue(int n)
   {
      this.n = n;
      setChanged();
      notifyObservers();
   }
   public int getValue()
   {
      return n;
   }
}
```

Implementation of an observer

```
import java.util.Observer;
import java.util.Observable;
public class TextObserver implements Observer
{
   private ObservableValue ov = null;
   public TextObserver(ObservableValue ov)
   {
      this.ov = ov;
   }
   public void update(Observable obs, Object obj)
   {
      if (obs == ov)
      {
         System.out.println(ov.getValue());
      }
```

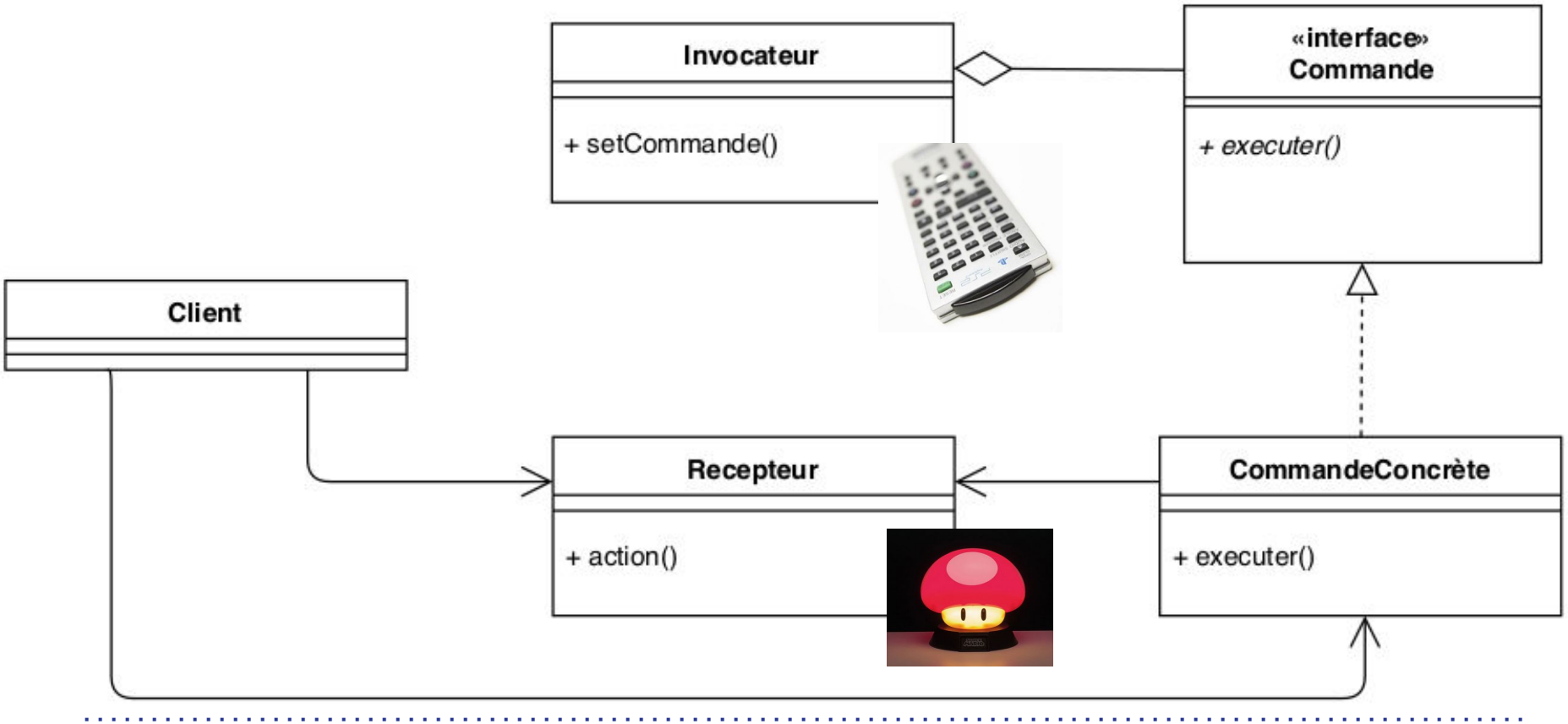
```
ObservableValue ov = new ObservableValue(0);
TextObserver to = new TextObserver(ov);
ov.addObserver(to);
```

main()

Design Pattern
Command

- Goals:
  - Perform queries on objects without having to know their structure:
    - It makes it possible to completely separate the initiating code of the action, from the code of the action itself;
  - Easy addition of new commands:
    - Without modification of existing classes;
- Method: decoupling between the calling object and the executing one, in order to pass the request encapsulated in an object.
- All command objects implement the same interface, which contains only one method.

Command Design Pattern: the class diagram



Client: It instantiates a ConcreteCommand object and configures a Receiver.
Receiver: He knows the specific action to be performed.
ConcreteCommand: It makes the link between the Receiver and an action.
Summoner: He asks the Command to perform a request.
Command: Interface to execute an operation.

Design Pattern
COMMAND

TelecommandeSimple.java

```
1  //     << INVOCATEUR >>
2  public class TelecommandeSimple {
3      Commande emplacement;
4      public TelecommandeSimple() {}
5      public void setCommande(Commande commande) {
6          emplacement = commande;
7      }
8      public void boutonPresse() {
9          emplacement.executer();
0      } }
```

CommandeAllumerLampe.java

```
1  //     << COMMANDE CONCRETE >>
2  public class CommandeAllumerLampe
3                              implements Commande {
4      Lampe lampe;
5      public CommandeAllumerLampe(Lampe lampe) {
6          this.lampe = lampe;
7      }
8      public void executer() {
9          lampe.marcheArret();
10     } }
```

Lampe.java

```
1  //     << RECEPTEUR >>
2  public class Lampe {
3      public void marcheArret()
4        { System.out.println("Bouton ON/OFF");}}
5
```

Commande.java

```
1  //     << COMMANDE >>
2  public interface Commande   {
3      public void executer(); }
```

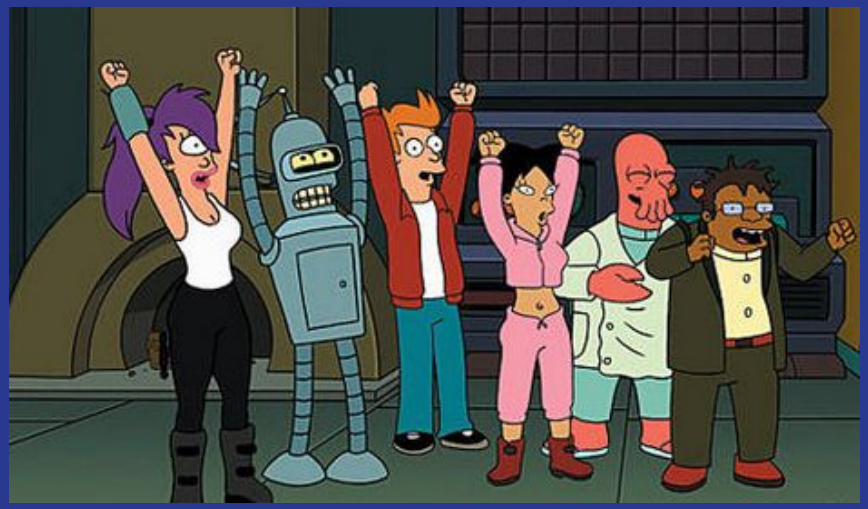
TestTelecommande.java

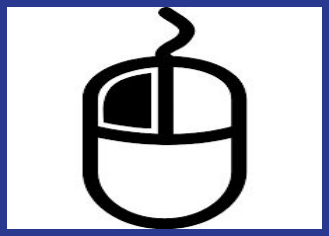
```
1  public class TestTelecommande {
2      public static void main(String[] args) {
3          TelecommandeSimple telecommande =
4                  new TelecommandeSimple();
5          Lampe lampe = new Lampe();
6          CommandeAllumerLampe lampeAllumee =
7                  new CommandeAllumerLampe(lampe);
8          telecommande.setCommande(lampeAllumee);
9          telecommande.boutonPresse();
10 } }
```

Here: the client exists in the main.

Practical Work
/ Travaux Pratiques

Design Patterns





Design Pattern Singleton

```
3  public class Bouilleur {
4      protected boolean vide;
5      protected boolean bouilli;
6
7      public Bouilleur() {
8          vide = true;
9          bouilli = false;
10     }
11     public void remplir() {
12         if (estVide()) {
13             vide = false;
14             bouilli = false;
15         }
16     }
17     public void vider() {
18         if (!estVide() && estBouilli()) {
19
20             vide = true;
21         }
22     }
23     public void bouillir() {
24         if (!estVide() && !estBouilli()) {
25
26             bouilli = true;
27         }
28     }
29     public boolean estVide() {
30         return vide;
31     }
32     public boolean estBouilli() {
33         return bouilli;
34     }
35 }
```

After having set fire to your chemical plant a dozen times, you understand that the problem lies with your boiler. Indeed, its controller manages several instances of the Boiler class then attached to the same machine...

After having imagined what could have happened with 2 instances, you set about adapting the Design Pattern Singleton to your Bouilleur class in order to solve the problem.

Practical Work 9

Design Pattern Singleton

```
3  public class Bouilleur {
4      protected boolean vide;
5      protected boolean bouilli;
6
7      public Bouilleur() {
8          vide = true;
9          bouilli = false;
10     }
11     public void remplir() {
12         if (estVide()) {
13             vide = false;
14             bouilli = false;
15         }
16     }
17     public void vider() {
18         if (!estVide() && estBouilli()) {
19
20             vide = true;
21         }
22     }
23     public void bouillir() {
24         if (!estVide() && !estBouilli()) {
25
26             bouilli = true;
27         }
28     }
29     public boolean estVide() {
30         return vide;
31     }
32     public boolean estBouilli() {
33         return bouilli;
34     }
35 }
```

Après avoir mis le feu une bonne dizaine de fois à votre usine chimique, vous comprenez que le problème vient de votre bouilleur. En effet, son contrôleur gère plusieurs instances de la classe Bouilleur alors rattachées à la même machine...

Après avoir imaginé ce qui a pu se passer avec 2 instances, vous vous employez à adapter le *Design Pattern* Singleton à votre classe Bouilleur afin de régler le problème.

Practical Work 9

“Post Office”

Practical Work 10

- You are a customer of the post office who expects to receive new messages every day.
- So, every day, you go to the post office to check if new messages have arrived.
- To model this process, we will use three classes in JAVA:
    - **PostOffice**,
    - **Person**,
    - **Main**.

“Il y a écrit la poste”

Practical Work 10

- Vous êtes un client du bureau de poste qui s'attend à recevoir chaque jour de nouveaux messages.
- Ainsi, chaque jour, vous allez au bureau de poste pour vérifier si de nouveaux messages sont bien arrivés.
- Pour modéliser cela ce processus, nous allons utiliser trois classes en JAVA :
    - **PostOffice**,
    - **Person**,
    - **Main**.

Of course, this is an easy way to deal with postal mail. However, this poses a lot of problems since a large number of customers will physically check that new mail is available. For example :

- One could fix the problem by going through the customer list and checking if they have new mail, but that would mean the post office would be too busy with too many requests.
- Thanks to a well-known Design Pattern, but without using Java classes (i.e., from the library), structure your code in order to make such a system more efficient. For example, it will be easy to have clients of different types (companies, people etc.).

Your program should include the functionality to add and remove mail subscribers. Set up a mechanism that alerts all customers whenever new mail is received.

Bien entendu, il s'agit d'une manière simple de gérer le courrier postal. Cela pose cependant beaucoup de problèmes dès lors qu'un grand nombre de client va physiquement vérifier qu'un nouveau courrier est disponible. Par exemple :

- On pourrait résoudre le problème en parcourant la liste des clients et en vérifiant s'ils ont un nouveau courrier, mais cela signifierait que le bureau de poste serait inondé de demandes.
- Grâce à un *Design Pattern* bien connu, mais sans utiliser les classes Java qui sont propres, structurez votre code afin de rendre un tel système plus efficace. Il sera, par exemple, facile d'avoir des clients de types différents (entreprises, personnes etc.).

Votre programme doit comprendre les fonctionnalités d'ajout et de suppression d'abonnés à la poste. Mettez en place un mécanisme qui alerte tous les clients chaque fois qu'un nouveau courrier est reçu.

Practical Work 10

Recopy and then run the following code.

Main.java

```
1  import java.lang.*;
2
3  class Main{
4
5      public static void main(String [] args)
6      {
7      PostOffice postOffice=new PostOffice();
8      Person subscriber=new Person("Chris");
9      subscriber.checkMail(postOffice);
10
11     postOffice.addMail("Chris");
12     subscriber.checkMail(postOffice);
13
14     }
```

Person.java

```
1  import java.lang.*;
2
3  class Person {
4
5      String name;
6
7      Person(String n){
8          name=n;
9      }
10
11     public void checkMail(PostOffice office){
12         if(office.checkMail(this)){
13             System.out.println("Mail found");
14         }else{
15             System.out.println("Mail not found");
16         }
17     }
18
19     public String getName(){
20         return name;
21     }
22 }
```

PostOffice.java

```
import java.lang.*;
import java.util.ArrayList;

class PostOffice{
    ArrayList<String> allMail;

    PostOffice(){
        allMail=new ArrayList<>();
    }

    public boolean checkMail(Subscriber person){

        for(int i=0; i < allMail.size(); i++){

            if(allMail.get(i)==person.getName()){
                return true;
            }
        }
            return false;
    }

    public void addMail(String s){
        allMail.add(s);
    }
25  }
```

Practical Work 10

Practical Work 11

Bibliothèque & Design Pattern

You continue to take care of the management of a library, this time for the development of the Database.

You make sure that, in order not to lose Data, there will only be a maximum of one Database. Only one method is available to retrieve this database, it has for parameter a name which will be used to name the Database, but, if this one already exists, this parameter will have no effect (only the first one can name the database.).

Find and implement the right Design Pattern that will solve the problem. Unroll your code over two attempts to retrieve the Database.

Practical Work 11

Bibliothèque & Design Pattern

Vous continuez à vous occuper de la gestion d'une bibliothèque et vous vous attaquez désormais à un gros morceau : celui du développement de la Base de Données.

Vous vous assurez que, pour ne pas égarer de Données, il n'existera qu'au maximum une seule Base. Une seule méthode est disponible pour récupérer cette base de données, elle a pour paramètre un nom qui sera utilisé pour nommer la Base, mais, si celle-ci existe déjà, ce paramètre n'aura aucun effet (seul le premier peut nommer la base).

Cherchez et implémentez le bon Design Pattern qui pourra régler le problème. Dérouler votre code sur deux tentatives de récupération de la Base.

Object Concept

It's over.

Example of SIMULATION (Weather)