Mila University Center
2nd Year – Bachelor's in Computer Science
Course: Object-Oriented Programming

CHAPTER I: Introduction To Oriented Object Programming

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Course outline

1. Programming Paradigms
2. From procedural programming to object-oriented programming
3. Fundamental Concepts of Object-Oriented Programming (OOP)
4. Overview of the Java Programming Language

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1. **Programming Paradigms**
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1. Programming Paradigms

Programming Paradigms

- A programming paradigm is a fundamental styles or approaches to programming , based on a set of principles or theory
- Each paradigm provides a distinct way of thinking programming and structuring code,

Classification of programming paradigms:

1. **Procedural Programmin (PP)**
2. **Object-Oriented Programming: (OOP)**
3. **Declarative Programming**

1. Programming Paradigms

Classification of programming paradigms:

1. **Procedural Programming**: Organizes code into procedures and/or functions: (**C**,C++, **Python,** etc.).

2. **Object-Oriented Programming: (OOP) :** OOP organizes code into objects that encapsulate data and behavior. **Java, C++, Python, C#.**

3. **Declarative Programming:** Focuses on **what** the program should accomplish rather than **how** to accomplish it.
   - **Domain-specific language: HTML, XML, LaTeX.**
   - **Functional Programming:** Treats computation as the evaluation of mathematical functions: **Lisp, Haskell**.
   - **Logic Programming :** Uses formal logic to express computations : **Prolog**
   - **Data definition languages (SQL)**

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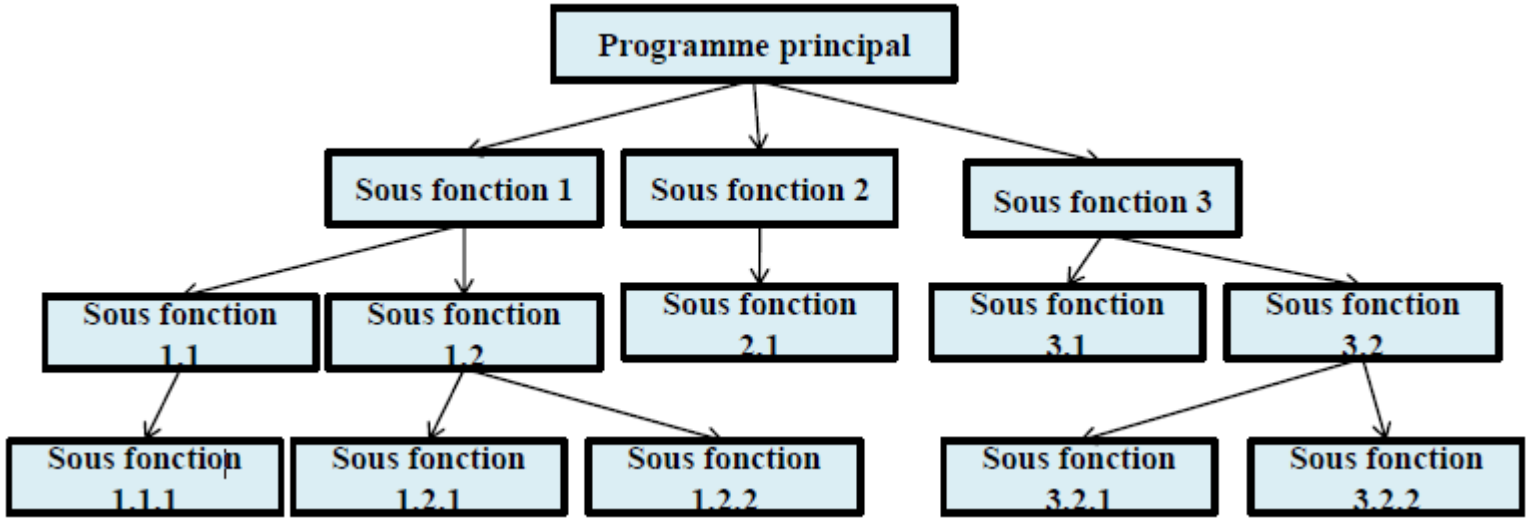
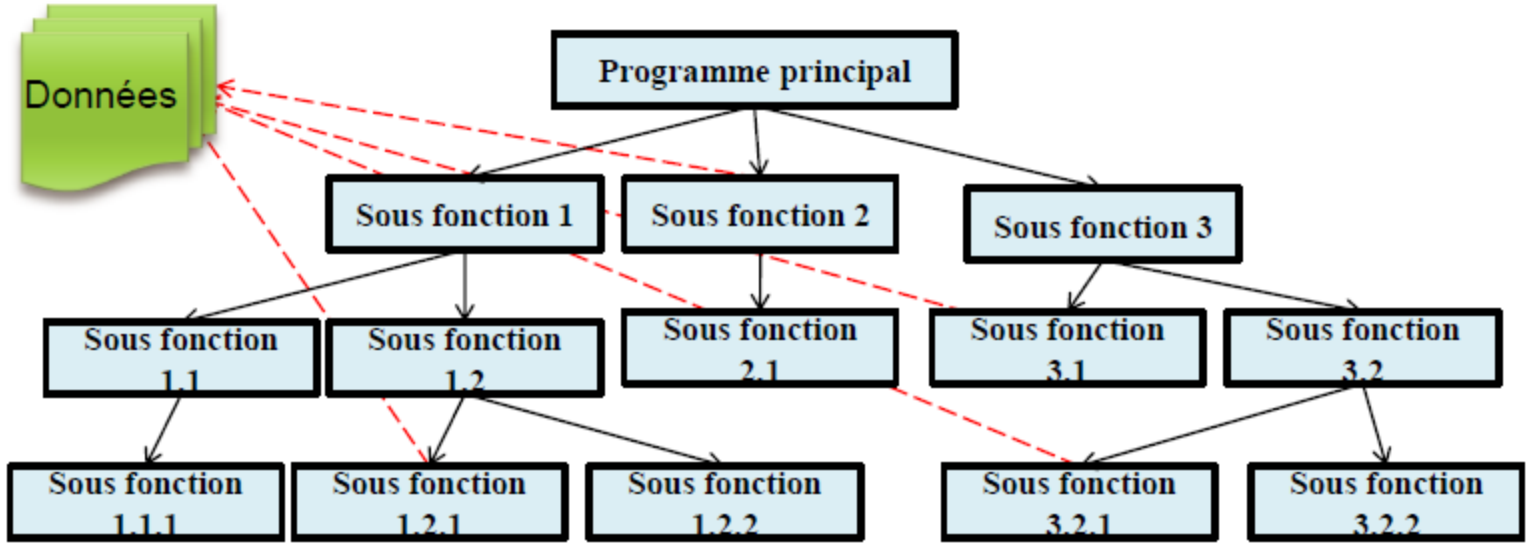
Top-down approach

- The main program is divided down into smaller modules (functions or procedures),
- Each module is then divided into sub-modules,
- The decomposition continues until it reaches controllable components (the length does not exceed one page if possible).
- Principal program is divided into smaller, reusable functions or procedures.



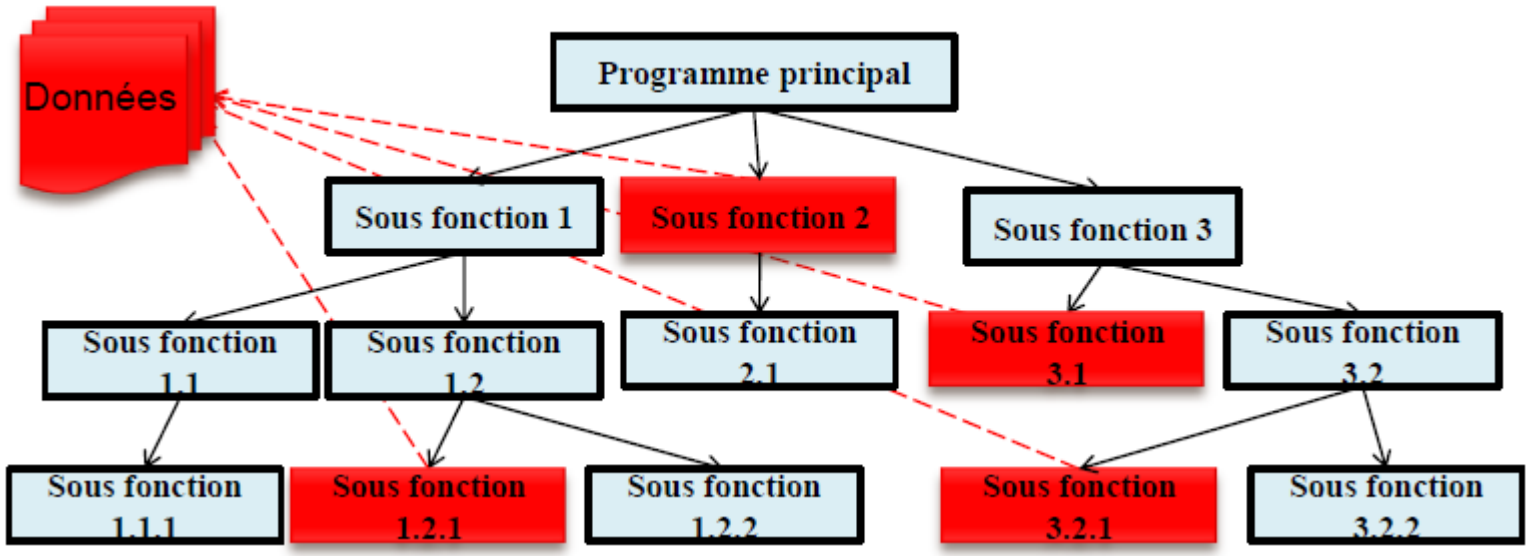
Data and Functions are Separate

- Variables can be global (accessible throughout the program) or local (accessible only within a function).
- Procedural programming separates between data and programs that manipulate them.
- Functions operate on external data rather than being part of the data structure itself.



Limitations:

1. **Maintenance in Procedural Programming is Hard :** Changes to data structures or global variables can require modifications to multiple functions.



Limitations:

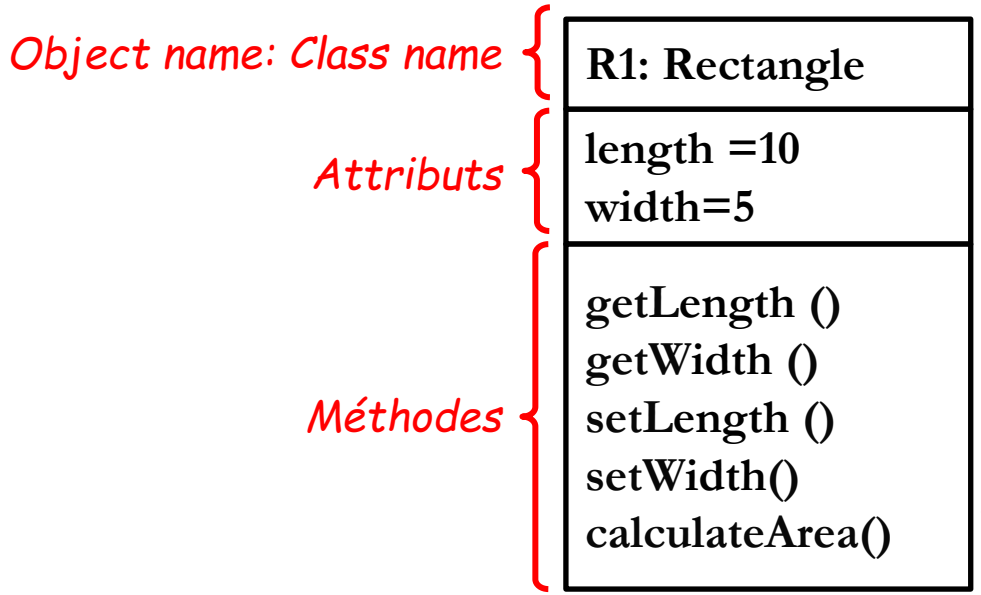
2. **Poor Data Security (Lack of Encapsulation) :** Data is not protected, as global variables can be accessed and modified from anywhere.
3. **Code Duplication :** Procedural programming does not support **inheritance**, so similar functions are often written multiple times.
4. **Scalability Issues in Large Applications:** As the project grows, the number of functions increase significantly, leading to **code complexity**.
5. **Difficult Debugging and Testing :** If multiple functions modify the same global variable, debugging becomes difficult.
6. **Lack of Real-World Modeling :** Procedural programming does not naturally represent real-world entities.
7. **Code Reusability Through Functions : F**unction reuse is limited compared to the inheritance and polymorphism of OOP.

2. From procedural programming to object-oriented programming

A. Characteristics of Procedural Programming (PP) | **B. Characteristics of Oriented Object Programming**

Object-Oriented Programming (OOP) was designed to **overcome the limitations of procedural programming** by :

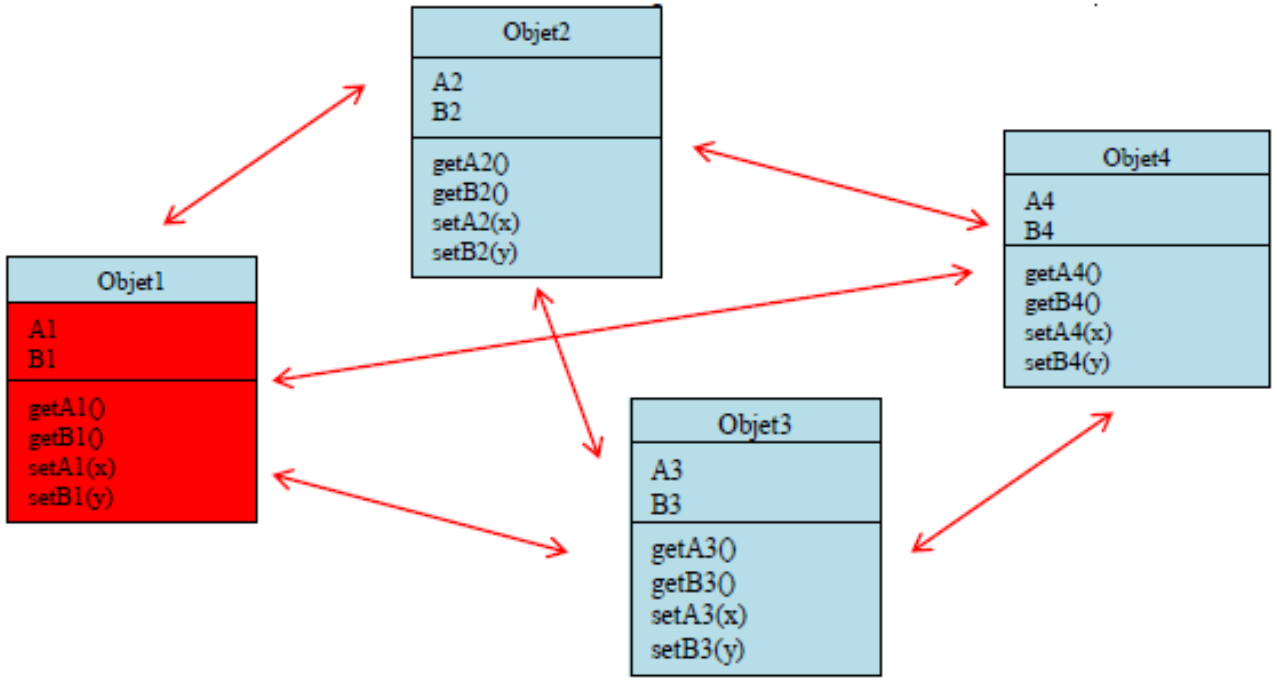
- Association of data structures and the processes that manipulate them in coherent entities
- These entities are **objects**.
- The data structures associated with an object are its **attributes**.
- The processes associated with an object are its **methods**.
- The **attributes** of an object **are only accessible by its methods**.
- **Exemple**



2. From procedural programming to object-oriented programming

A. Characteristics of Procedural Programming (PP) | **B. Characteristics of Oriented Object Programming**

- The object-oriented approach views software as a **collection of interacting objects**.
- Each object represents an **independent entity** with its own **data (attributes)** and **behavior (methods)**.
- The software's functionality emerges from the **collaboration and interactions** between these objects, promoting **modularity, reusability, and scalability**..



Course outline

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3. **Fundamental Concepts of Object-Oriented Programming (OOP)**
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3. Fundamental Concepts of Object-Oriented Programming (OOP)

Object	Class	Message	Inheritance	Encapsulation	Polymorphism

A. Object

- An object is a coherent runtime entity that that has :
  - **Attributes**: Variables that store the **state** or data of the object.
  - **Methods**: Functions that define the **behavior** or actions the object can perform.

Objet = Identity + State (attributs) + Behavior (methods)

  - L'identité: L'objet possède une identité, qui permet de le distinguer des autres objets, indépendamment de son état: (Deux objets demeurent distincts même si leurs attributs contiennent les mêmes valeurs)

3. Fundamental Concepts of Object-Oriented Programming (OOP)

B. Class

- **Definition of a Class**
- A **class** is a template for creating objects. It defines the structure and behavior that its objects will have.
- A class defines:
  - **Attributes** with their **names** and types (but not their values which are specific to each object).
  - **Methods** (operation) with their **signatures** and the **code** that describes the associated behavior.

- An object is an instance (entity) of a class.
- Multiple objects can be created from a single class, each w
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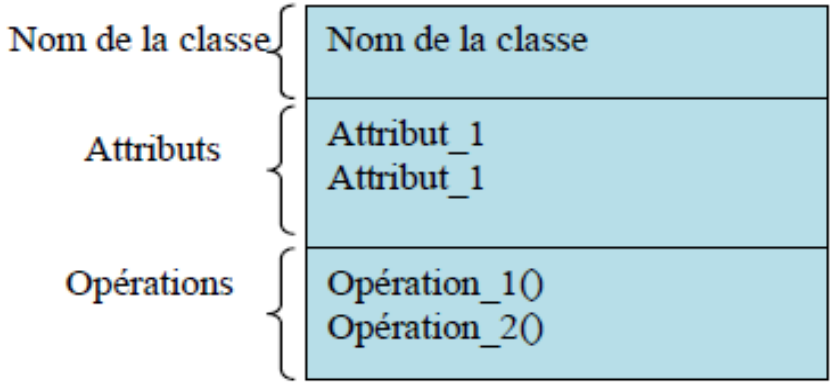
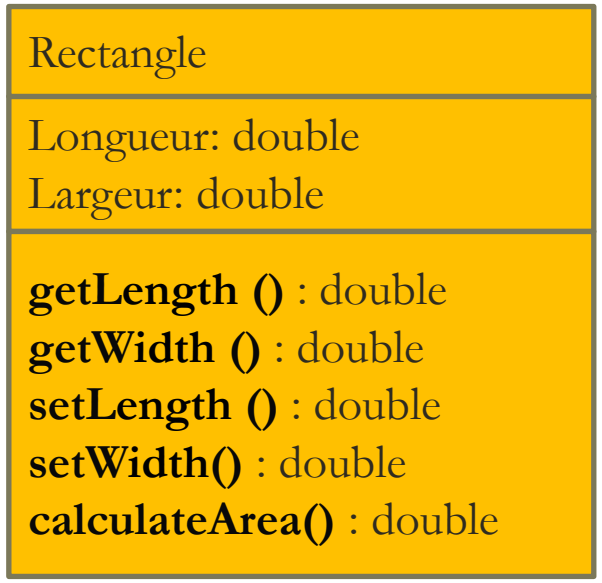
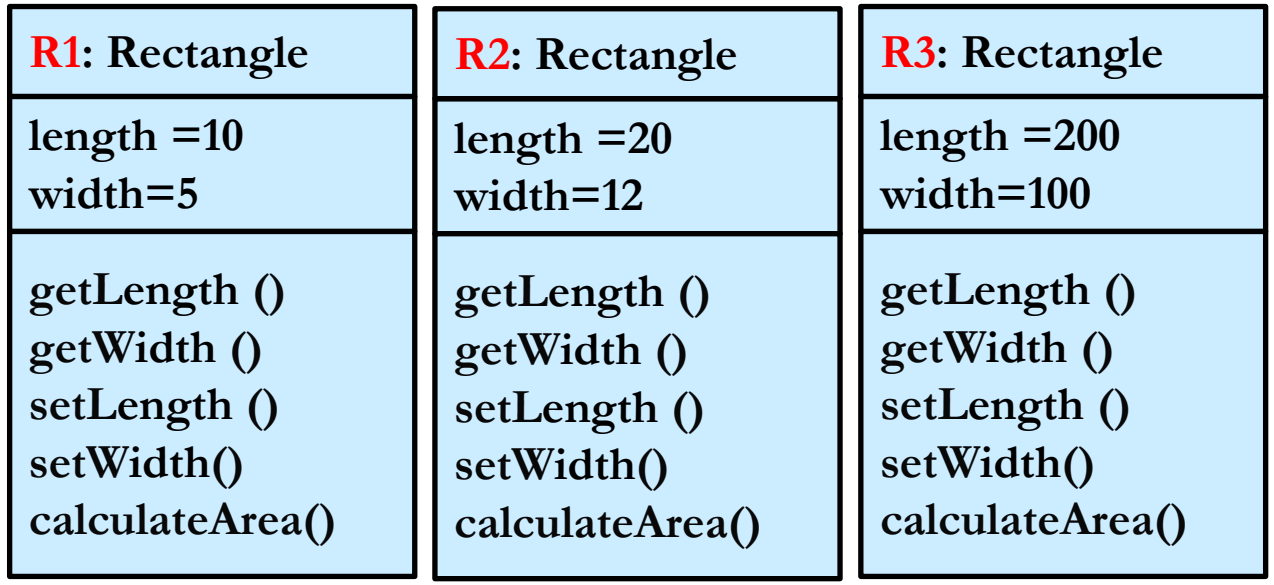


B. Class

Example



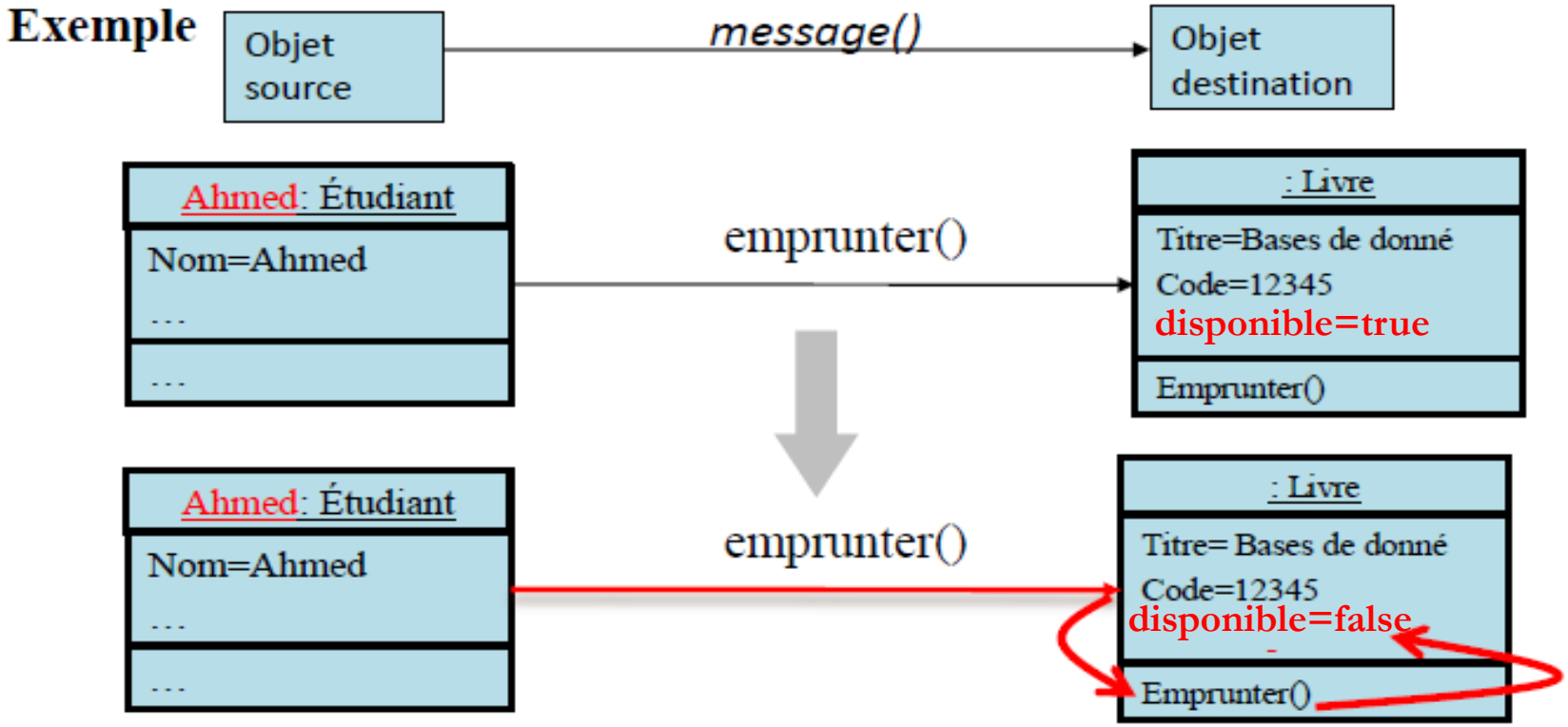
The Rectangle class



Objects R1, R2, and R3 of the Rectangle class.

C. Message

- Objects communicate with each other by sending messages.
- A message is a request sent from one object to another, asking the receiving object to perform a specific action
- Typically : A **message** represents the **call** of a **method** of the **destination object** by a **source object**.



3. Fundamental Concepts of Object-Oriented Programming (OOP)

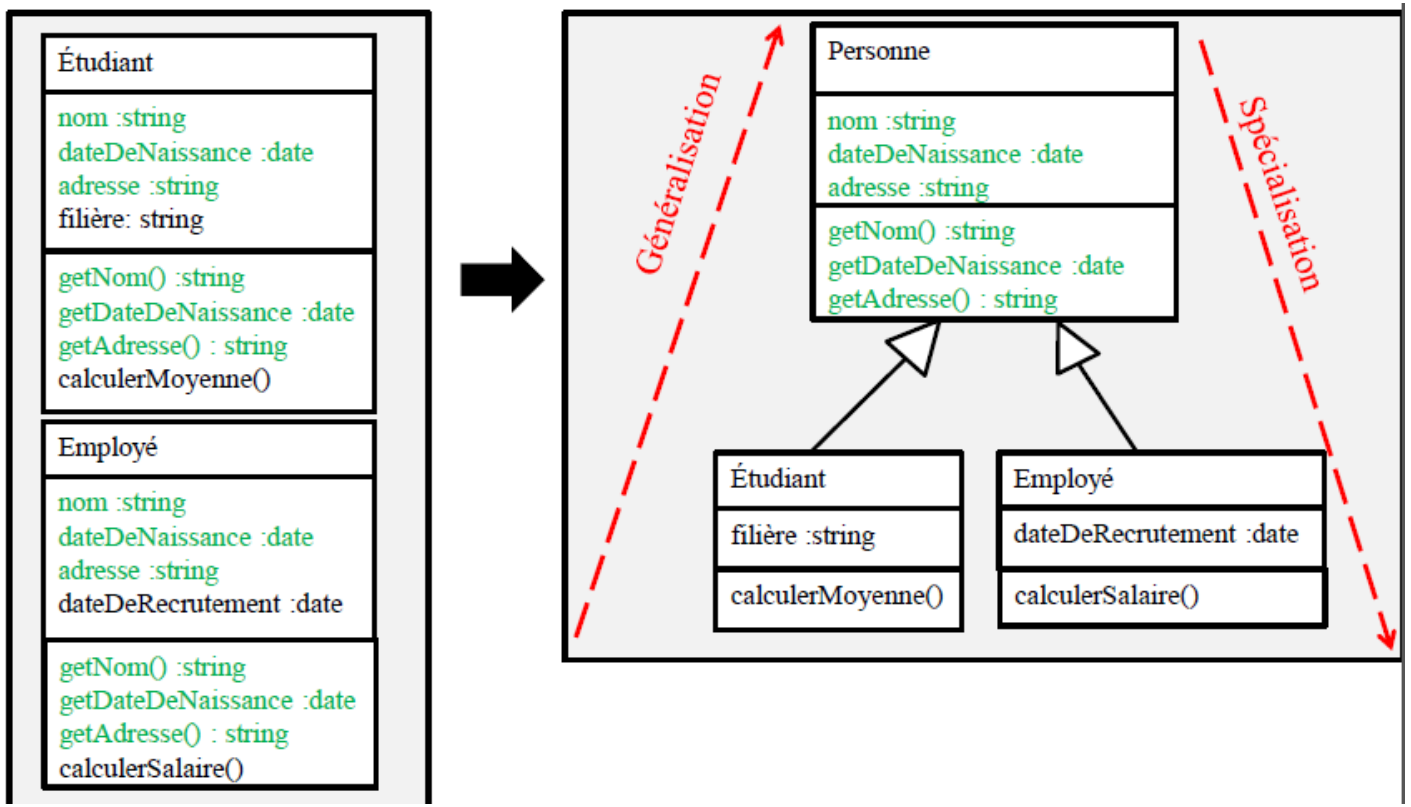
D. Inheritance :

- Inheritance describes a relationship between a **parent class or superclass** and a **child class** or **subclass**.
- The **child class (subclass)**:
  - **Inherits all attributes** and **methods** from the **parent class (superclass)**
  - **Can add** new **attributes** and **methods**

- **Purpose on Inheritance**
  - Reuse existing code of the **superclass** (or **parent class**) in a new class the **subclass** (or **child class**).
  - **Avoid duplication :** Reuse existing code reduces redundancy, and makes programs more efficient and maintainable.
  - Create a logical hierarchy of classes.
  - Extend or modify the behavior of the parent class.

3. Fundamental Concepts of Object-Oriented Programming (OOP)

Example :



3. Fundamental Concepts of Object-Oriented Programming (OOP)

Inheritance enables **generalization** and **specialization**

1. Generalization

- Generalization is the process of extracting common attributes and methods from multiple classes and combining them into a more general, higher-level class. This higher-level class is often referred to as a **superclass** or **parent class**.
- **How It Works**:
  - Identify common attributes and methods in multiple classes.
  - Create a superclass that contains these common attributes and methods .
  - Use inheritance to allow subclasses to inherit from the superclass.

3. Fundamental Concepts of Object-Oriented Programming (OOP)

Inheritance enables **generalization** and **specialization**

- **2. Specialization**
- Specialization is the process of creating new classes (subclasses) that inherit from a more general class (superclass) and add or modify specific attributes and methods.
- **How It Works**:
  - Create a subclass that inherits from a superclass.
  - Add new attributes or methods specific to the subclass.
  - Override methods from the superclass to provide specialized behavior.

E. Encapsulation

- Encapsulation consists of hiding part of attributes and methods and only allowing access through controlled methods.
- Hidden attributes are accessible by other objects through **services** (visible methods).
- An object's **services** can be invoked through **messages**.
- The list of **messages** to which an object is capable of responding constitutes its **interface** (its external view).

- **Purpose**:
  - Provides a **clear** and **consistent interface** for interacting with the object.
  - **Maintains the integrity** of the data : it allows to prohibit direct access to the attributes of the objects (use of accessors).
  - **Improved Maintainability**: Allows to change the internal implementation of a class without affecting external code.
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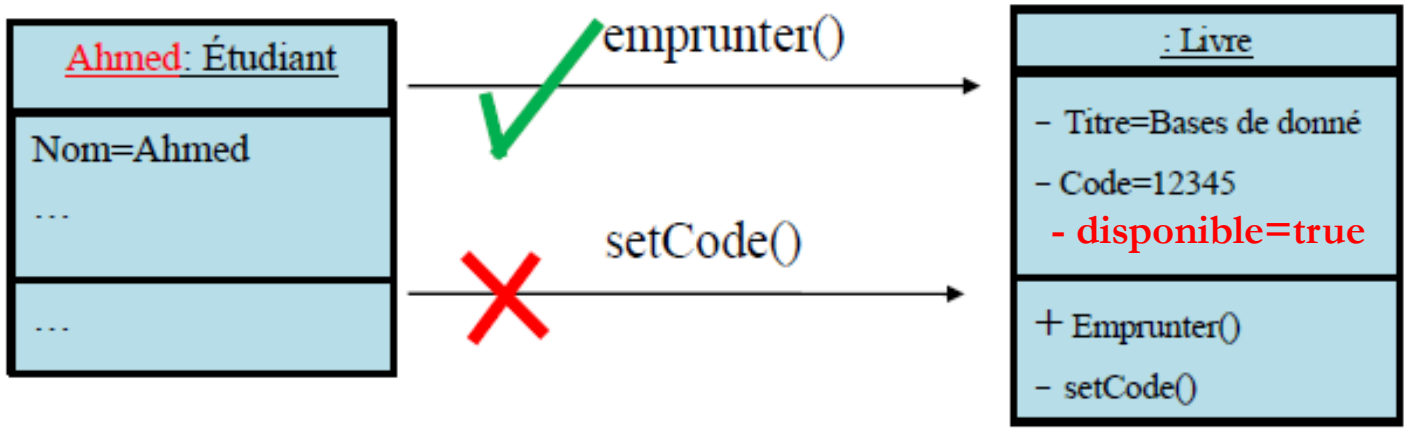
3. Fundamental Concepts of Object-Oriented Programming (OOP)

Encapsulation allows to define visibility levels for attributes and methods. There are three levels of visibility:

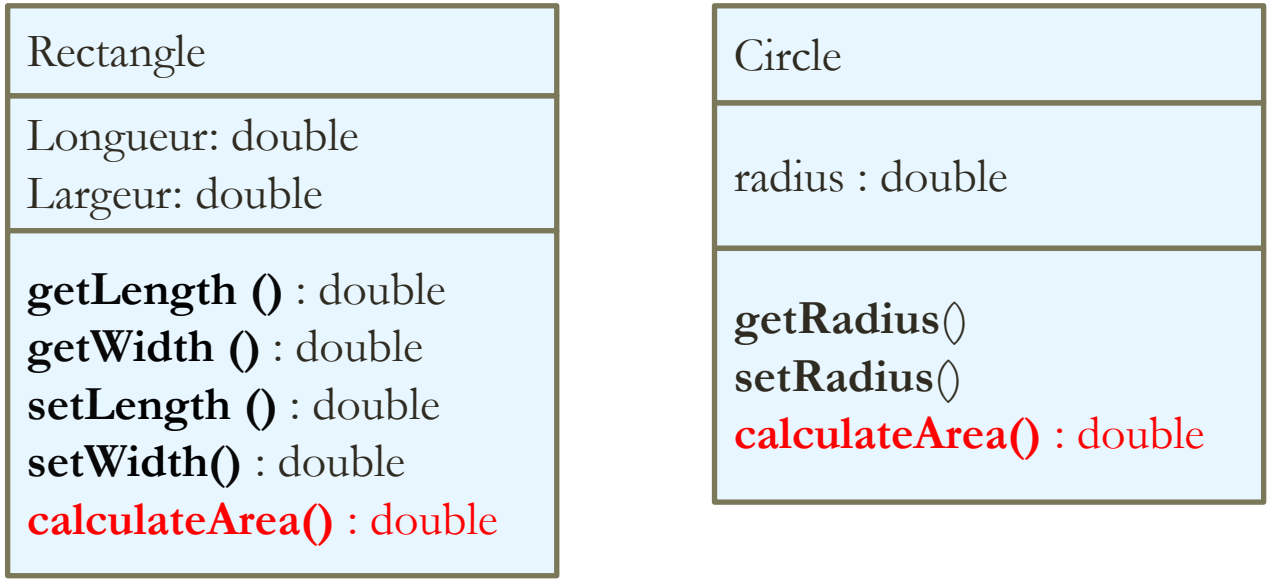
- **Public(+):** All objects can access an object's attributes or methods defined with the public visibility level. This is the lowest level of protection.
- **Protected(#):** Access is restricted to derived objects.
- **Private(-)**: Access is restricted to methods of the same class. This is the highest level of data protection



3. Fundamental Concepts of Object-Oriented Programming (OOP)

F. Le polymorphisme

- Polymorphism allows **one interface to have multiple implementations**, making the code more flexible and scalable.
- Polymorphism is the ability of a single interface to represent multiple forms of behavior.
- It allows the same method name to be used for different types of objects, where each object can provide its own specific implementation of the method.
- **Exemple**



When the message " **calculateArea**()" is executed, it does not have the same effect on an object class Rectangle and an of class Circle. The method "calculateSurface()" is polymorphic.

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4. Overview of the Java Programming Language

Présentation de Java

- Java is an object-oriented programming language.
- It was developed in 1991 by **Sun Microsystems** (purchased by Oracle Corporation in 2009).
- In 2010, **Oracle** Corporation acquired **Sun Microsystems**, making Java an Oracle product.
- Oracle continues to maintain and update Java, introducing new features and performance enhancements.

4. Overview of the Java Programming Language

- **Quelques chiffres à propos de Java (2011):**
  - **Enterprise Adoption:** Java remains widely used, with over **90%** of **Fortune 500 companies** relying on it for critical applications.
  - **Number of Developers**: Estimated 18.7 million Java developers worldwide in 2024.
  - **Language Popularity**: Ranked 3rd in the TIOBE Index (Jan 2025), with 10.15% market share (https://www.tiobe.com/tiobe-index/).
  - **Mobile Devices**: Java remains key for Android development, powering billions of devices.
  - **Smart Cards**: Over 1.4 billion Java-based smart cards are produced annually in

Jan 2025	Jan 2024	Change	Programming Language	Ratings	Change
1	1		Python	23.28%	+9.32%
2	3	↑	C++	10.29%	+0.33%
3	4	↑	Java	10.15%	+2.28%
4	2	↓	C	8.86%	-2.59%
5	5		C#	4.45%	-2.71%

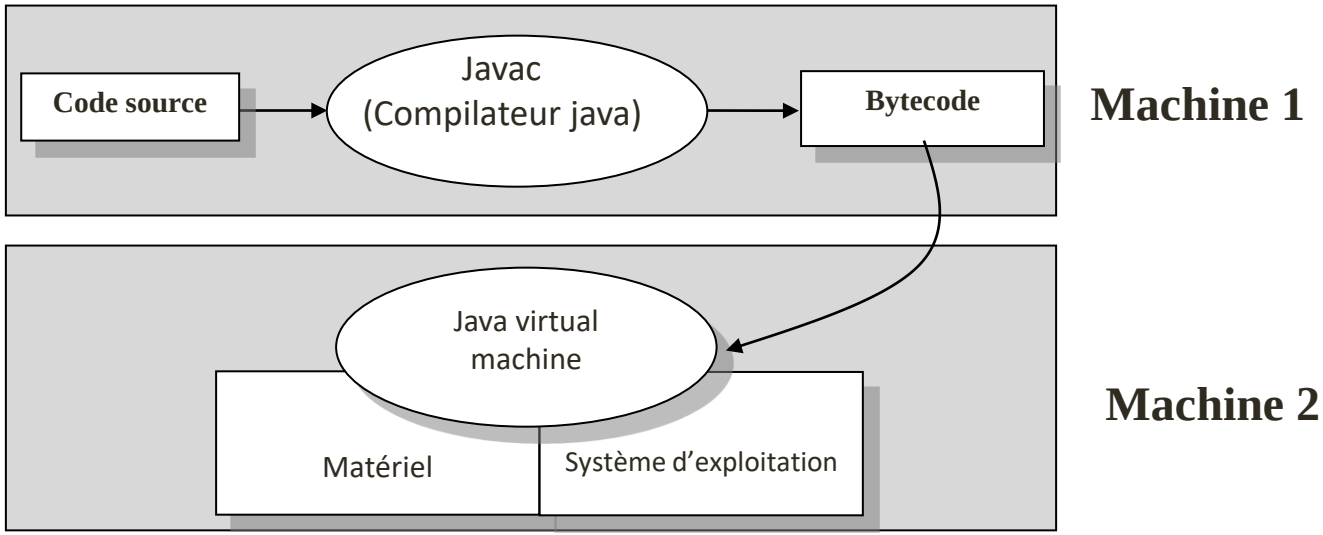
Key Features of Java

- Java has several key features that have contributed to its widespread success. Here are its most important characteristics

1. Java is Interpreted and Compiled

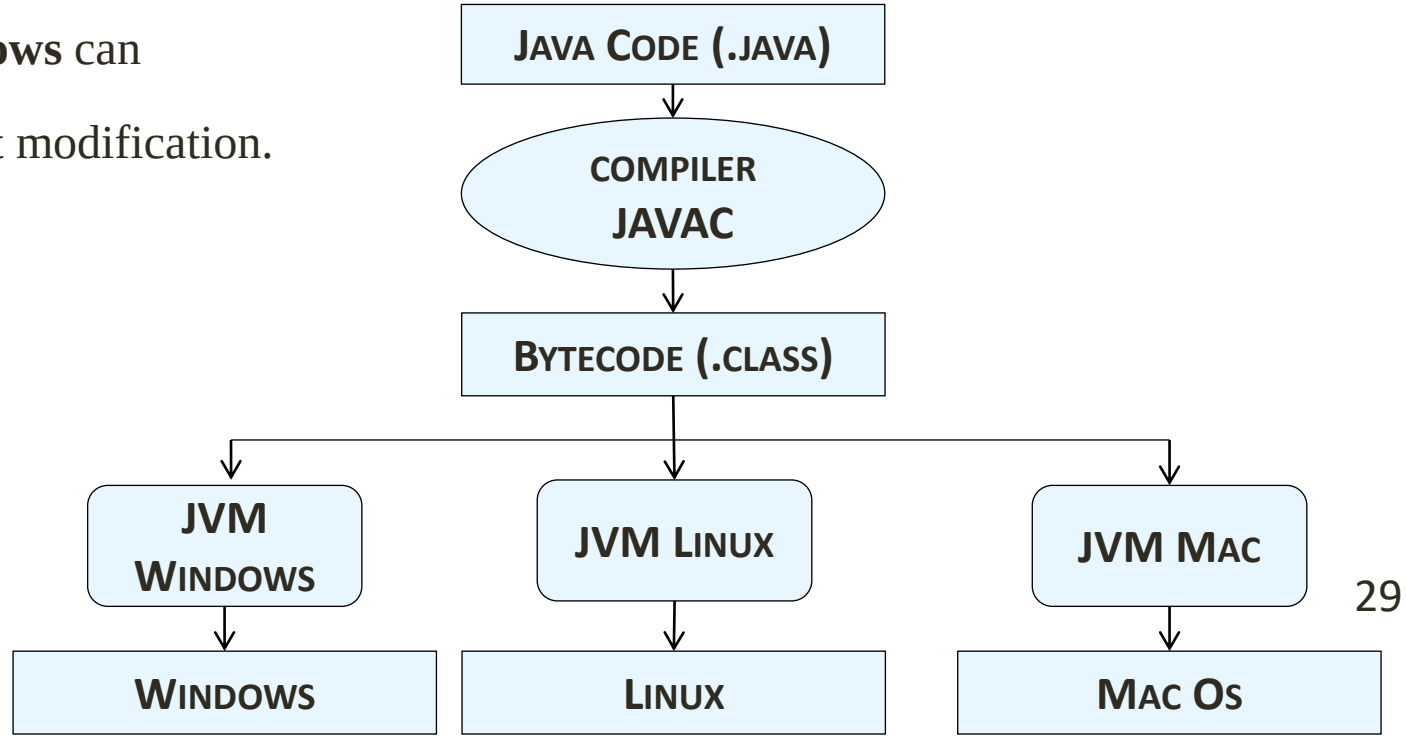
- Java uses a **hybrid approach** of **compilation and interpretation**:
  - The **source code** is compiled into **bytecode** by the **Java Compiler (javac)**.
  - **Bytecode** is an **intermediate representation** that is **not directly executed** by the CPU.
  - Instead, the **Java Virtual Machine (JVM)** interprets and executes the bytecode.

This process allows Java programs to be **portable and platform-independent**.



Key Features of Java

- **2. Java is Platform-Independent (Portable)**
- Java follows the **"Write Once, Run Anywhere" (WORA)** principle.
- Compiled **bytecode** can run on **any device** that has a **JVM**, regardless of the operating system.
- The JVM is platform-specific, but Java code itself does **not** depend on the underlying system.
- **Example:** A Java program compiled on **Windows** can run on **Linux, macOS, or any other OS** without modification.



4. Overview of the Java Programming Language

Key Features of Java

3. Java is fully Object-Oriented, meaning everything is based on **classes and objects**.

4. Java is Simple and Developer-Friendly : java is **inspired by C and C++**, but **removes** complex features like: **Manual memory management** (Java has automatic garbage collection), **Pointers** (avoiding security risks and errors), **Multiple inheritance** (Java uses interfaces instead).

5. Java is Strongly Typed :

- Java enforces **strict type-checking** at **compile-time**.
- Implicit type conversions that may **lead to data loss** are **not allowed**

- **Example:**
- This is **valid in C** but **invalid in Java**:

```
double a = 5.5;
int y = a; // Allowed in C (but may lose precision)
```

- In Java, an **explicit cast** is required:

```
double a = 5.5;
int y = (int) a; // Explicit type conversion
```