Software Engineering Course

Chapter 2
Modeling with UML

2020-2023

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Plan

1. Introduction: Modeling, Model, Object Oriented Modeling, UML in application.

2. General Elements and Mechanisms

3. UML diagrams

4. Packages

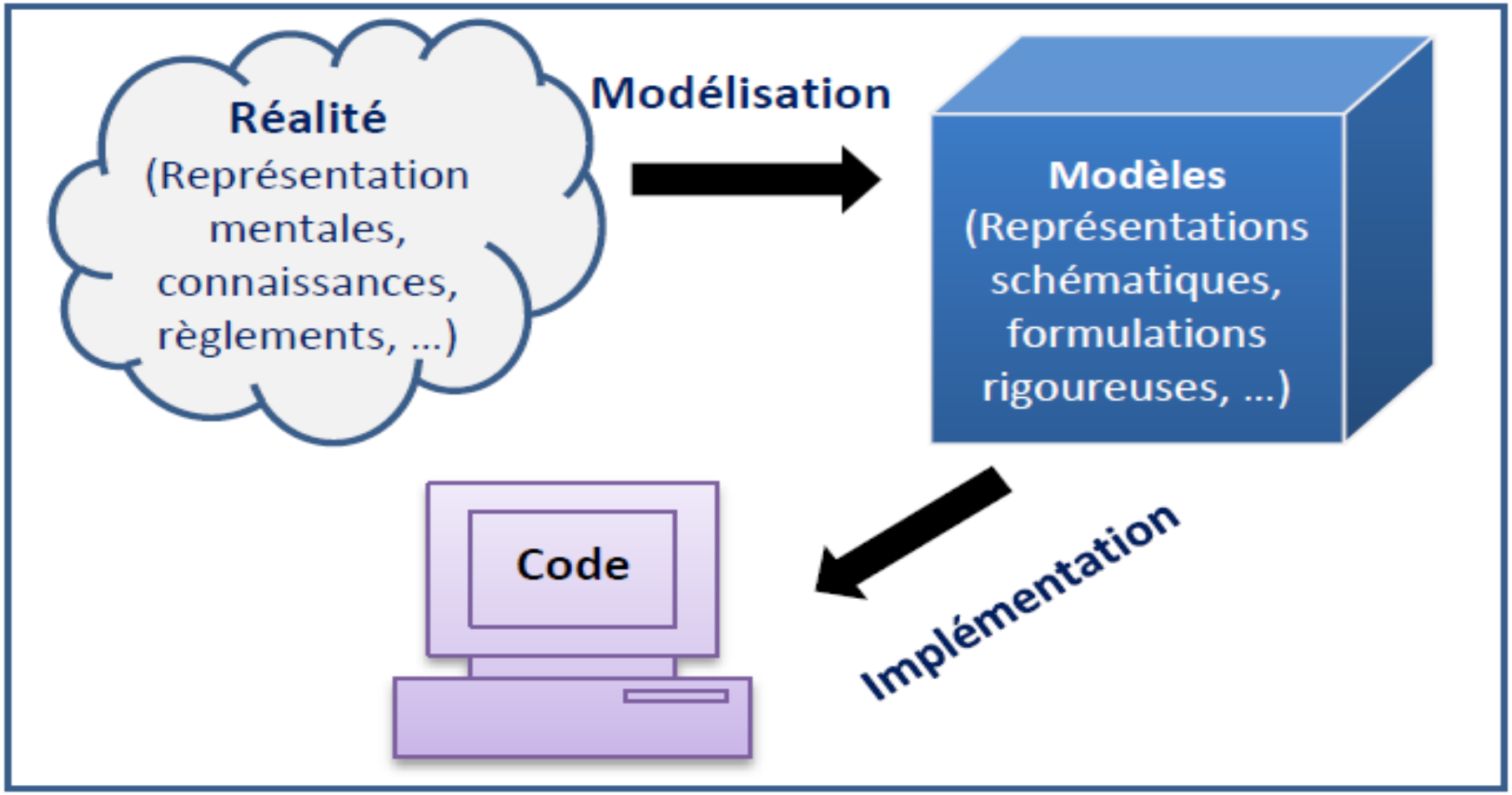
Introduction

Modeling

- ✓ **Model:** Simplification of reality, abstraction, subjective view
- ✓ **Examples:** meteorological, economic, demographic models
- ✓ **Modeling a concept or an object, why?**
  - ✓ to better understand it (modeling in physics)
  - ✓ to build it better (Engineering Modeling)
- ✓ **In software engineering:**
  - ✓ Modeling = specification + design
  - ✓ Help the realization of a software from the requirements of the customer.

Introduction

Modeling



Introduction

Model, Method, Tool ?

- ✓A **Model** is an abstraction of reality. it is an abstract representation of all or part of reality.
- ✓A **model** makes it possible to capture the relevant aspects responding to an objective defined in advance.
- ✓A **Tool** is an automated or semi-automated **medium** to support methods (Formalism or language for expressing a model).
- ✓A **Method** is the way we will conduct an activity, it uses models and tools, and follows an implementation process.

Introduction

Software design methodology provides a logical and systematic means of proceeding with the design process as well as a set of guidelines for decision-making.

Introduction

Design methods

1) Functional method

✓ **System** = set of functions

✓ **System state** (data): centralized and shared by functions.

2) Object-oriented methods

✓ **System** = set of objects

✓ **Object** = data + functions

✓ **Examples of object-oriented methods:**

- OOA (Object-Oriented Analysis), Coad.

- OOD (Object-Oriented Design), Grady Booch.

OMT (Object Modeling Technique), James Rambaugh.

OOSE (Object-Oriented Software Engineering), var Jacobson.

3) Data-Driven Methods

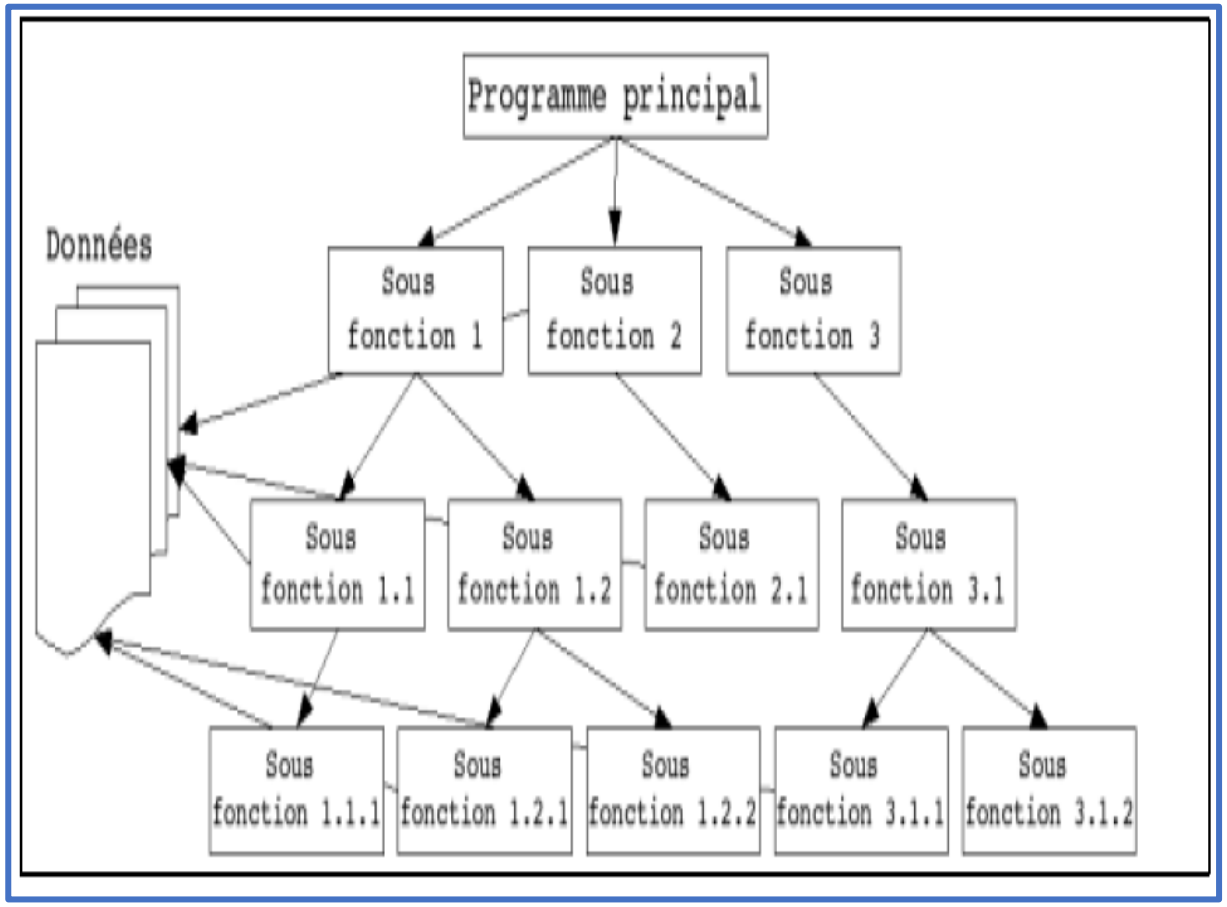
✓ The structure of a system can be deduced from the structure of the data appearing at the input and at the output of this system.

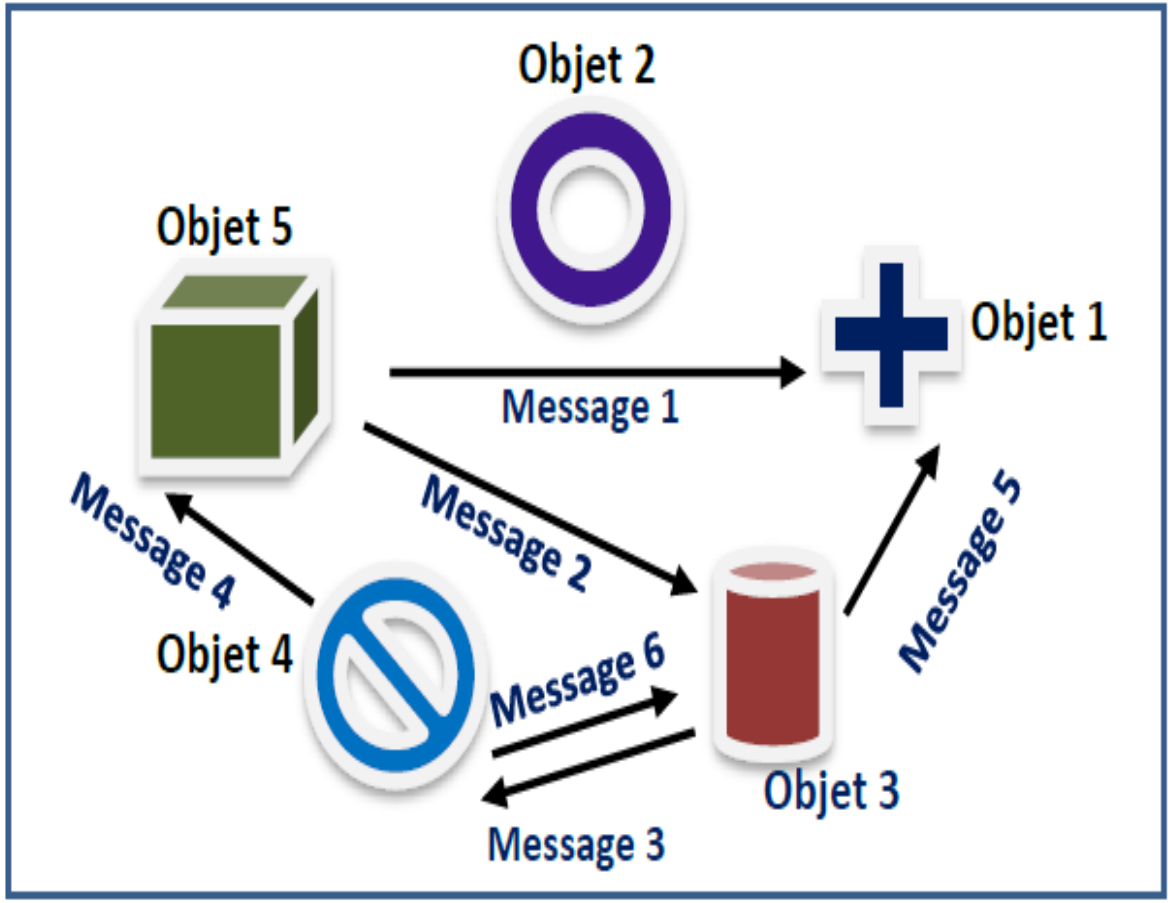
4) **Systematic methods**

✓ Merise

Introduction

Functional method Vs Object-oriented methods





Introduction

Object Oriented Modeling

✓Principles:

- Application domain concept = **object**
- Described by: **state** (attributes) + **behavior** (operations)
- Links between concepts: inheritance, aggregation, composition, etc.

✓Characteristics of objects

- **Identity**: Object = Single entity (same attributes ⇏ same object)
- **Classification**: grouping of objects of the same nature (attributes + operations)
- **Polymorphism**: different behavior of the same operation in different classes
- **Inheritance**: hierarchical sharing of attributes and operations

Introduction

UML in application

UML: **Unified Modeling Language**

✓**Language :**

- Syntax and writing rules
- Standardized graphical notations

✓**Modeling language:**

- Abstraction of the functioning and structure of the system
- Specification and design

✓**Unified language:**

- Merger of several previous notations: Booch, OMT, OOSE
- Standard defined by the **Object Management Group** (OMG)

Introduction

UML in application: **Unified Modeling Language?**

- ✓**Graphical language** for **visualization, specification, documentation, and building** Software.
- ✓**Graphical language**: **a set of diagrams** to software model according to **different views** and **at different abstraction levels.**
- ✓**Object-oriented modeling**: modeling the system as a **set of objects that interact together.**
- ✓UML is not a design method

Introduction

UML in application: Why UML ?

✓**Need to model in order to build software:**

- Modeling of static and dynamic aspects
- Modeling in multiple views and at different abstraction levels.

✓ **Independent of the development process**

✓Need for **standardized languages** for modeling

- Semi-formal language
- Standard widely used

✓**Object-oriented design**

General Elements and Mechanisms

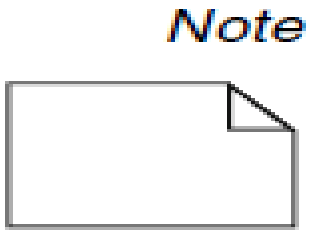
✓**NOTE**: is a concept that could occur in **all UML diagrams**.

✓It can comprise any **form of expression** that **specify the diagram and its elements more precisely**.

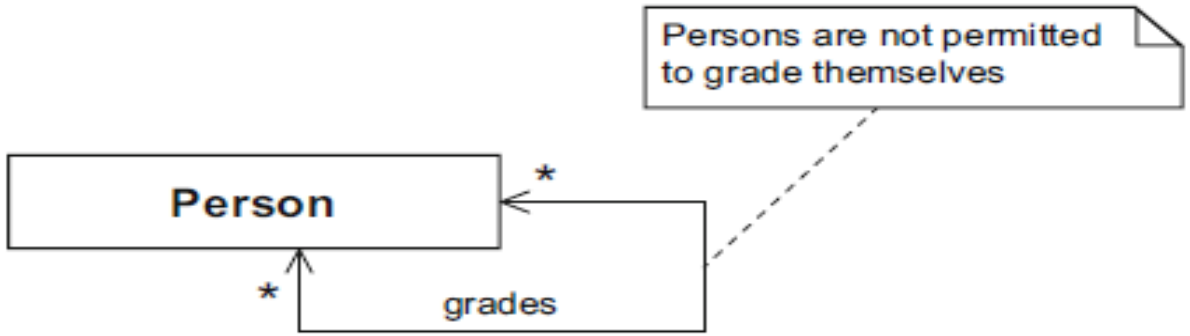
✓**Example**: natural language or Object Constraint Language (OCL).

✓It may be attached to all other model elements.

✓**Notation**:



Example:



General Elements and Mechanisms

- **Encapsulation**:
  - is the mechanism that **protect objects against unauthorized access** to their internal state, through a **uniquely defined interface**.
  - These **various access authorizations** can be ensured by **different visibility levels** of the **corresponding interfaces**.
- For instance, In Java, there is **explicit visibility markers:**
  - public: access **for all**.
  - private: access **only within the object**.
  - and protected: access **for members of the same class, its subclasses, and within the same package.**

General Elements and Mechanisms

- **Messages**: mechanism that ensures communication between Objects.
- The intuition behind sending a message to a given object is to **request** the **execution of an operation**.
- Thus, the object, when receiving a message, decides itself whether and how to execute the required operation, depending on the associated access authorization defined through visibility and a suitable implementation. .

General Elements and Mechanisms

- ✓**Inheritance**: is a mechanism that allows **deriving new classes** from existing ones.
- ✓A class derived from another class is called **subclass**, it **inherits all visible properties** (attributes and operations) of the superclass.
- ✓**A subclass:**
  - ✓Can add new attributes and/or operations
  - ✓Can overwrite (redefine) inherited operations implementation
  - ✓Also, can add its specific behavior (i.e. code) to inherited operations

General Elements and Mechanisms

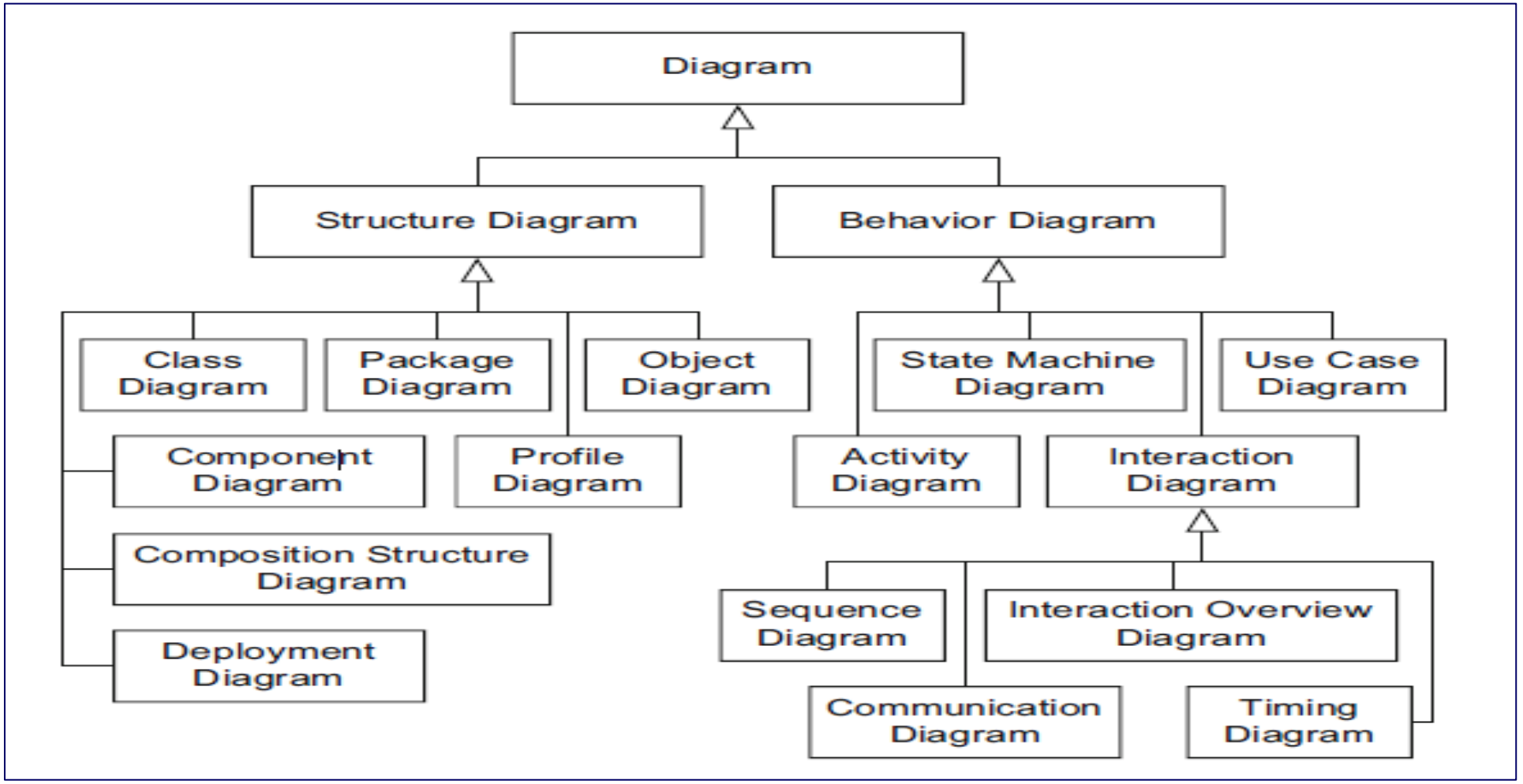
- ✓ **Inheritance** allows classes extensibility, therefore, the **creation of hierarchies of classes, which serves** as the basis of object oriented system development.
- ✓ A **class hierarchy** comprises **classes having similar properties.**
- ✓ Example: Person ← Employee ← Professor ← ...
- ✓ The notation A← B designates that **B is a subclass of A.**
- ✓ The **advantages of the inheritance** can be summarized as follows:
  - ✓ **Reusing program** or parts' model.
  - ✓ Defining interfaces in consistent manner.
  - ✓ Supporting **incremental and gradual development** (a step-by-step refinement of concepts).
  - ✓ Considered as a **modeling assistance** mechanism due to its natural categorization of elements occurrence.

General Elements and Mechanisms

- ✓ **Polymorphism** is the mechanism that enables adopting different forms.
- ✓During the program execution, a polymorphic attribute can refers to objects from diverse classes. When declaring such attribute:
  - ✓a type (e.g., class Professor) is assigned statically during compiling.
  - ✓At runtime, this attribute can also be dynamically bound to a subtype.

UML Diagrams

- ✓ **UML is defined over 14 hierarchically** dependent diagrams
- ✓ Modeling at all levels along the development process



UML Diagrams

- ✓ UML diagrams are divided mainly into:
  - ✓ **Structural diagrams**
  - ✓ **Behavioral diagrams**
- ✓ **Structure diagrams include :** Classes diagram, Object diagrams, Component diagram, Composite Structure diagram, deployment diagram, package diagram, and profile diagram.
- ✓ **Behavior diagrams include:** use case diagram, interaction diagram, activities diagram, and states machine diagram.
- ✓ **At turn, the Interaction diagrams** are divided into: sequence diagram, Timing diagram, communication diagram, and interaction overview diagrams.

UML Diagrams

- **Class diagram** is a static diagram which describes the system structure by displaying its classes and their properties and operations. Also, it shows the relationships between objects.
- **Use Case Diagram** comprises use cases, roles, and the relationships between them. It represents the interaction of users with the system. Also, it defines the corresponding specifications of the use cases.
- **Sequence diagram** models communication between objects in a sequential manner. It displays the chronological order of objects, classes and roles and information engaged in a scenario.
- **Activity diagram** is a behavior diagram which represents a scenario by means of flow of actions. It specifies a sequence of actions, decisions, concurrency, and other features.

UML Diagrams

- **Communication diagram** represents the interaction between objects and parts in term of messages exchange. It is similar to sequential diagram, however, objects are represented horizontally.
- **State Machine Diagram** is a behavior diagram that specifies the state of an object (device, program, module, software, , process, etc.) and the transitions between states.
- **Object diagram** is a structured UML diagram which represents a system or its parts at a specific time. It can models instances with the corresponding values and relationships.

UML Diagrams

- **Package diagram** represents the potential dependencies between packages in a given model. It shows the structure and organization of large-scale projects.
- **Component diagram** shows the provided and/or required interfaces for the various parts of the system and the relationships between them. These parts are represented by means of components and artifacts.
- **Deployment Diagram:** represents the location of components and artifacts (systems, software, modules, etc.) on physical nodes (servers, hardware, databases, etc.) and the relationships between specific parts of the system.

UML Diagrams

- **Composite Structure Diagram** represents the internal structure of a classifier, its parts and ports. It aims to model collaboration between objects having specific roles.
- **Interaction Overview Diagram** shows a view of the interactions in a given system or subsystem at a high level. It represents the processes in a similar way to activity diagrams, however, it utilizes other interaction diagrams and references instead of action nodes.
- **Timing Diagrams** is dedicated to specify temporal systems by focusing primarily on time and describing the changes in the classifier on a timeline.
- **Profile Diagram** allows describing and defining UML language extensions . Such extension mechanism enables adaptation of the language to a specific domain or platform.

Packages

- ✓It shows the **model logical organization** and the **relationships** between packages.
- ✓The package is a **mechanism that groups numerous UML elements** (classes, use cases, components, interfaces, etc.).
- ✓The package diagram is utilized for the following purposes:
  - ✓ Have an **overall view the system under study** (different subsystems).
  - ✓ **Represent the overall system architecture** and help organizing code (java or C#).
  - ✓ Modularize UML diagrams, especially complex ones.

Packages

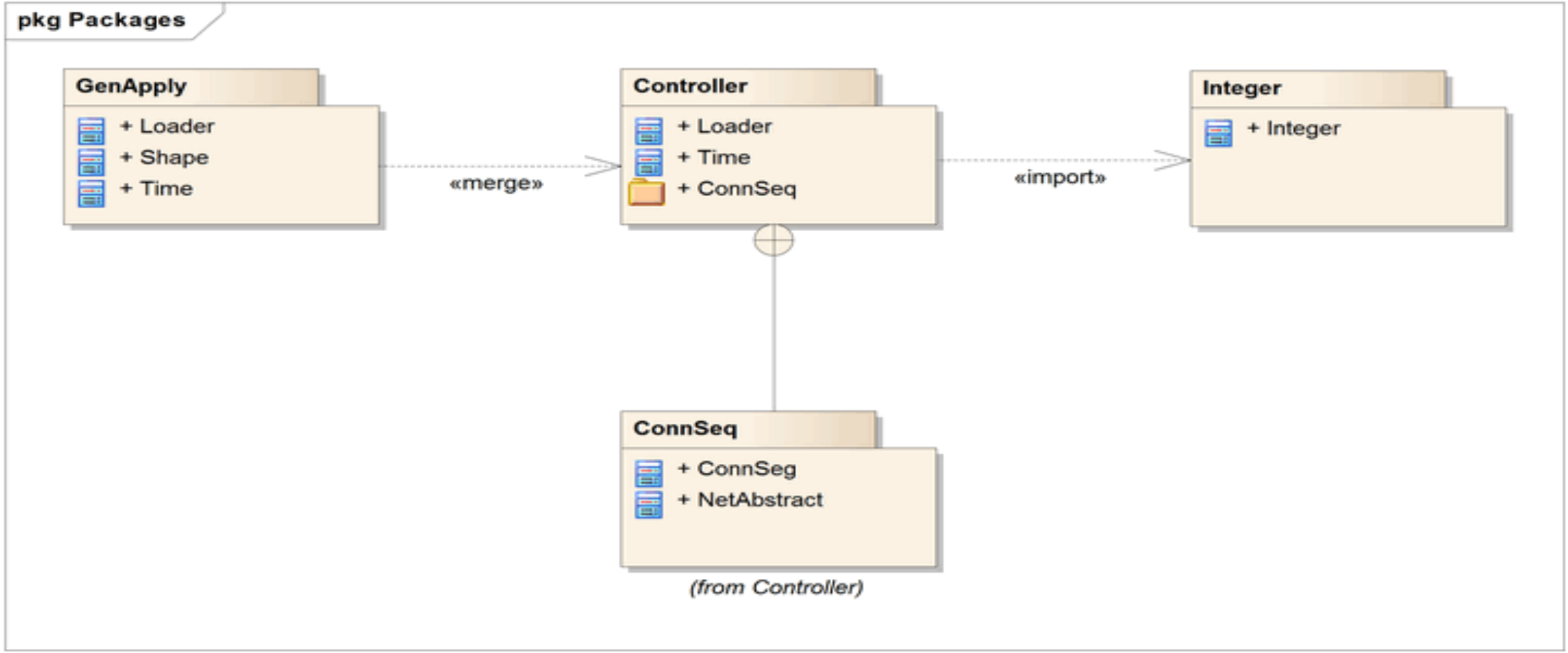
- ✓The **decomposition of a model** (of classes or use cases) is **a delicate activity**. It will be necessary to group the classes from a semantic point of view, that is to say:
- ✓The **classes of the same package** should provide **services of the same nature** to the users.
- ✓**Minimize dependencies** between packages.
- ✓**Dependencies between packages** should reflect the **internal relationships** to the system.
- ✓There should be **no cyclic dependency** between packages.

Packages

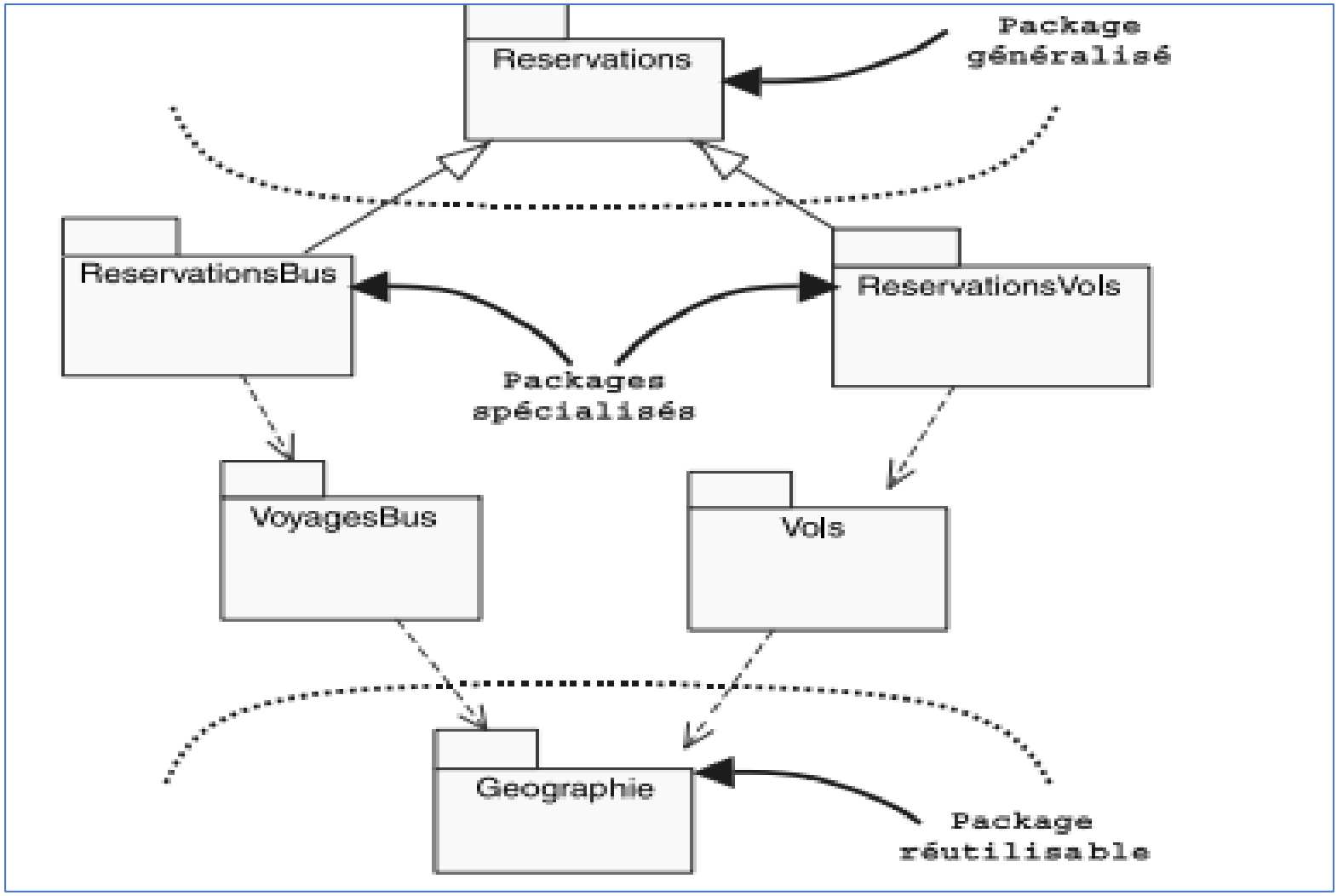
- ✓Package diagram is utilized to reflect the natural organization of packages and their elements.
- ✓Using package diagram to present class elements, it provides a visualization of the **namespaces**.
- ✓**Package diagram is commonly used for organizing** use case diagrams and class diagrams.
- ✓It is not limited to these elements, it can also used to built Packages to describe logical or physical relationships.

Packages

- Example of package diagram.



Packages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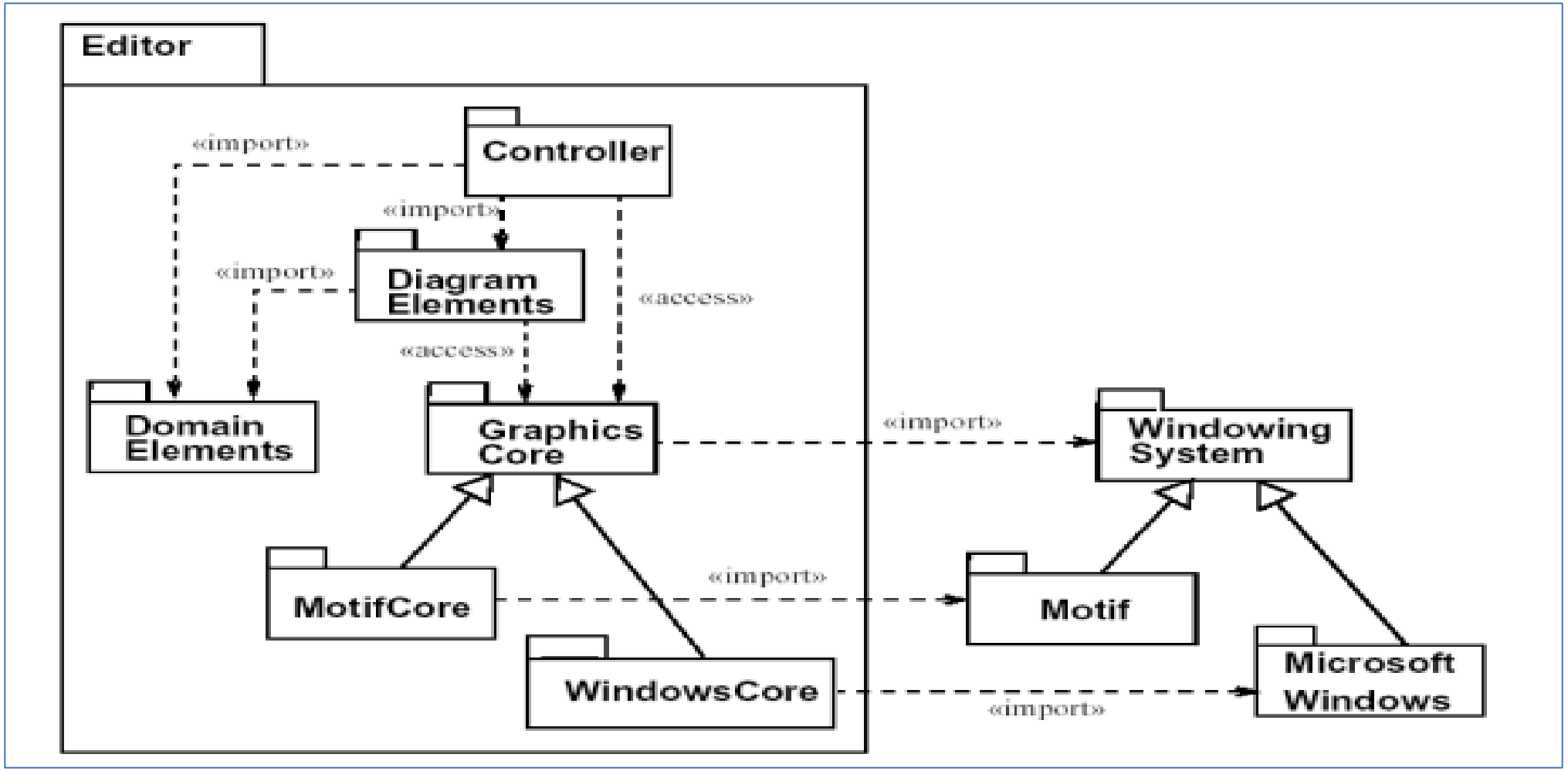
Packages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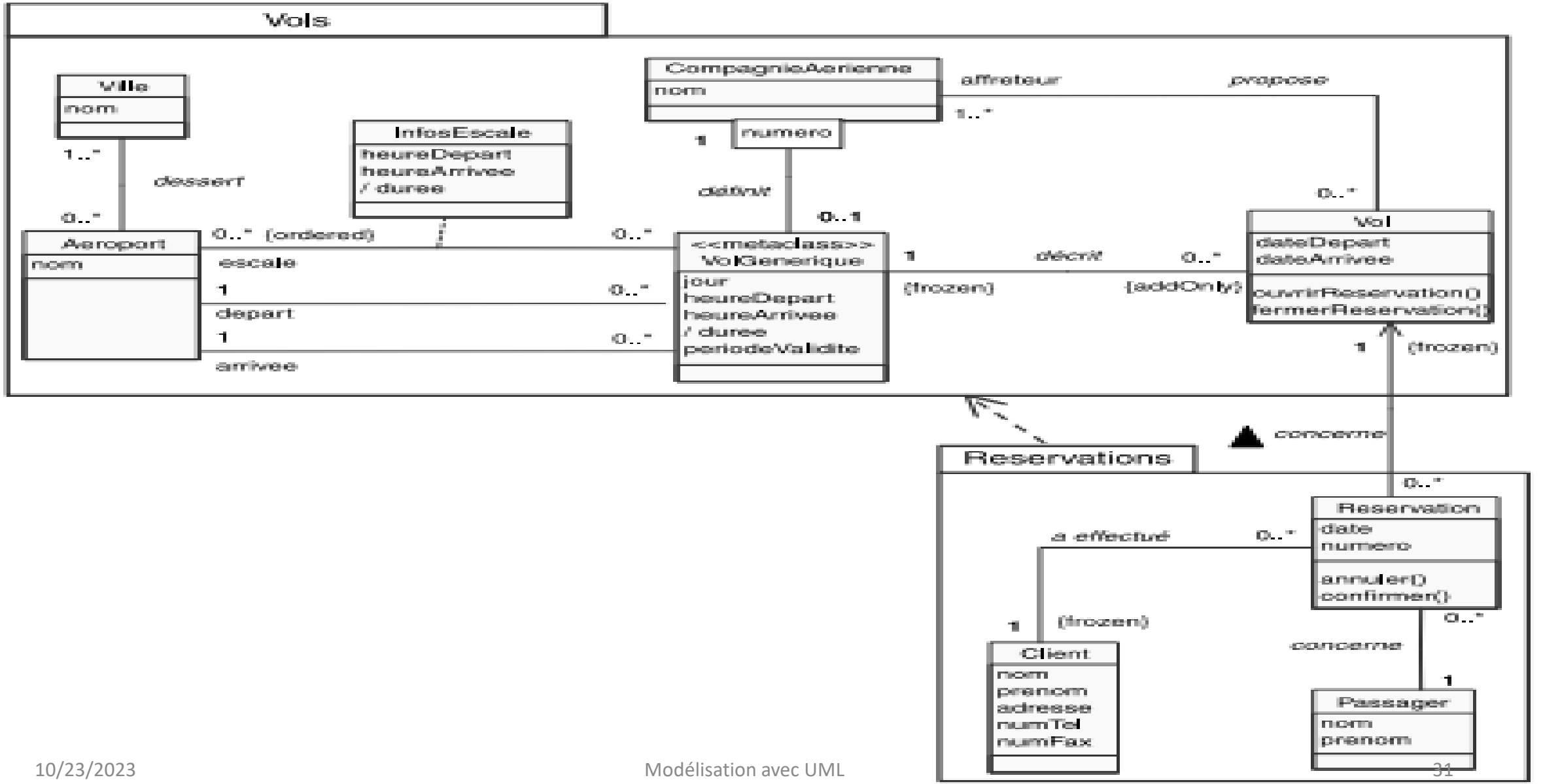
Packages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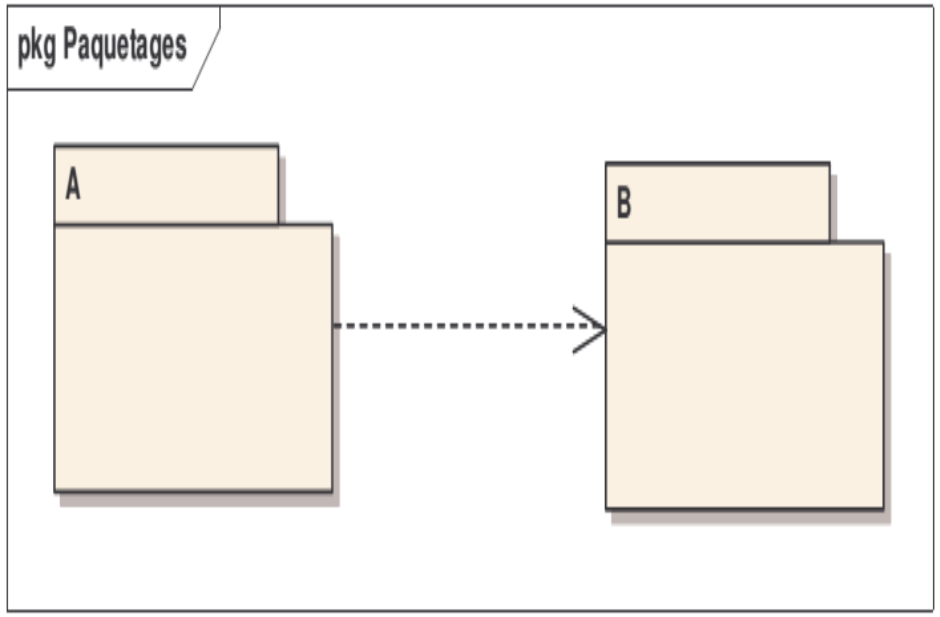
Packages

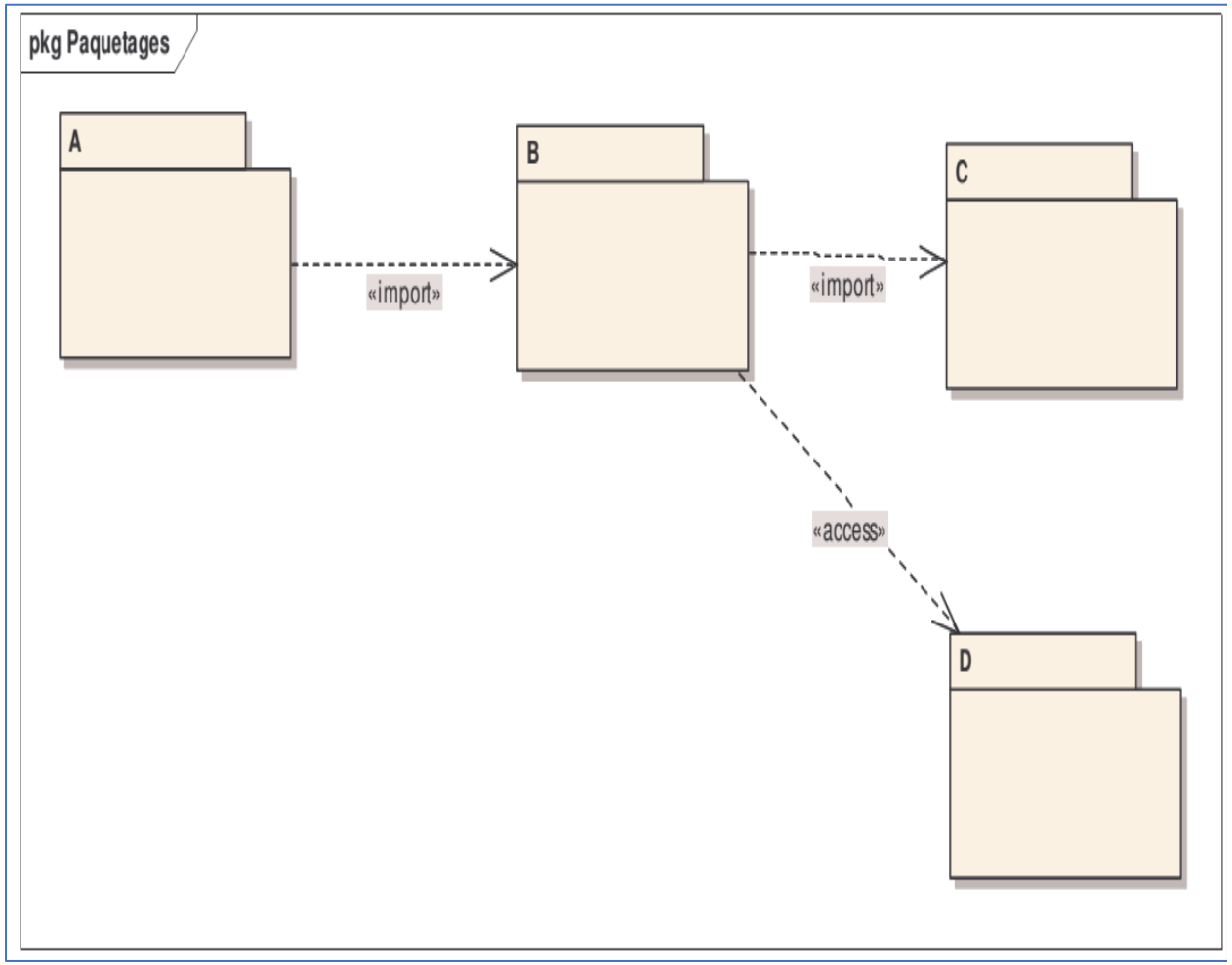


Dependency: the possibility for a given class from one package to use a class from another one. Such necessity creates a dependency between packages.

Example: if an element of **package A** utilizes an element of **package B** , we can say that package A depends on package B .

Packages

Import and Access



✓ **Import** and **access relationships** can be used to model importing classes into a namespace , so that importing namespace elements can reference those in the target namespace , without using its name.

✓ Package B **imports** C and accesses **D:**

- B therefore sees the public elements of C and D.

- Since A imports B, A sees the public elements of B.

- A also sees the public elements of C because C is imported publicly into B ,

- but A does not see the contents of D because D is privately accessed in B.

Conclusion

Using UM Diagrams presents serval advantages:

- Make the entire software design easier to understand prior to software development,
- Reduce development risks.
- Facilitates communication between developers.
- It is an expressive modeling language which allows people acquiring the necessary information they need during software development process.