

Business Informatics 2 (PWIN) WS 2025/26

ICS Development II
Object Orientation & UML

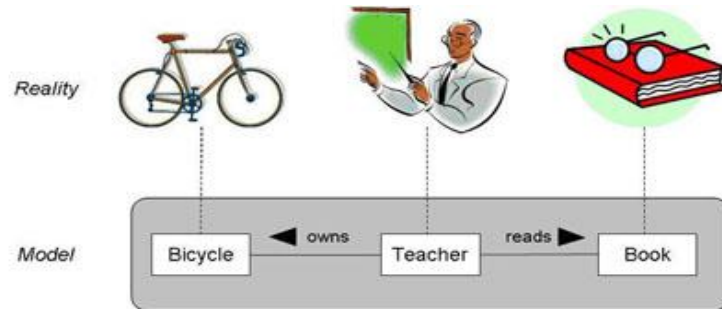
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- Object-Oriented Approach
- Unified Modelling Language (UML)
- Model-Driven Development and Architectures

The Idea of Object Orientation (OO)

- OO sees things that are part of the real world.

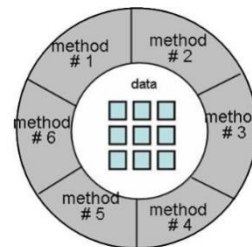


- OO-Models represent only the relevant aspects of real world things.



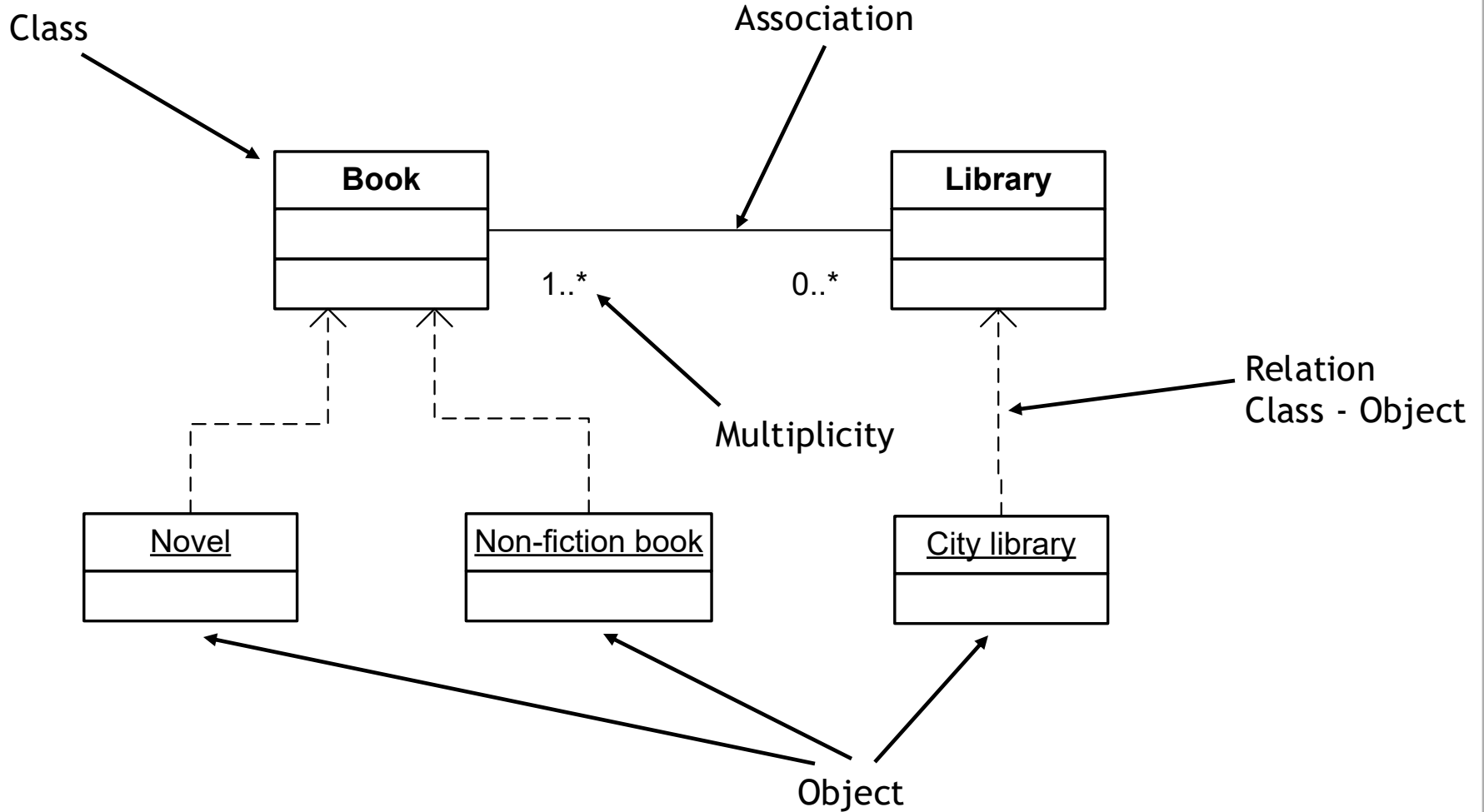
- Name
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- Objects store their data by themselves and encapsulate them for protection from other objects.



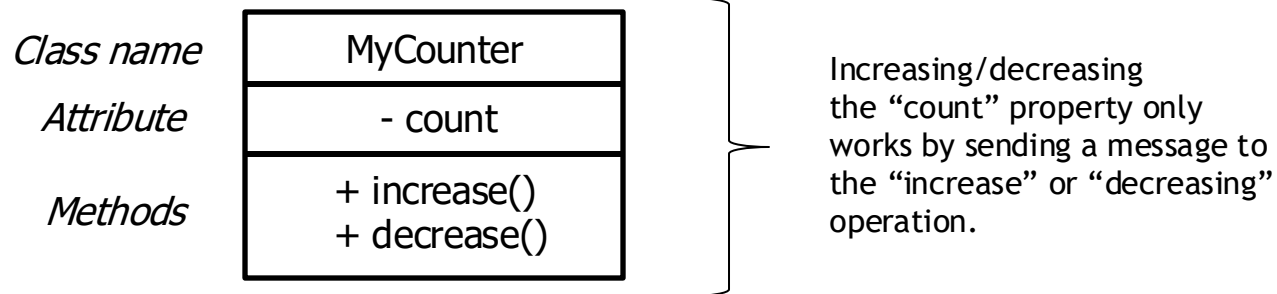
- Consideration of software as collection of interacting objects that work together in order to accomplish tasks.
 - Objects - things in a computer system that can respond to messages.
 - Conceptually, no processes, programs, data entities, or files are defined - just objects.

- **Class**
 - A class is a template for an object. It contains variables, constants and methods.
- **Object**
 - Objects are instances of classes, which exist during runtime. Multiple objects can be instantiated from a single class.
- **Association**
 - Relation between classes or objects
- **Instantiation**
 - Creation of objects according to the template of a class during runtime



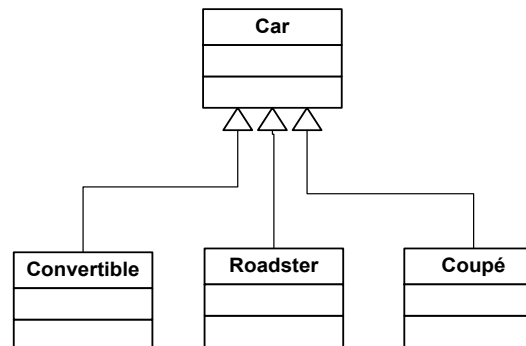
Encapsulation

- Data is stored in an object and can only be accessed via the offered methods.



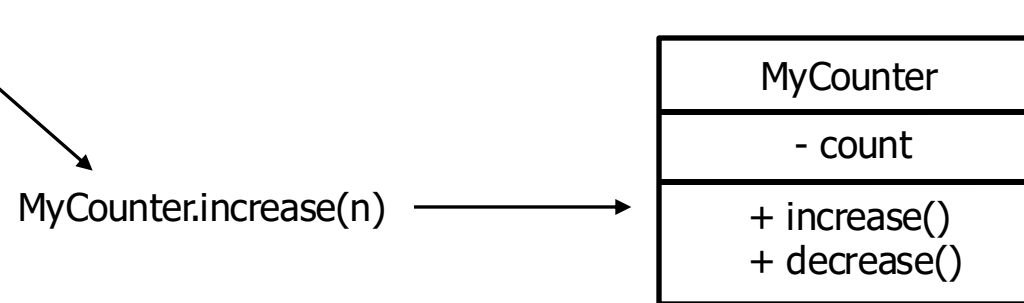
Inheritance

- Classes can inherit attributes or methods from other classes. The bequeathing class is called “super class” or “parent class”. The inheriting class is called a “subclass”.



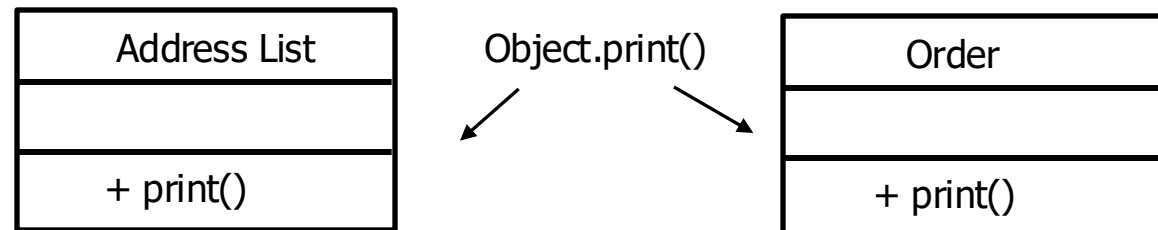
Messages

- A message is sent to an object in order to instruct it to call a method.



Polymorphism

- If a message is sent to objects of different classes, these objects return different results, as the called method can be implemented differently for each object.
- For instance, the message "Print" sent to the objects "Address List" and "Order"






- Object-oriented Analysis (OOA)
- Object-oriented Design (OOD)
- Object-oriented Programming (OOP)

Object-Oriented Analysis (OOA)

- OOA describes a system as a group of interacting objects, generating a conceptual model within a problem domain.
- This results in a description of how the software is required to behave.
- The conceptual model does not describe any implementation details. Those are developed in the design phase.

- Takes the conceptual model generated by object oriented analysis as input.
- Refines each object type to be implemented with a specific language according to its environmental context
- Takes into account the chosen architecture, technological and environmental constraints
- Typical Output: Class-Diagram

- OOP is a programming paradigm for software
- It centres around the concept of “Objects”, which consist of data structures and methods
- It takes the results of the OOD as input
- OO languages: Java, C++, C#.NET, VB.NET

- Object-oriented Analysis (OOA)

- Object-oriented Design (OOD)

- Object-oriented Programming (OOP)

- OO Software

- Object-Oriented Approach
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Unified Modelling Language (UML)

- Modelling language developed by Booch, Jacobson und Rumbaugh in 1996
- Standard of the OMG (Object Management Group)
- Current Version: 2.5.1 (December 2017)
- Standardisation ...
 - of different object-oriented notations and
 - of methods through all phases of the software developmentby using different types of models (data-oriented, object-oriented, process-oriented, etc.).

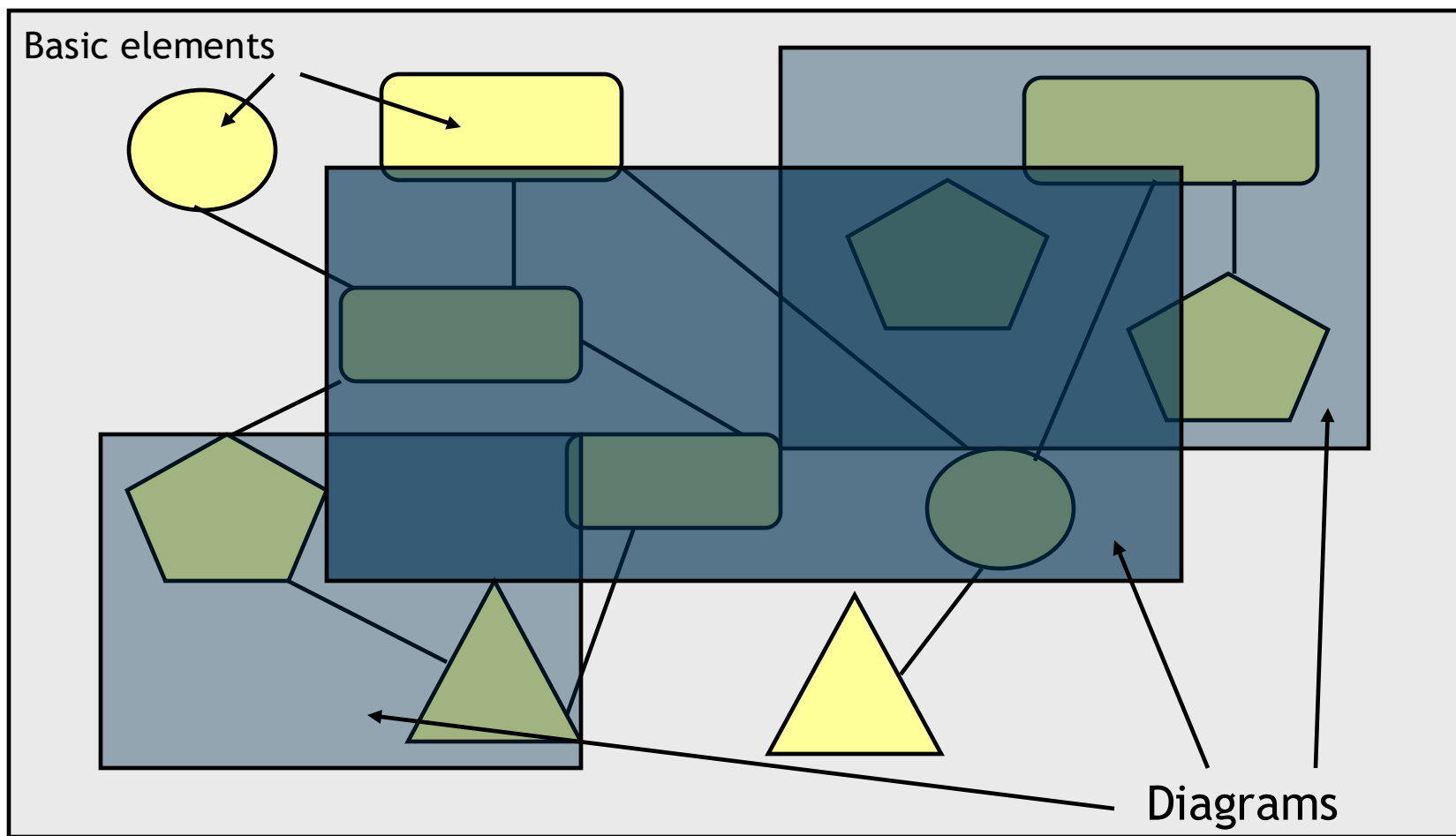


- Supports analysis and design of object-oriented software systems
- UML includes multiple Views on a system
 - Each View specifies and documents a system from a different perspective.
 - Each View is supported by one or more diagrams.
- UML is not a process model → UML does not define a process for creating UML models.

- Basic elements
 - Object-oriented notation elements
 - Additional elements to describe the modelled system (e.g. activities, actor, etc.)

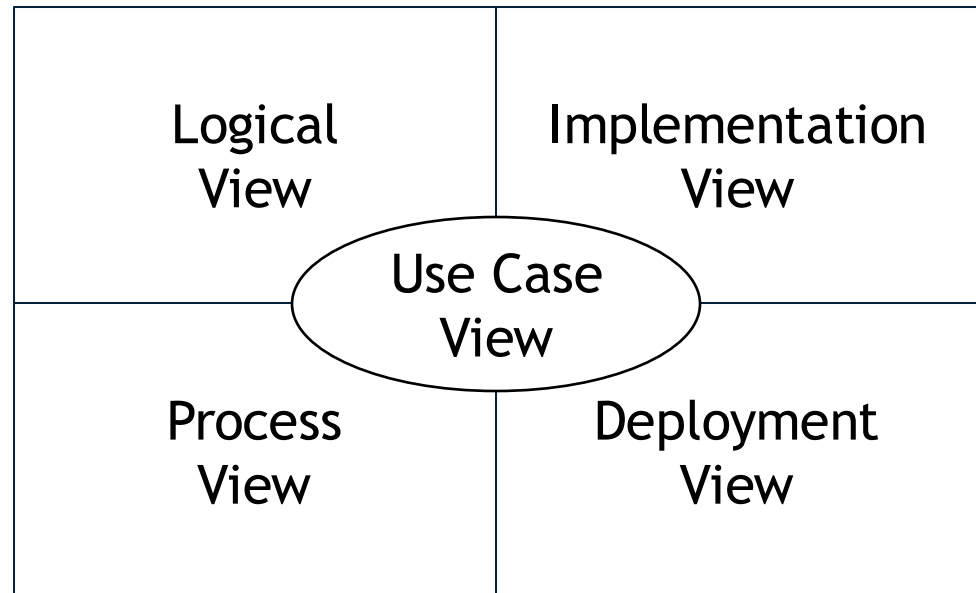
- Diagrams
 - Composition of notation elements
 - Represents a certain View on a system

- Complete model
 - The complete model is based on the basic elements.
 - Different Views on the complete model by different diagram types



Complete model

- Use case view
- Logical view
- Implementation view
- Process view
- Deployment view



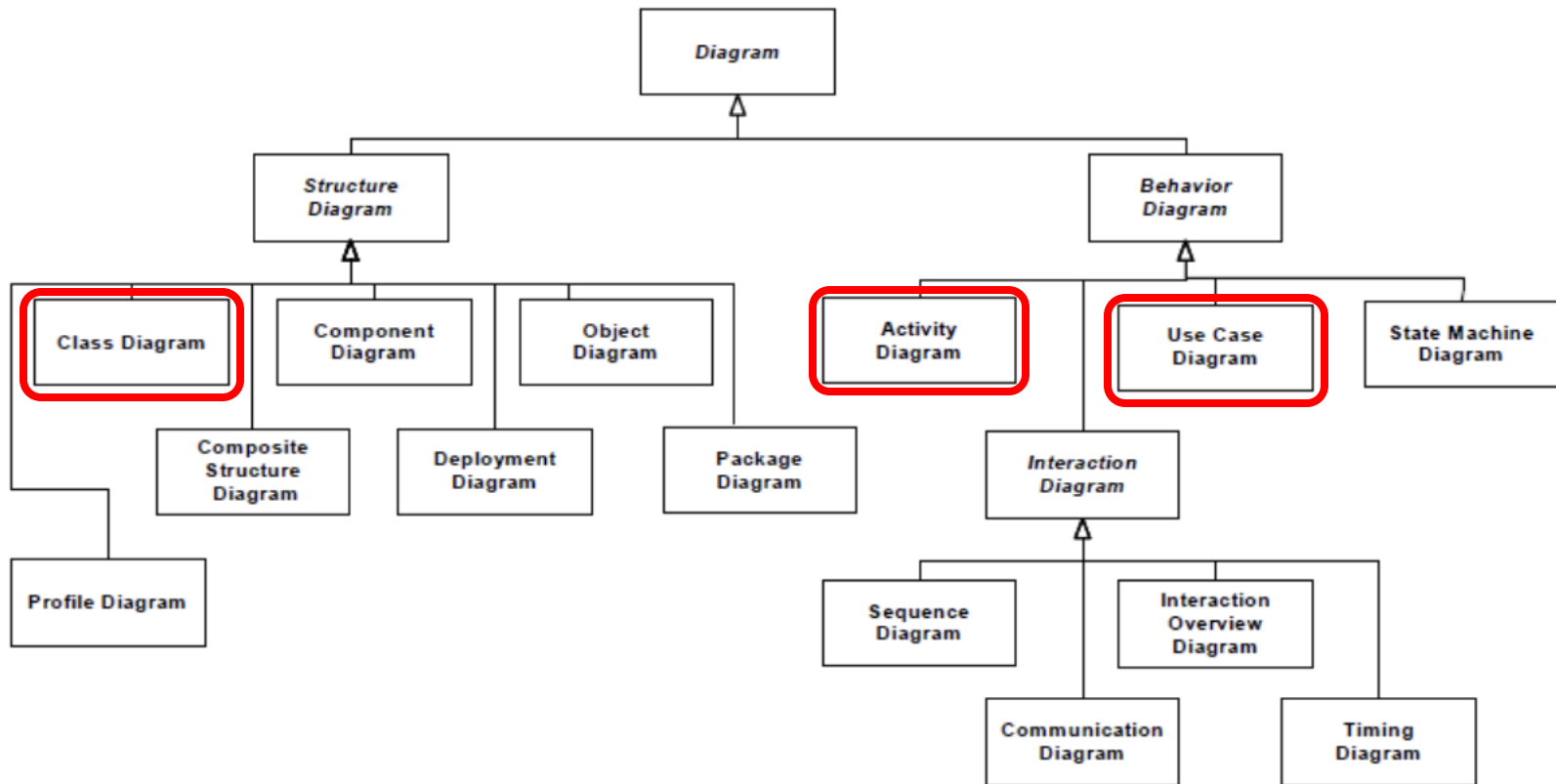
- Describes high level functionalities of a system
- Used by stakeholders, designers, developers and testers
- Represented by use case diagrams
- Serves as the basis for other views

- Describes functionalities to be designed and implemented
- Describes static and dynamic aspects of a system
- Mostly used by designers and developers
- Represented by class diagrams, object diagrams (static view), state diagrams, interaction and activity diagrams (dynamic view)

- Describes the organisation of software components
- It divides the logical entities into actual software components
- Represented by component diagrams
- Mostly used by developers

- Describes processes in a system
- Mostly used by developers and testers
- Represented by state, interaction and activity diagrams
- Supports concurrency and handling of asynchronous events

- Describes physical architecture and assignment of components to architectural elements
- Mostly used by designers, developers and managers
- Represented by package, component and deployment diagrams



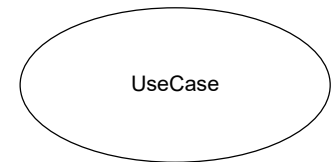
Presented in
this lecture

Source: OMG (Object Management Group)
Version: UML 2.5.1 (December 2017), page 685

- Use cases describe the functionality, which a system has to provide
- The sum of all “Use cases” comprises the technical requirements of a system.
- Use cases define the interfaces between a user and the system
- Specification is developed together with the client/customer

Use Case Diagram Notation Elements

- Use Case
 - Representation of a sequence of actions that provides value to an actor.

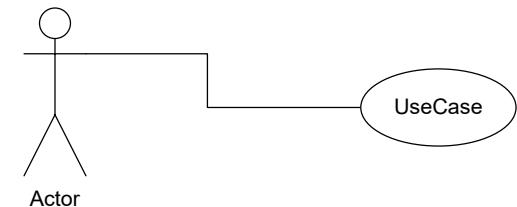


- User of the system

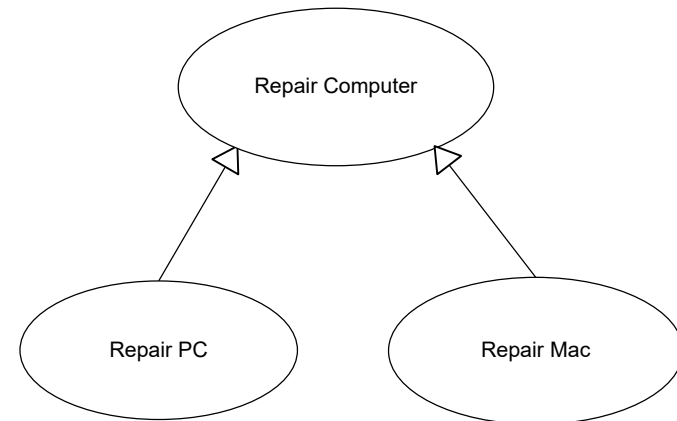
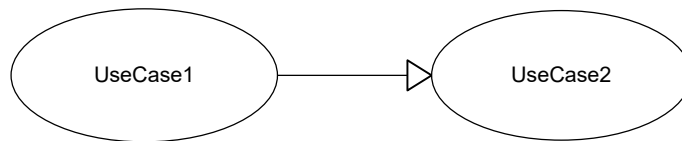


- Association

- Interaction of an actor with a use case

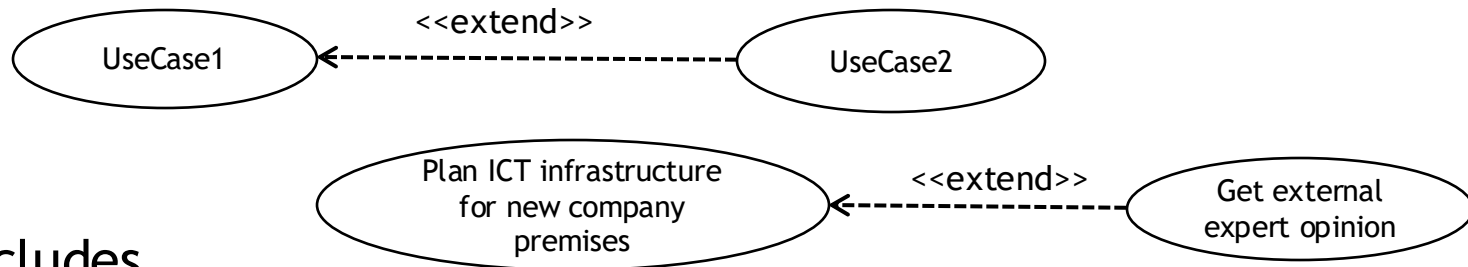


- Generalisation
 - Generalisation of Use Cases
 - UseCase2 generalises the behaviour of UseCase1



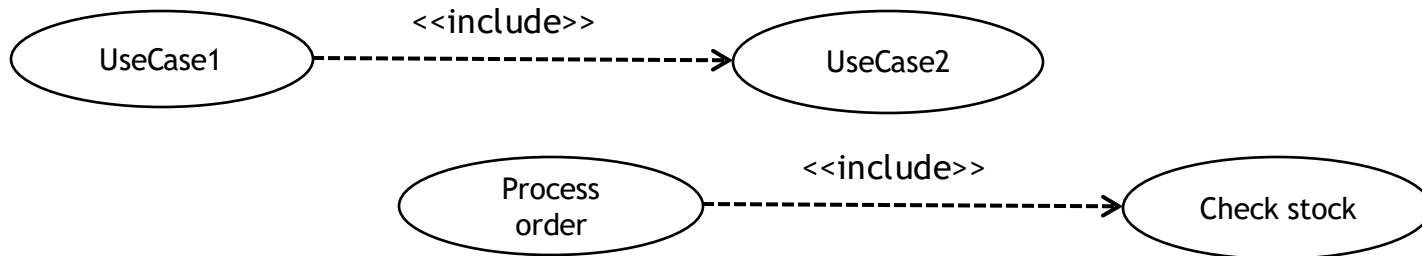
- Extends

- Extends a Use Case
- UseCase2 extends UseCase1

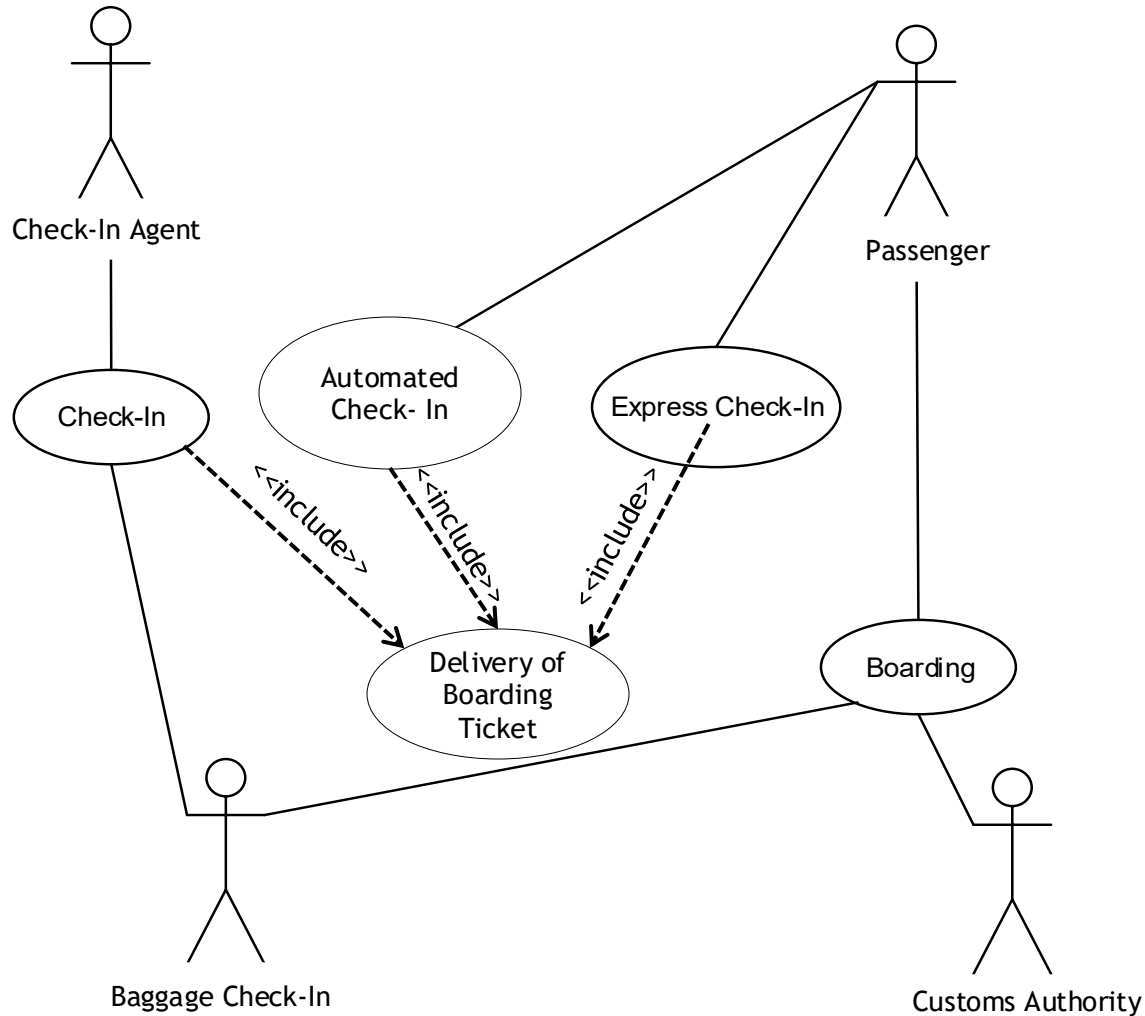


- Includes

- Inclusion of a Use Case
- UseCase1 includes the behaviour of UseCase2

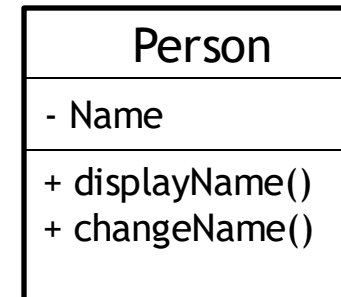
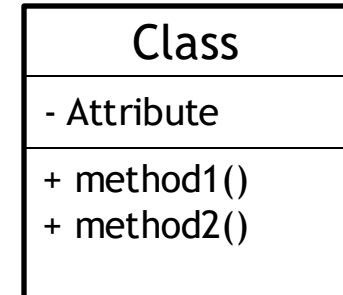


Use Case Diagram (Example)



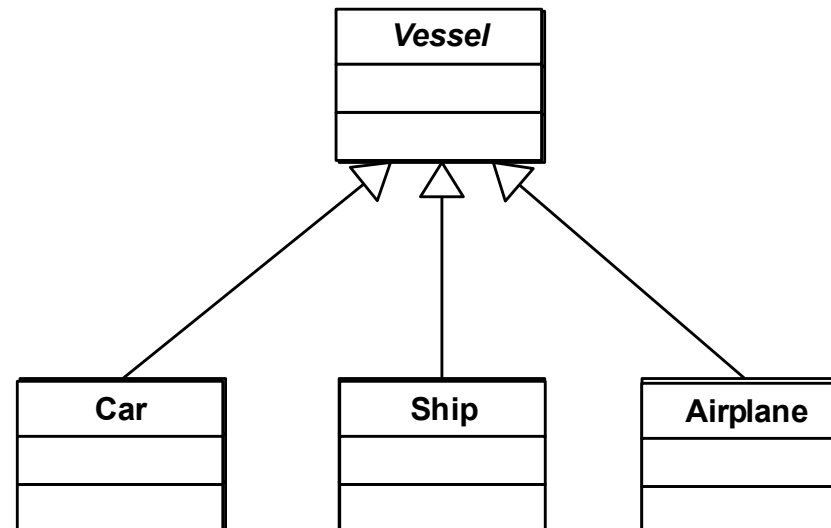
- Class diagrams
 - Representation of the static structure of a software system
 - Description of logical relations between structural elements
 - No activity or control logic
- Object diagrams
 - Instances of a class diagram
 - „Snapshot“ of a system during runtime

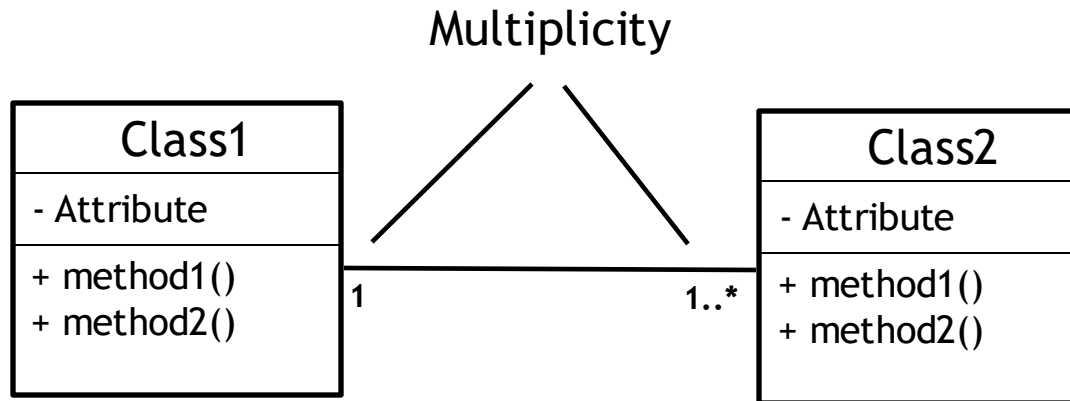
- Classes are represented by rectangles, which include the name of the class, its attributes and methods.
- The class name is in singular and starts with an upper case letter.
- Attributes and methods are separated by horizontal lines.
- „+/-“: Attribute/Method is public/private



- Class attributes
 - Class attributes belong to the class, not to the object.
 - Class attributes have the same value for all instances (objects). For instance, attribute „Number“ to count the number of created objects for a class.
 - Class attributes are underlined in the class diagram.
- Class methods
 - Class methods are executed within the class not on the object.
 - E.g. „count number of created objects of the class“
 - The class method is underlined in the class diagram.

- Definition / aggregation of common properties
- An abstract class does not allow objects to be instantiated.
- Template to create subclasses
- Abstract methods get “overwritten” by default
- The name of abstract classes is written in italic.



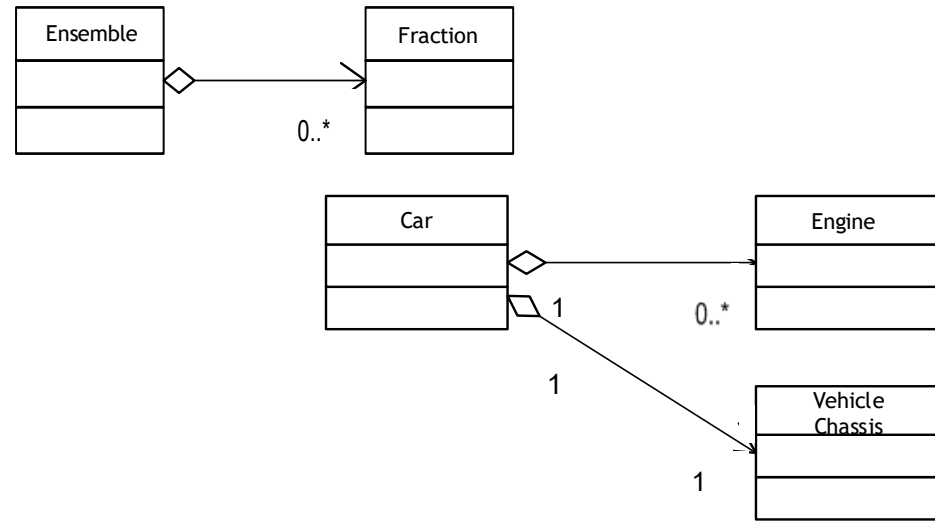


- Describes the relationship between two classes
- It is represented by a line connecting the two classes.
- The multiplicity min..max attached to the association defines the minimal or maximal number of associations between the objects of the two classes.

(*) denotes any number of objects.

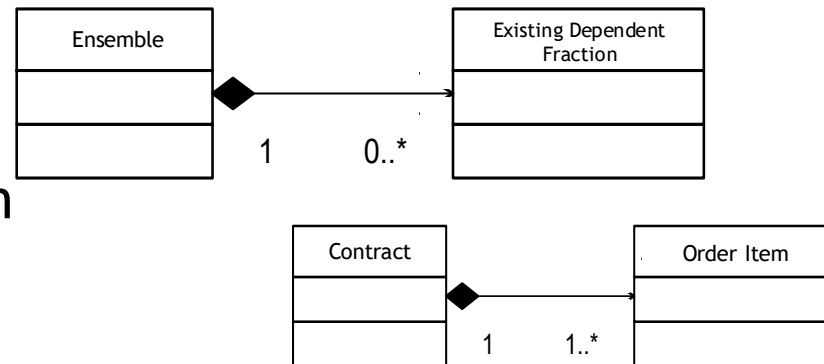
- Aggregation

- Denotes a „has a“ relationship

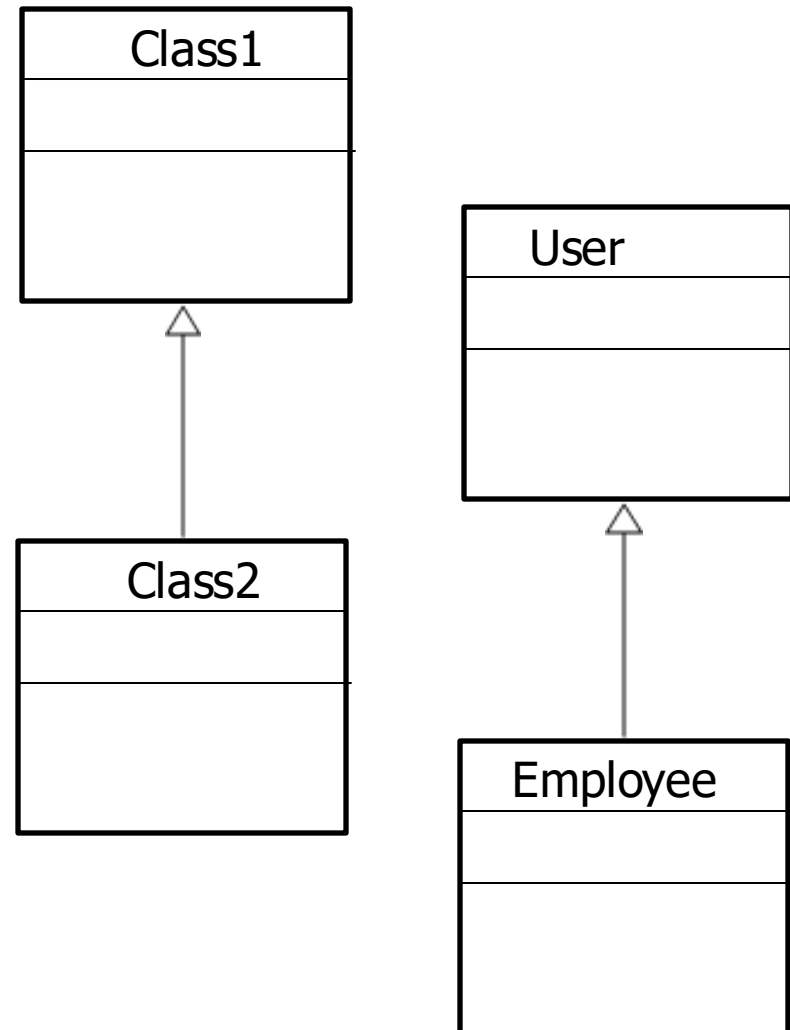


- Composition

- Composition is a stronger variant of the aggregation
- Denotes an “owns a” relationship



- Denotes an relation between parent class and subclass
- Is represented by a line with an empty arrow at the end, pointing towards the parent class
- Class2 inherits from Class1.
- Purpose:
 - Reuse code, by objects which can be based on previously created objects



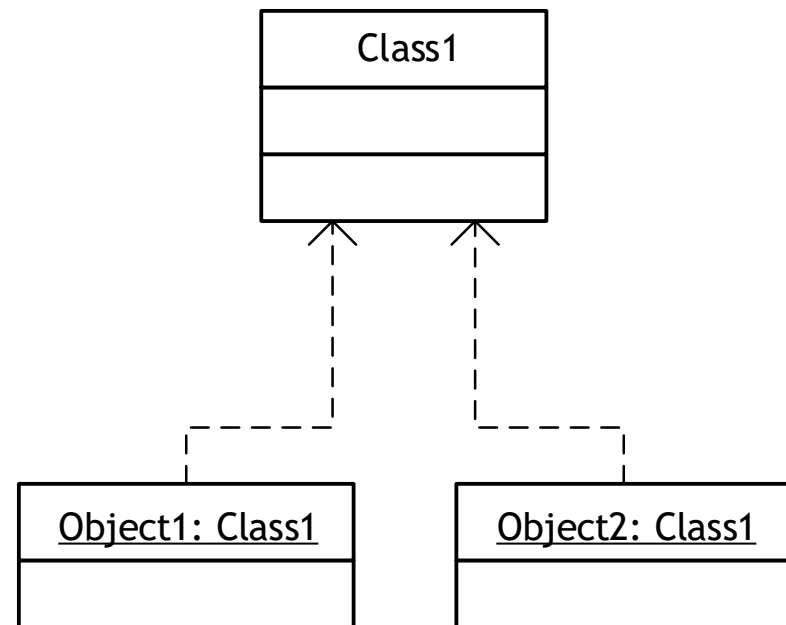
- Representation of the relation “class-object”
- An object is an instance of a class.

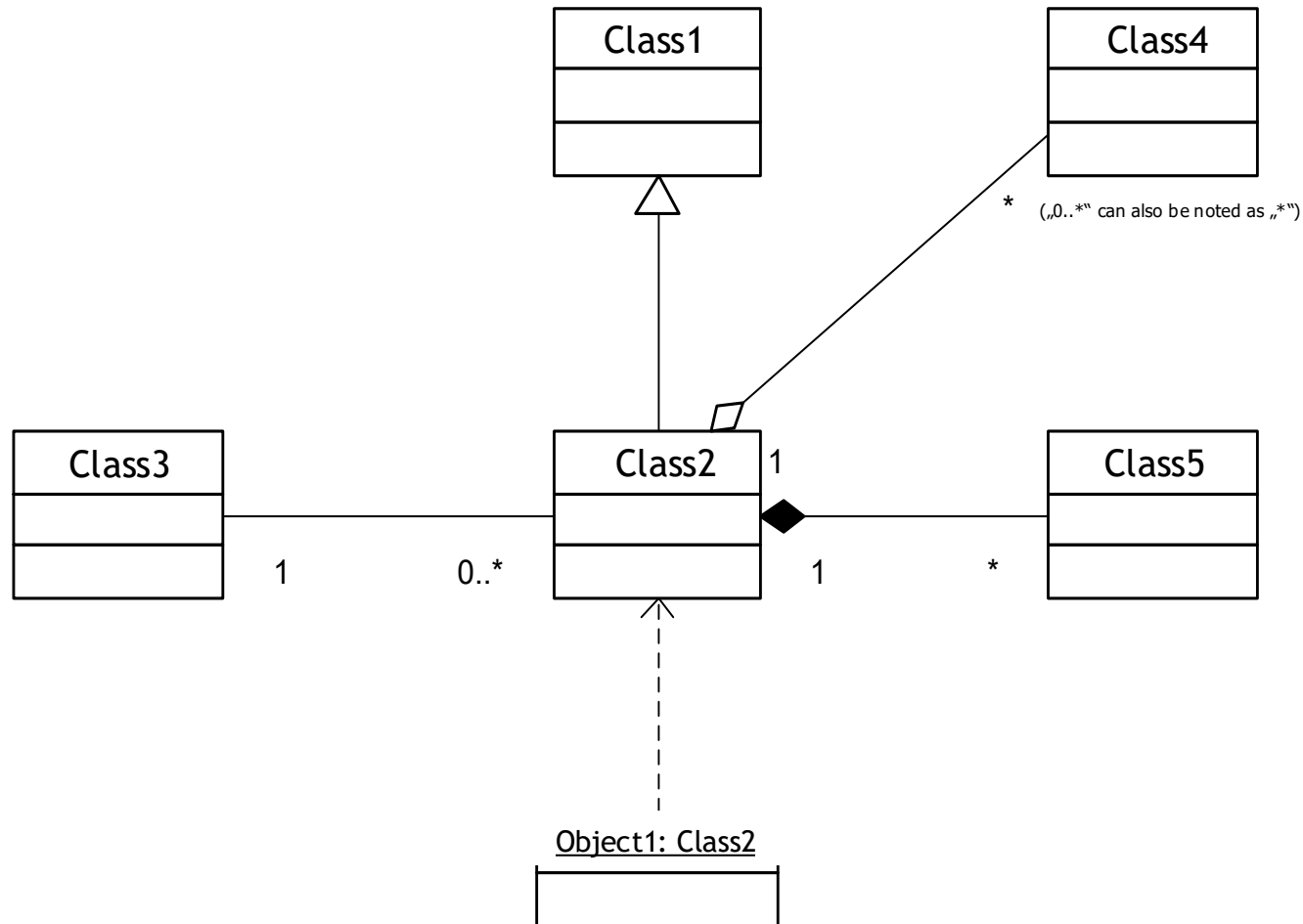
- Class

- Attributes
- Methods

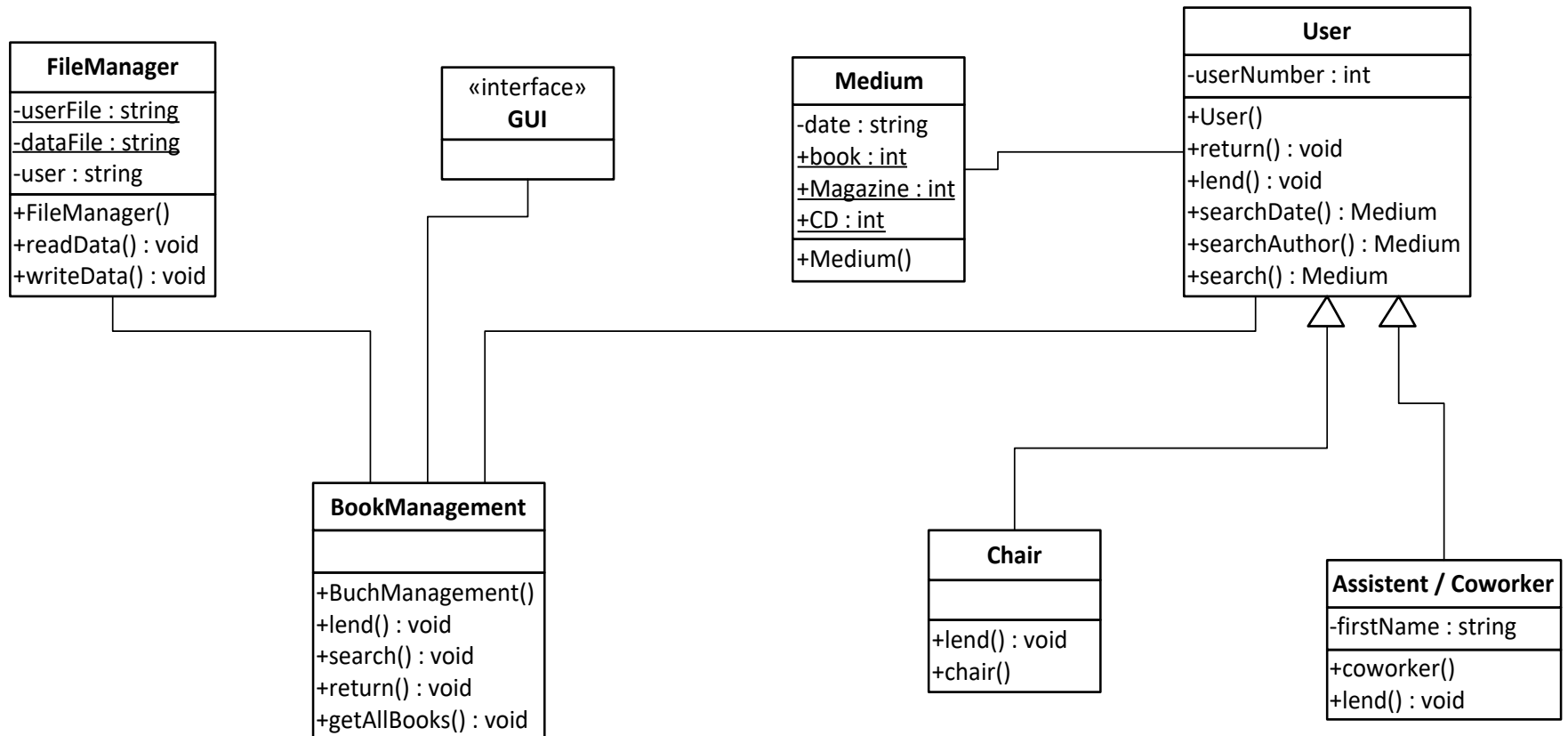
- Object

- Attribute values
- Messages





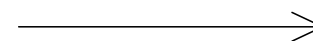
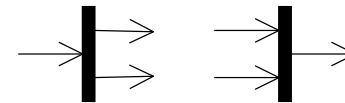
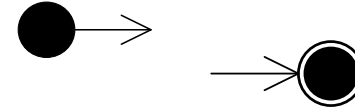
Class Diagram (Example)



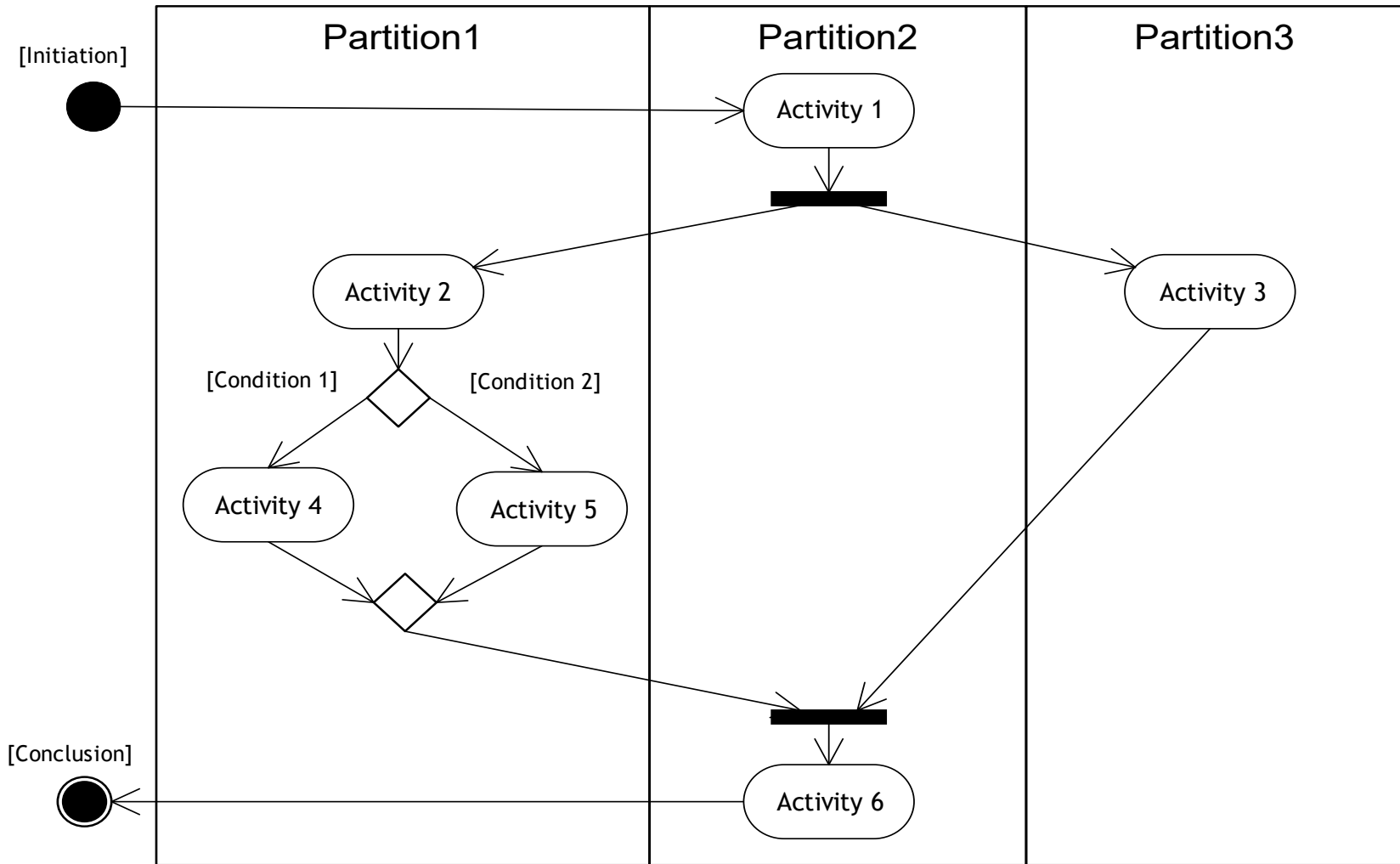
- Activity diagrams are used to model workflows in a system.
- Central element “Activity”: An activity is any kind of action.
- Activities are structured by responsibilities.
- Different views:
 - Conceptual View
 - e.g. business processes
 - Implementation View
 - e.g. methods of objects

Notation elements

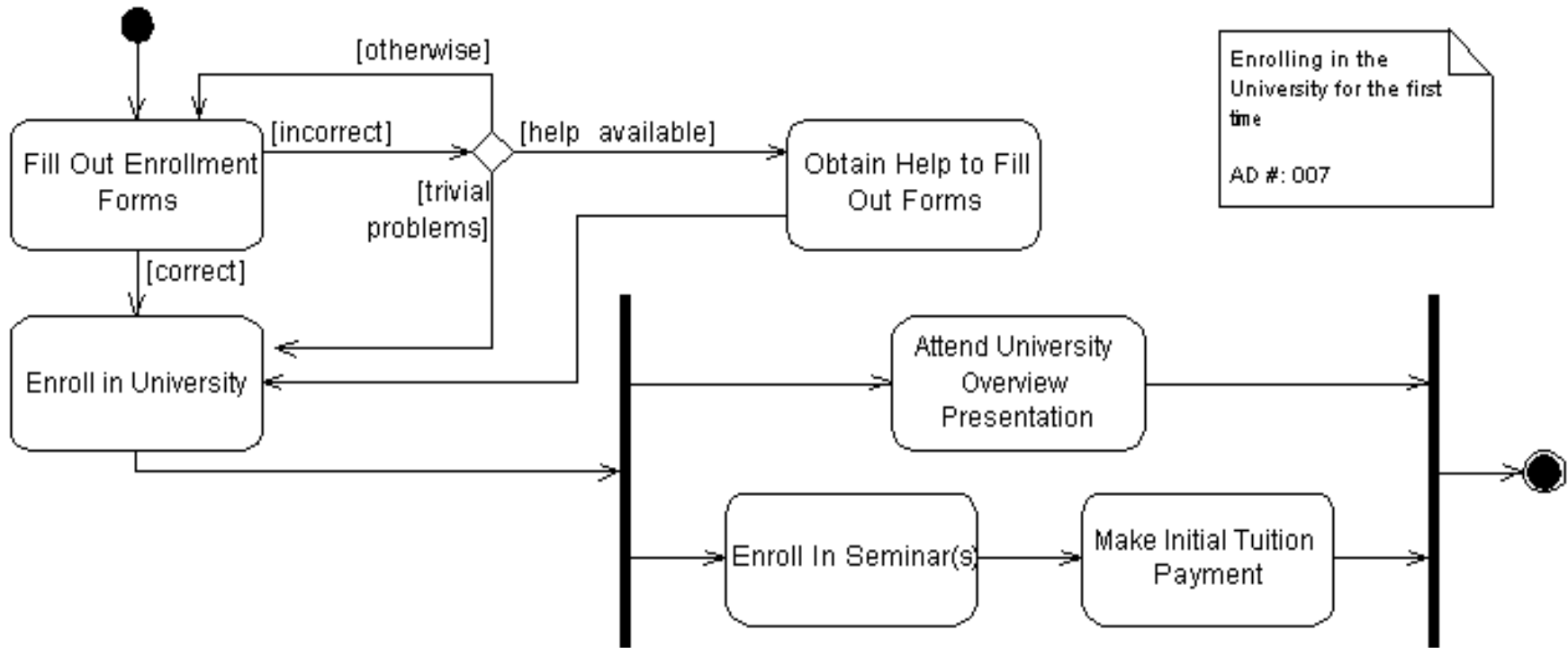
- Initial state/final state
- Activity
- Decision
- Split/join
- Responsibility
- Activity flow



Activity Diagram

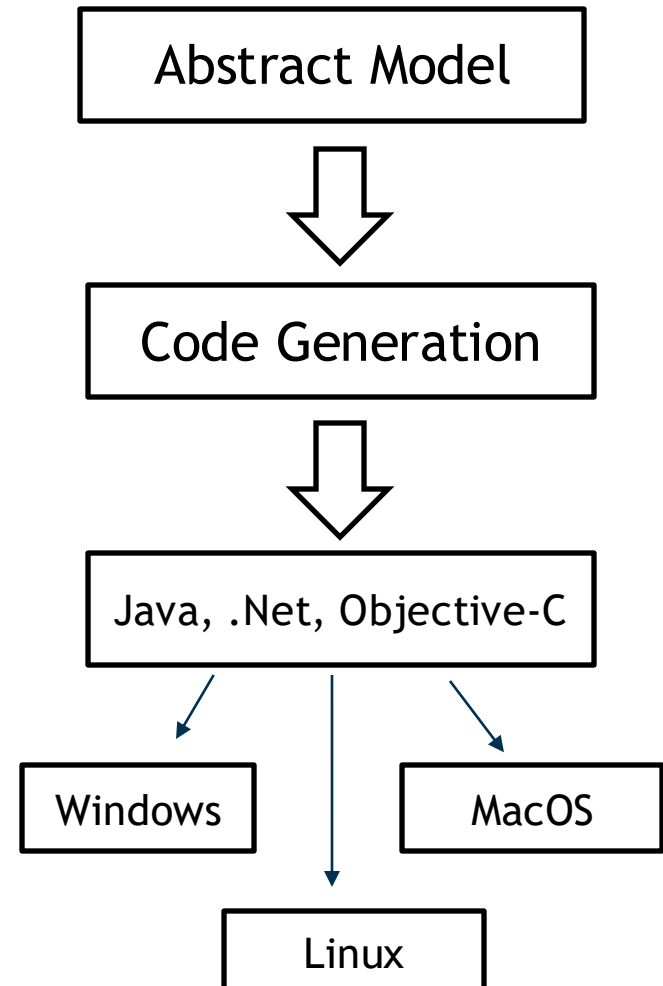


Activity Diagram (Example)



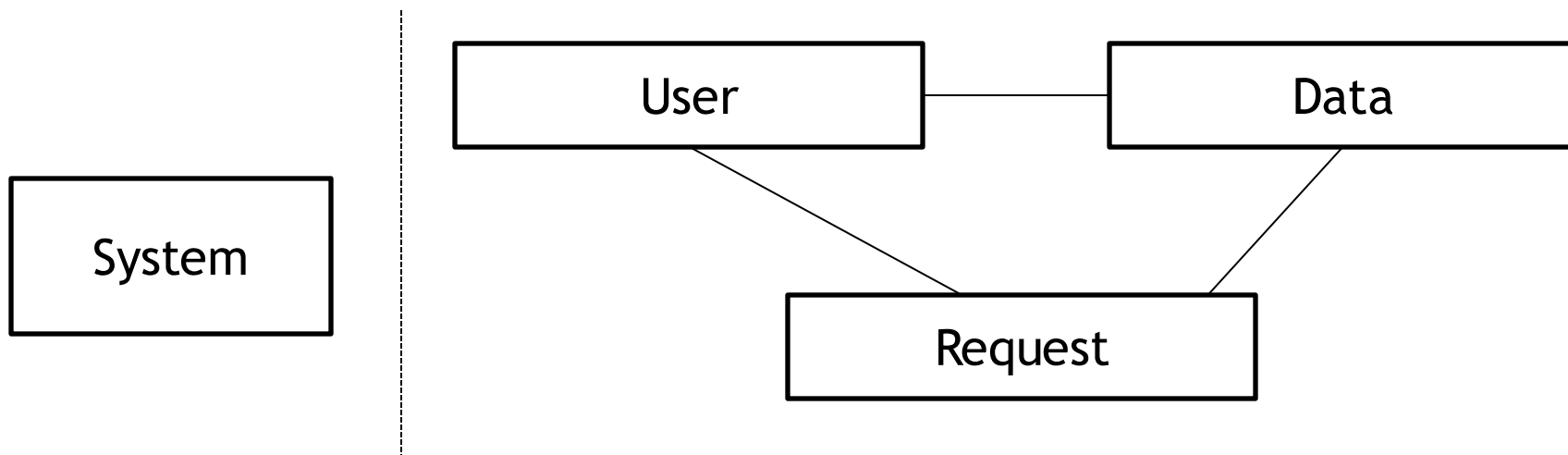
- Object-Oriented Approach
- Unified Modelling Language (UML)
- Model-Driven Development and Architectures

- MDD is a concept for the development of software
- The software system is described by an abstract model (e.g. based on UML)
- The abstract model is typically independent from the target programming language, OS platform or other any underlying technology
- The abstract model allows an automatic transformation into code for multiple target OS platforms
- The resulting code may vary from skeleton classes to complete software products



What is an Abstract Model?

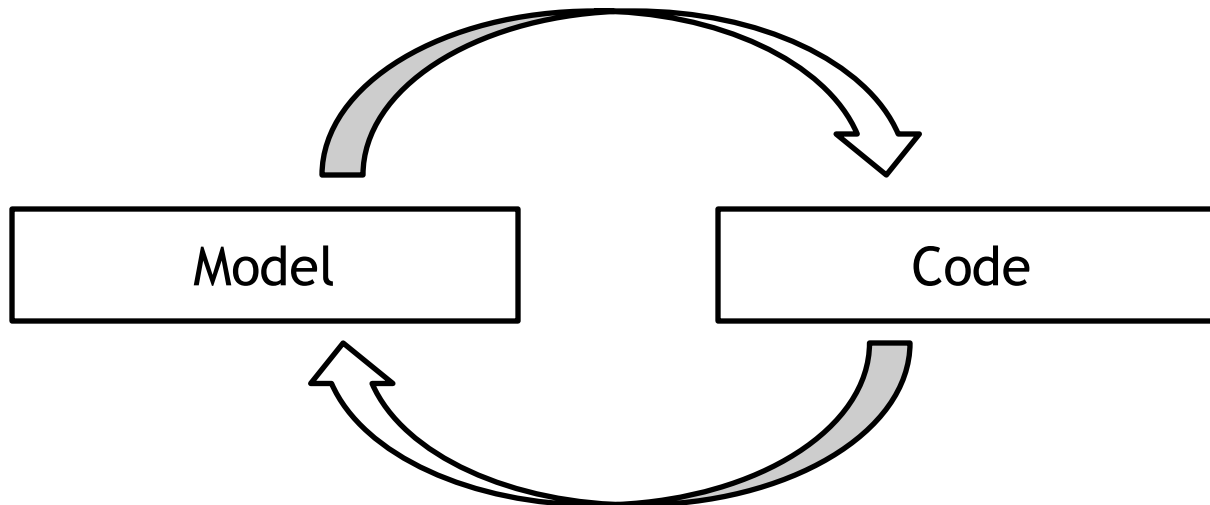
- Abstraction of the real software system (not the real world)
- Comprised of only the relevant aspects of a system - irrelevant ones are ignored
- Different abstraction levels are possible



Round-Trip Engineering

- Modifications to the model can automatically be transformed into code and vice versa.

Forward Engineering



Reverse Engineering

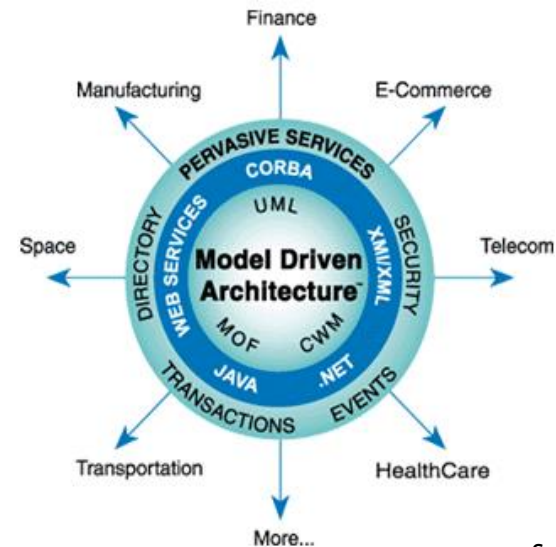
Automation in the Development Process

- MDD promotes automation within the development process.
- Automated analysis and verification of model
 - Since models do not contain implementation details they are easier to analyse.
- Automated code generation from model, which guarantees the conformance to the model
- Runtime monitoring based on a model
 - Runtime monitoring makes sure that the implementation follows the behaviour specified in the model.
- Automated test generation
 - Models can be used to generate test cases for the implementation.

- Reduced development time
- The model is timeless: It will age with the domain and not with the technology.
- Improved documentation of the software system
 - A model is a better documentation than code
 - Improved readability - especially by non IT-personnel
 - Because of automated generation always consistent with the code
- The system can be adjusted more easily.
- Platform and programming language independence
- ...

Model-Driven Architecture (MDA)

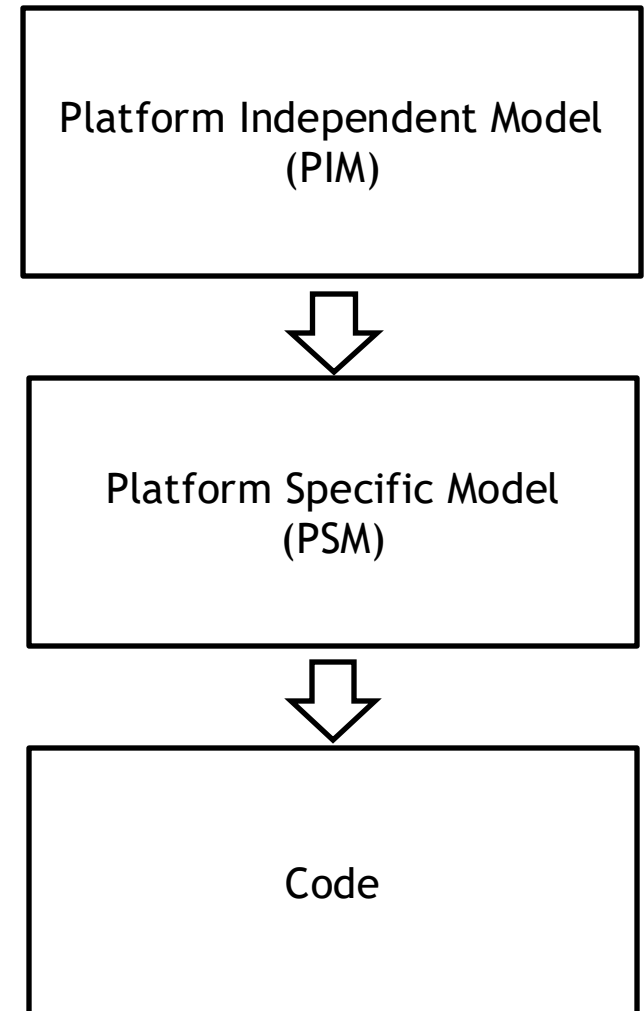
- MDA was introduced by the Object Management Group (OMG).
- MDA separates the business and application logic from the underlying implementation platform.
- MDA is a forward engineering approach where first abstract model diagrams are developed which are later transformed to code.
- The goal of MDA is to separate the conceptual design from the implementation architecture.



Source: OMG, 2011

Model-Driven Architecture Development Process

- Developers develop platform independent models (PIM) for the software (e.g. readable design models or UML).
- The platform independent models document the business functionality of a software – independent from the technology-specific code.
- After the target implementation platform was chosen, the platform independent models can automatically be translated to platform specific models (PSM).
- The platform specific models are used to guide the implementation for the chosen platform.



MDA Benefits for the Software Lifecycle

- *Implementation:* MDA enables the integration of new target software platforms based on the existing design models.
- *Integration:* Integration is easier since both the implementation and the design models exist at the time of integration.
- *Maintenance:* The availability of the design in a machine-readable form gives developers direct access to the specification of the system, making maintenance much simpler.
- *Testing and simulation:* The design models can be validated against existing requirements and executable models can be used to simulate the behaviour of the system.

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