Chair of Mobile Business & Multilateral Security

Lecture 9
Business Informatics 2 (PWIN)

IC Software Development II
Object Orientation & UML

SS 2011

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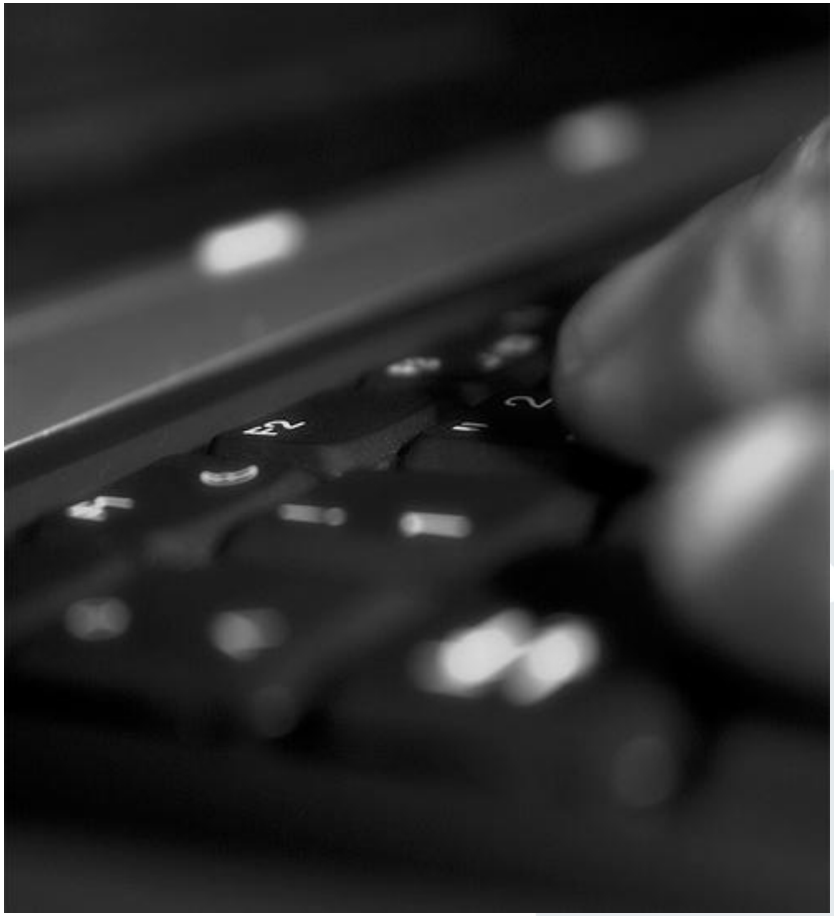


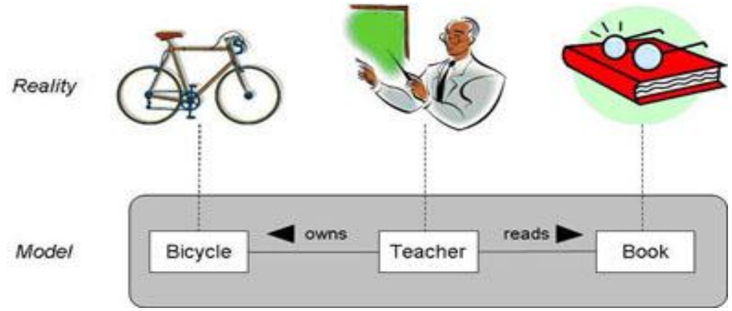
Jenser (Flickr.com)

Agenda

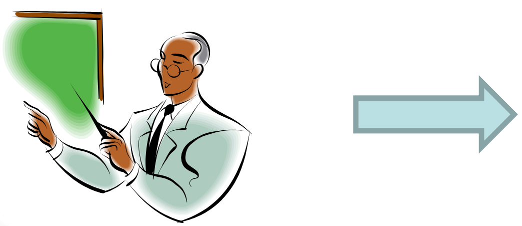
- Object-Oriented Approach
- Unified Modelling Language (UML)
- Model-Driven Development and Architectures

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.



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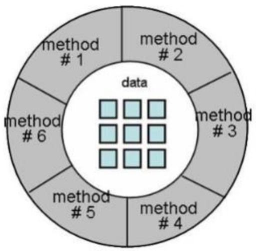
- Objects store their data by themselves and encapsulate them for protection from other objects.



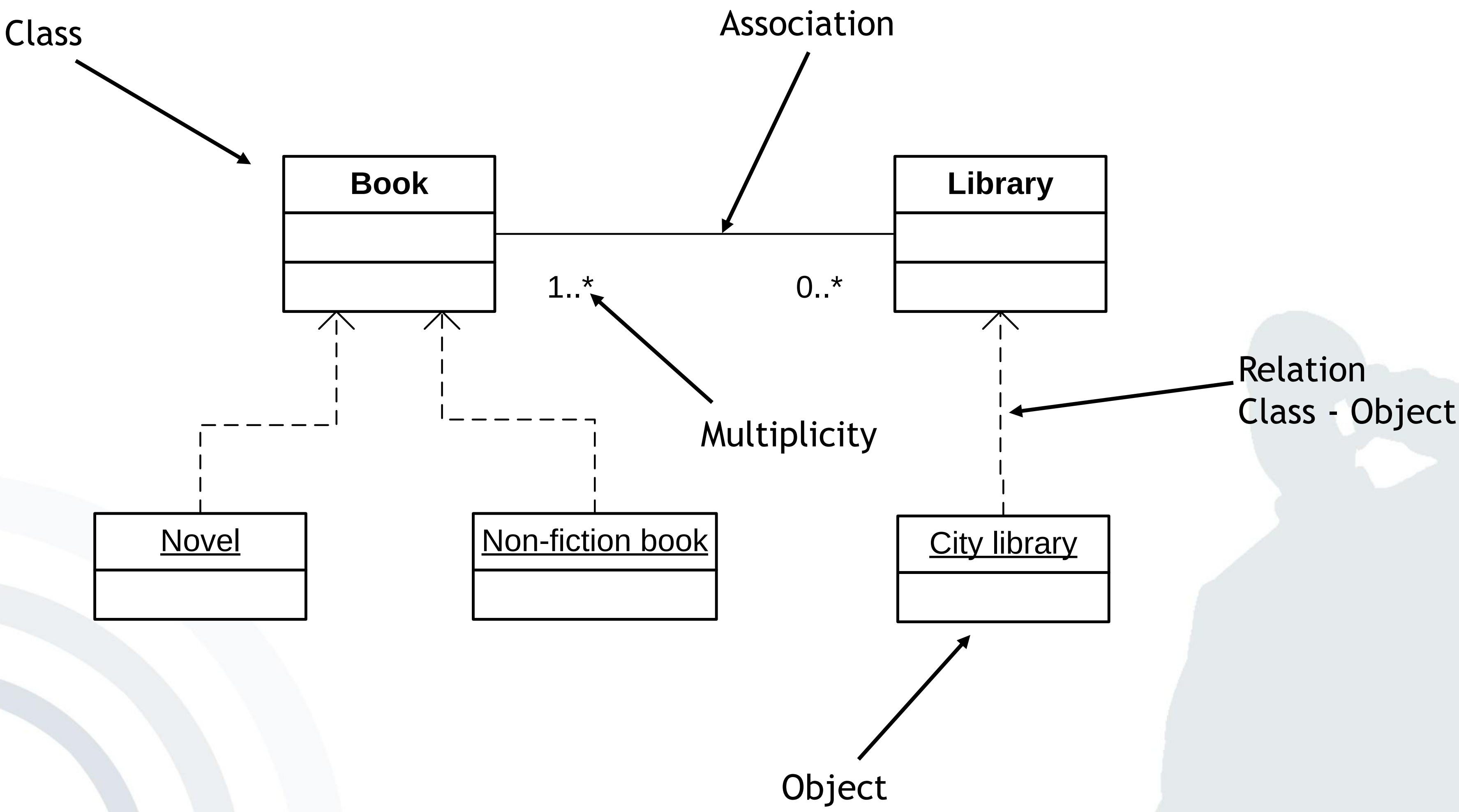
Object-Oriented Software Development

- 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.

Basic OO Elements

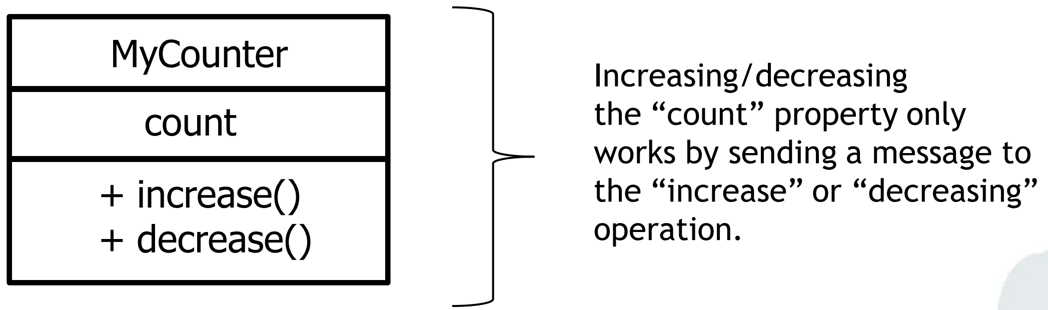
- Class
  - A class is a template for an object. It contains variables, constants and methods.
- Object
  - Objects are instances of classes, which exist during runtime. Multiple objects can be instantiated from a single class.
- Association
  - Relation between classes or objects
- Instantiation
  -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

Basic OO Elements

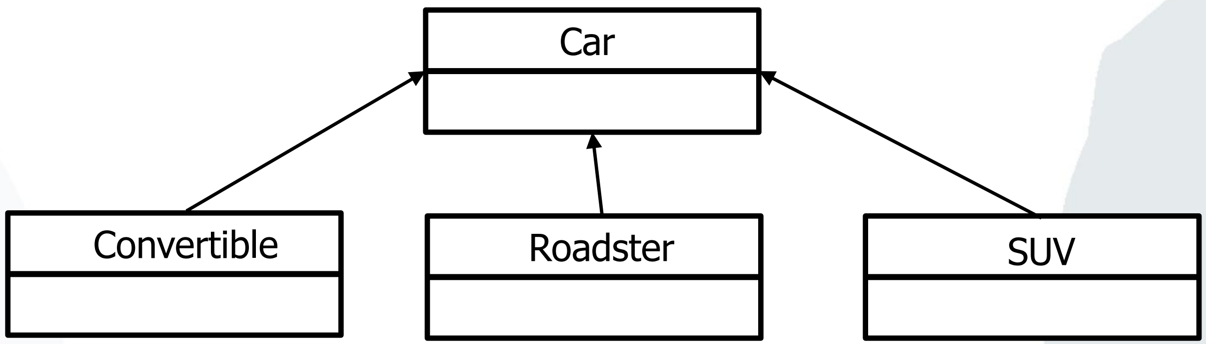


Basic OO Concepts

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

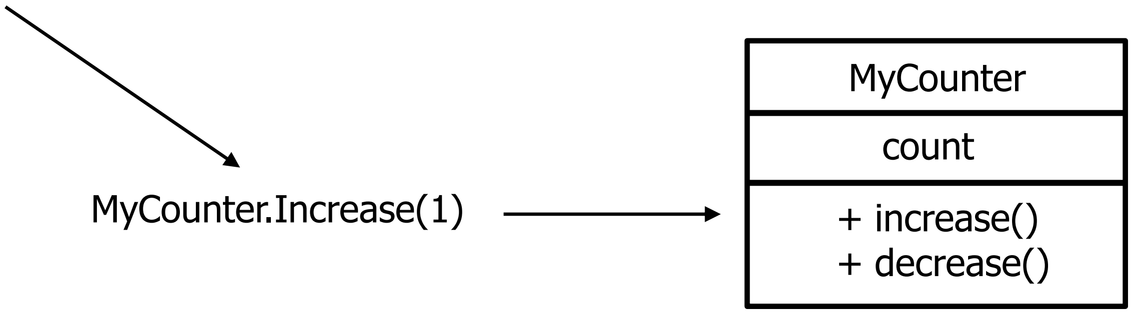


- Inheritance
  - Classes can inherit attributes or methods to other classes. The inheriting class is called "super class" or "parent class". The new class is called a "sub class".



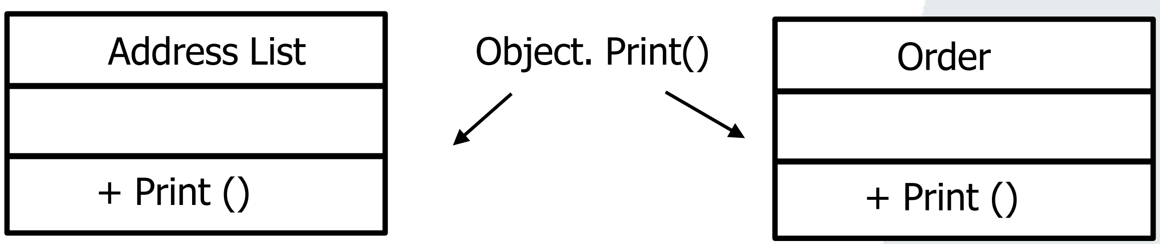
Basic OO Concepts

- 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”



OO Terminology and Concepts

- 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.

Object-Oriented Design (OOD)

- 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

Object-Oriented Programming (OOP)

- 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

OO Development Process

- Object-oriented Analysis (OOA)

⇩

- Object-oriented Design (OOD)

⇩

- Object-oriented Programming (OOP)

⇩

- OO Software

Agenda

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

Unified Modelling Language (UML)

- Modelling language developed by Booch, Jacobson und Rumbaugh in 1996

- Standard of the OMG (Object Management Group)
- Current Version: 2.3 (May 2010)

- Standardisation …
  - of different object-oriented notations and
  - of methods through all phases of the software development

  by using different types of models (data-oriented, object- oriented, process-oriented, etc.).

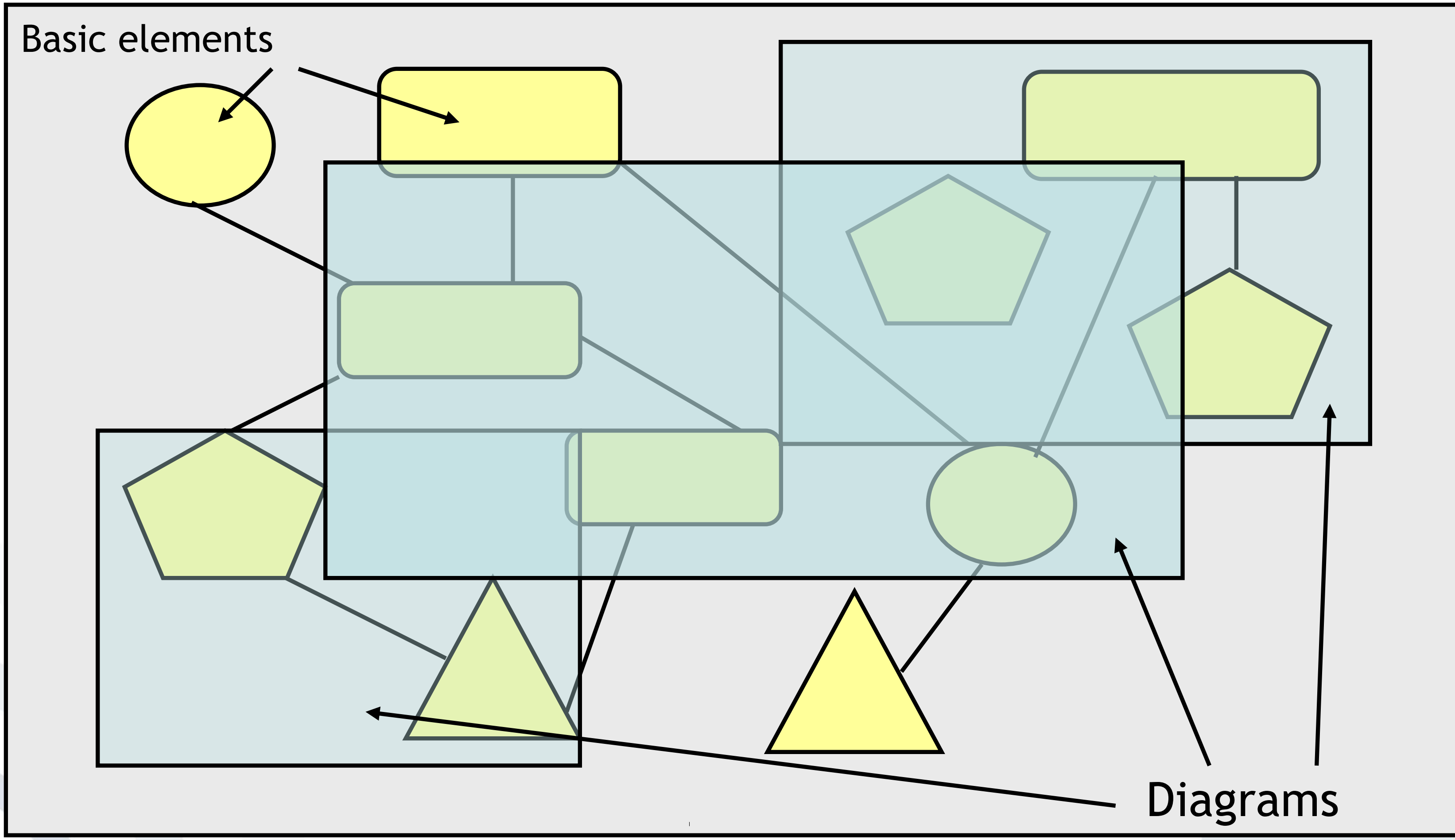
UML Concept

- 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.

UML Structure

- 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

UML Structure



Complete model

UML Views

- Use Case 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.

UML Views (continued)

- Logical View
  - 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)

UML Views (continued)

- Process View
  - 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

UML Views (continued)

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

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UML Diagrams Overview

- Use case diagram
- Class diagram
- Object diagram
- Activity diagram
- Sequence diagram
- Collaboration diagram
- State diagram
- Component diagram
- Deployment diagram

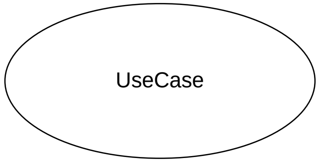
Diagrams	Category	Elements
Use case diagram	Use case diagram	Static elements
Class diagram, Object diagram	Structural diagrams	Static elements
Activity diagram, Sequence diagram, Collaboration diagram, State diagram	Behavioural diagrams	Dynamic elements
Component diagram, Deployment diagram	Architectural diagrams	Architectural elements

Use Case Diagram

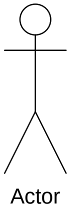
- Use cases describe the functionality, which a system has to provide
- The sum of all “Use cases” comprises the technical requirements of a system.
- Use cases define the interfaces between a user and the system
- Specification is developed together with the client/customer

Use Case Diagram Notation Elements

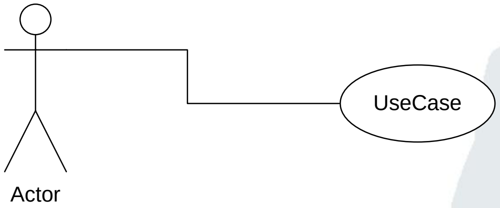
- Use Case
  - Representation of a sequence of actions that provides value to an actor.



- User of the system

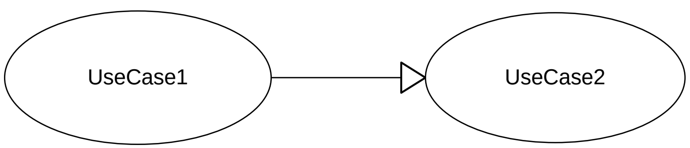


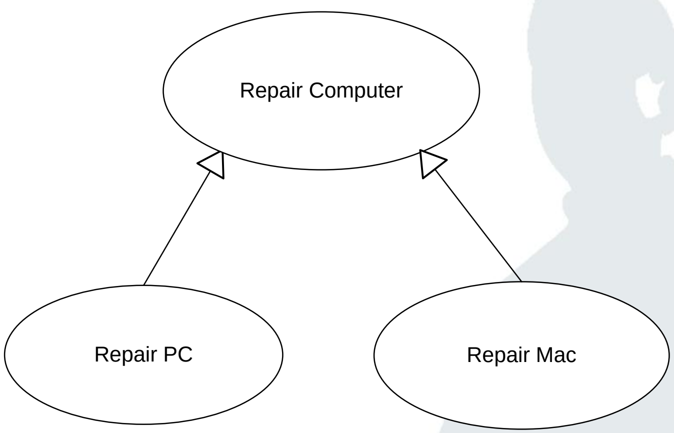
- Association
  - Interaction of an actor with a use case



Use Case Diagram Notation Elements

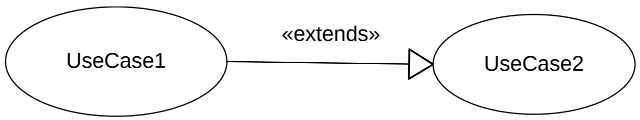
- Generalisation
  - Generalisation of Use Cases
  - UseCase2 generalises the behaviour of UseCase1

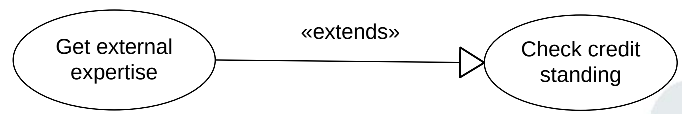




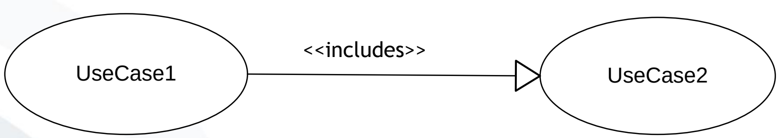
Use Case Diagram Notation Elements

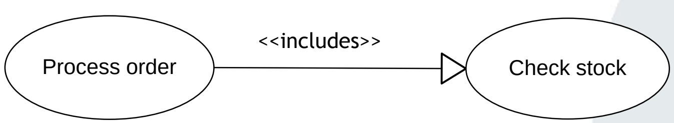
- Extends
  - Extends an Use Case
  - UseCase2 is extended by UseCase1



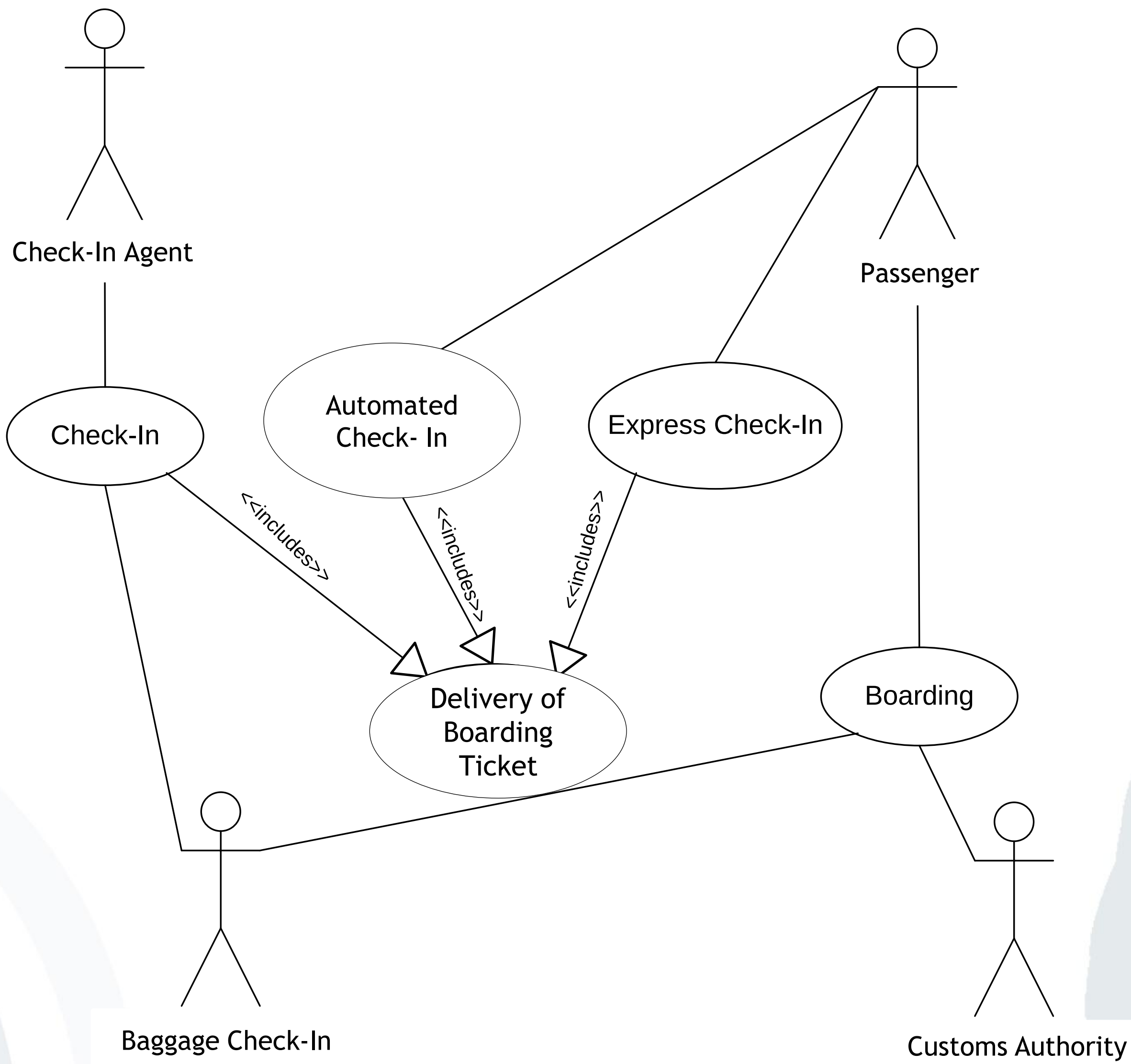


- Includes
  - Inclusion of an Use Case
  - UseCase1 includes the behaviour of UseCase2





Use Case Diagram (Example)



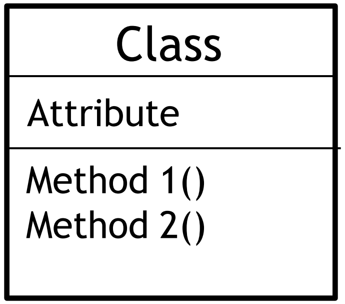
Structural Diagrams

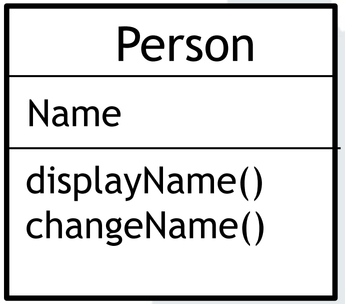
- Class diagrams
  - Representation of the static structure of a software system
  - Description of logical relations between structural elements
  - No activity or control logic

- Object diagrams
  - Instances of a class diagram
  - „Snapshot“ of a system during runtime

UML Class

- 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





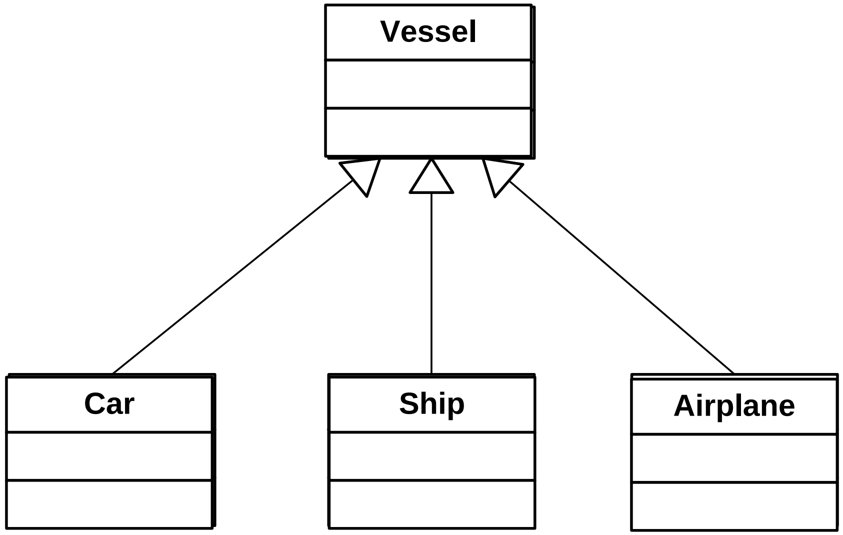
UML Class

- Class attributes
  - Class attributes belong to the class, not to the object.
  - Class attributes have the same value for all instances.
    For instance, attribute „Number“ to count the number of created objects for a class.
  - Class attributes are underlined in the class diagram.

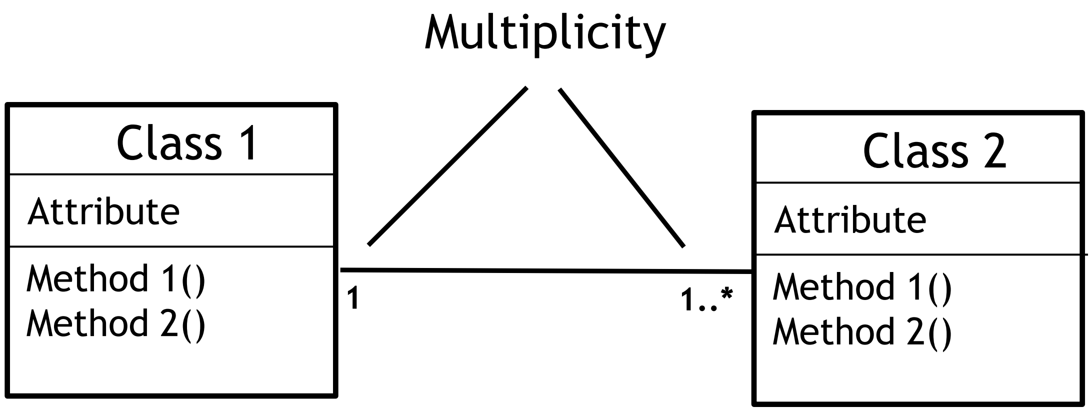
- Class methods
  - Class methods are executed within the class not on the object.
  - E.g. „count number of created objects of the class“
  - The class method is underlined in the class diagram.

Abstract Classes

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



Associations

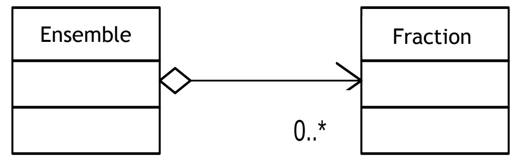


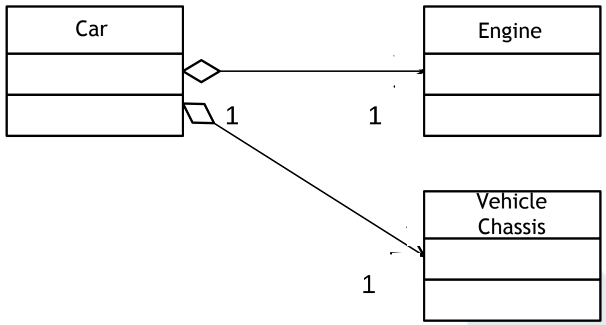
- Describes the relationship between two classes
- It is represented by a line connecting the two classes.
- The multiplicity min..max attached to the association defines the minimal or maximal number of associations between the objects of the two classes.

(*) denotes any number of objects.

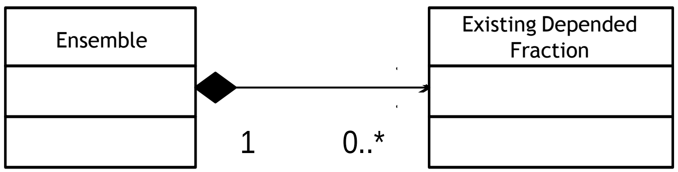
Associations

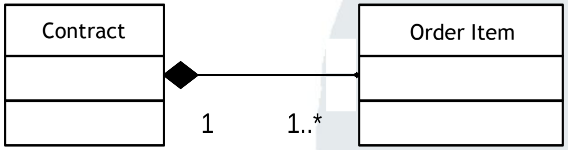
- Aggregation
  - Denotes an „has a“ relationship





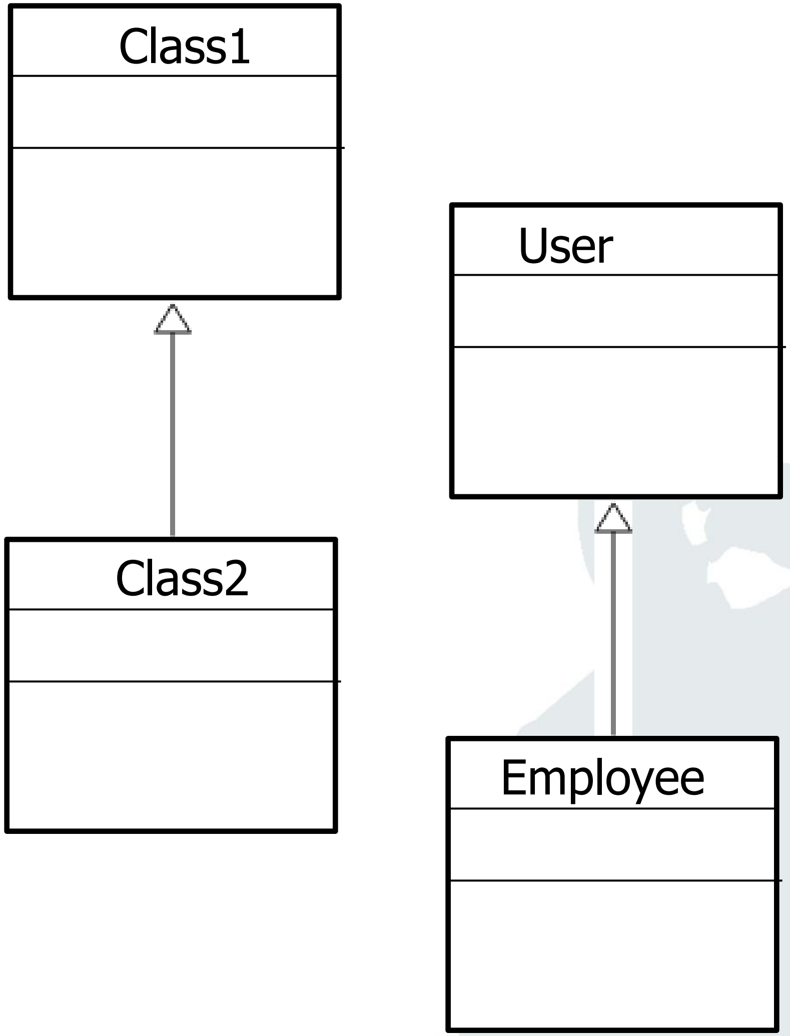
- Composition
  - Composition is a stronger variant of the aggregation
  - Denotes an „owns a“ relationship





Inheritance

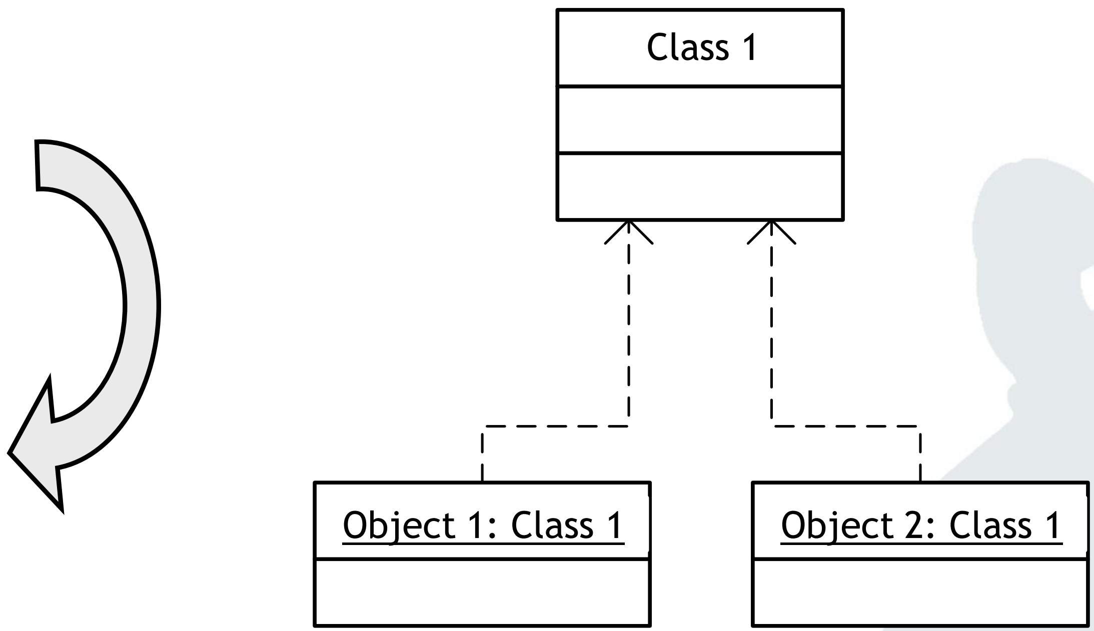
- Denotes an relation between parent class and sub class
- Is represented by a line with an empty arrow at the end, pointing towards the parent class
- Class2 inherits from class1.
- Purpose:
  - Reuse code, by objects which can be based on previously created objects



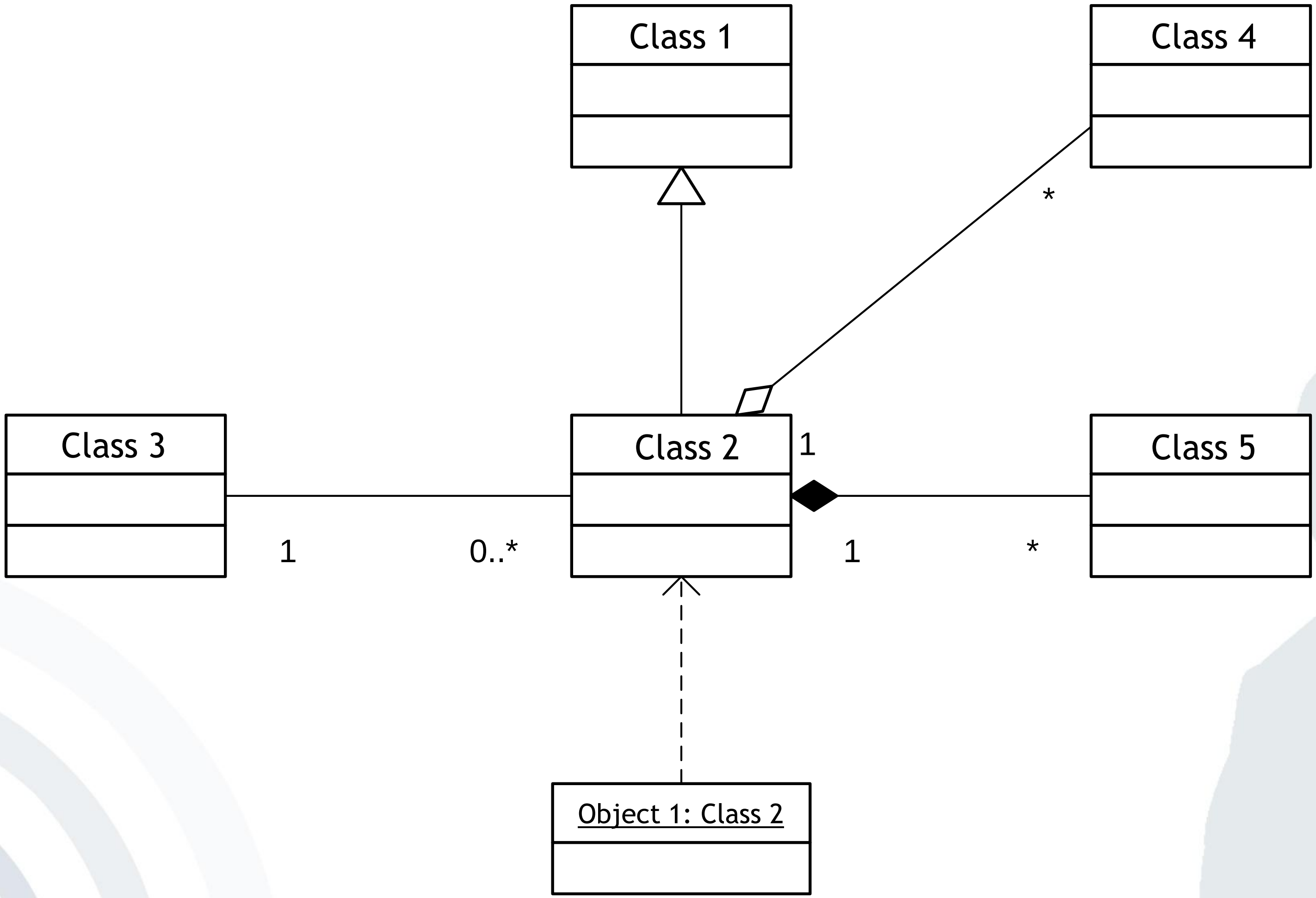
Instantiation

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

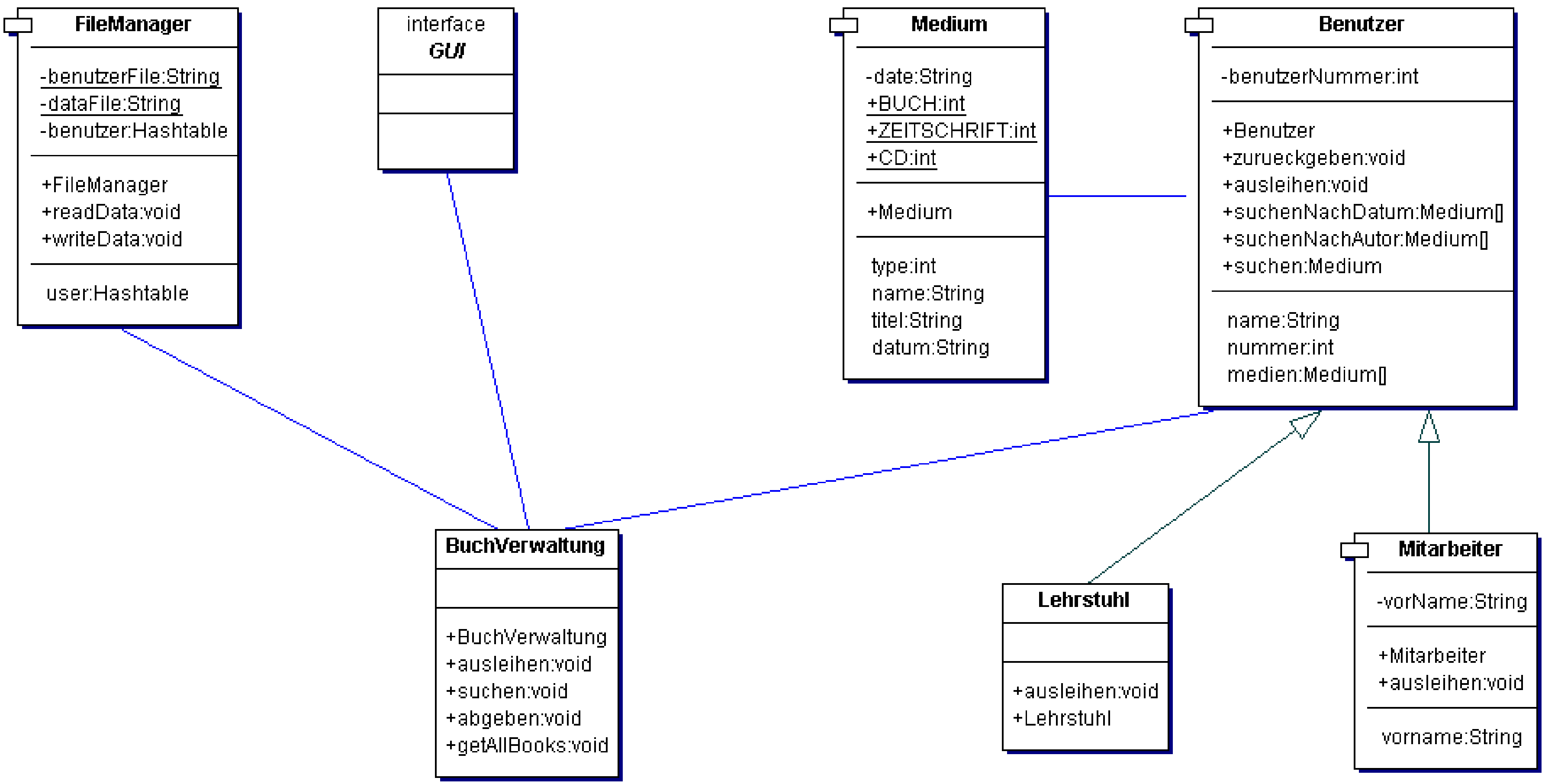
- Class
  - Attributes
  - Methods
- Object
  - Attribute values
  - Messages



Class Diagram



Class Diagram (Example)



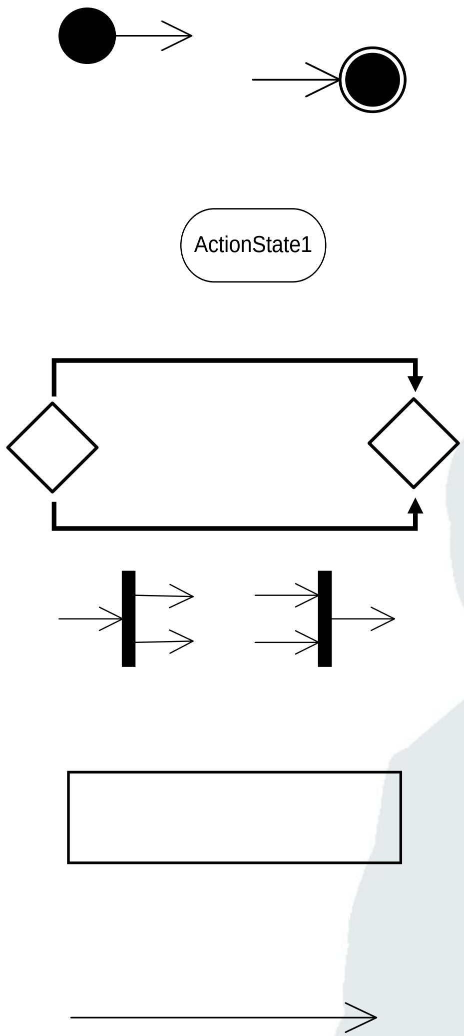
Activity Diagram

- Activity diagrams are used to model workflows in a system.
- Central element: Activity
  An activity is an "action" within a process.
- Activities are structured by responsibilities.
- Different views
  - Conceptional View
    - e.g. business processes
  - Implementation View
    - e.g. methods of objects

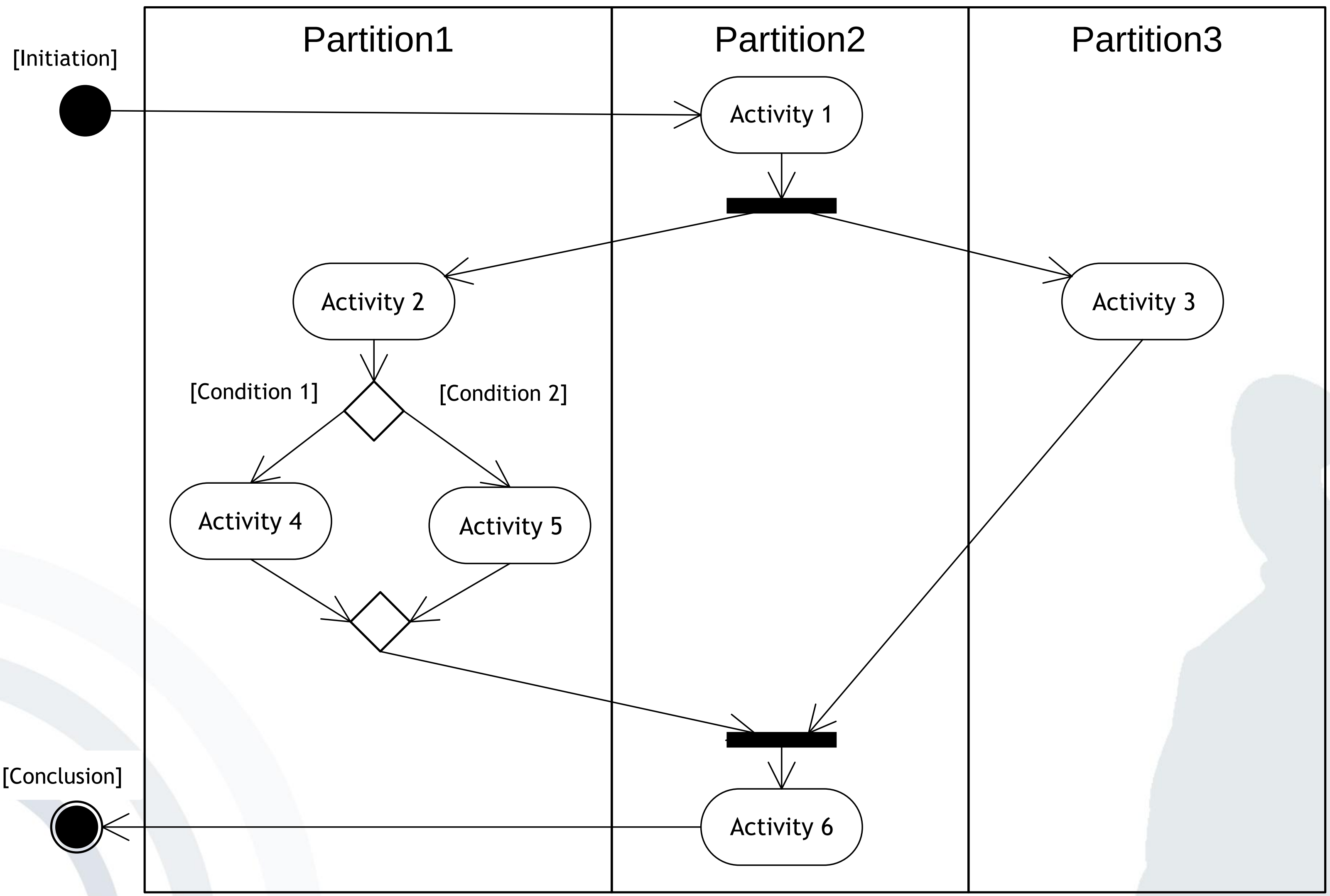
Activity Diagram Notation Elements

Notation elements

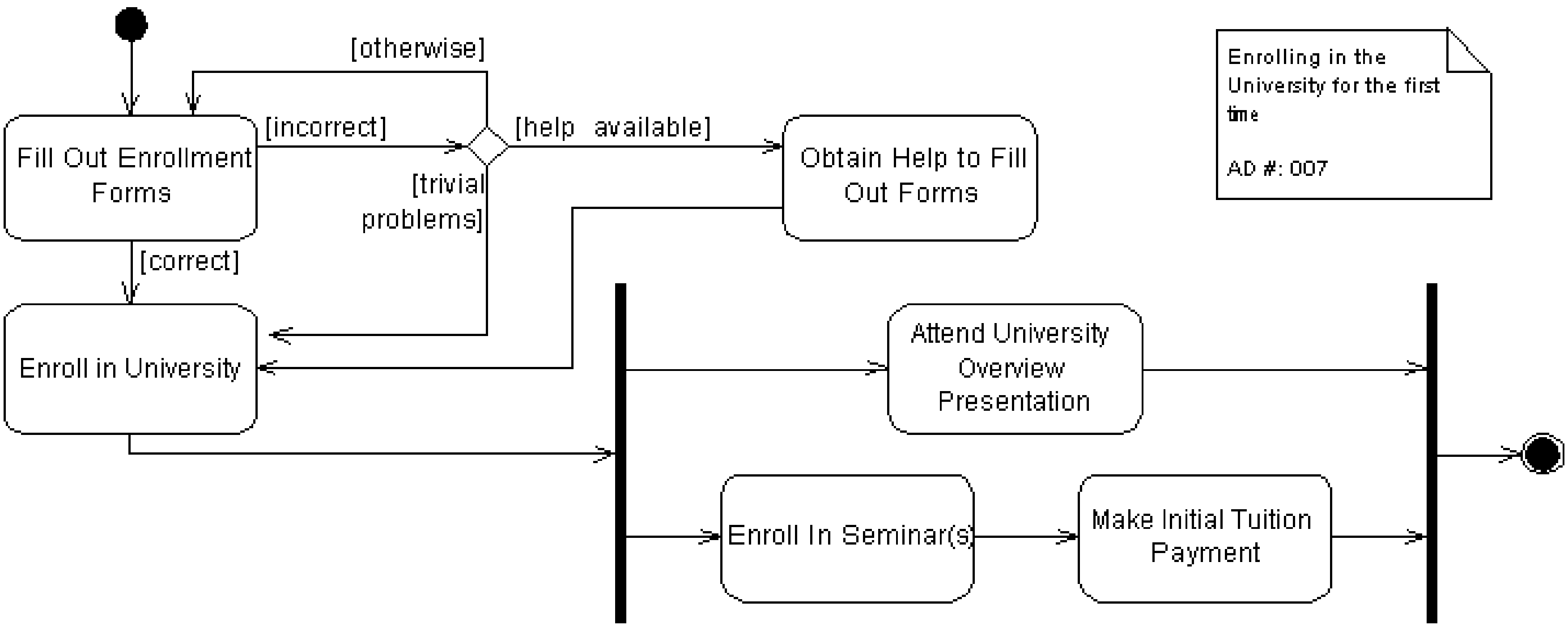
- Initial state/final state
- Activity
- Decision
- Split/join
- Responsibility
- Activity flow



Activity Diagram



Activity Diagram (Example)

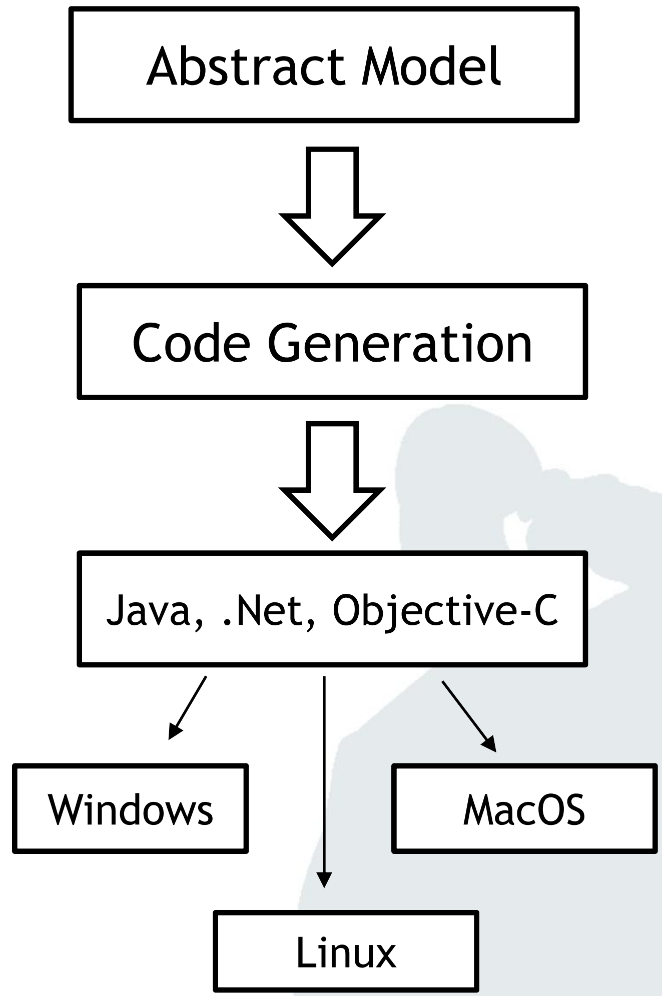


Agenda

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

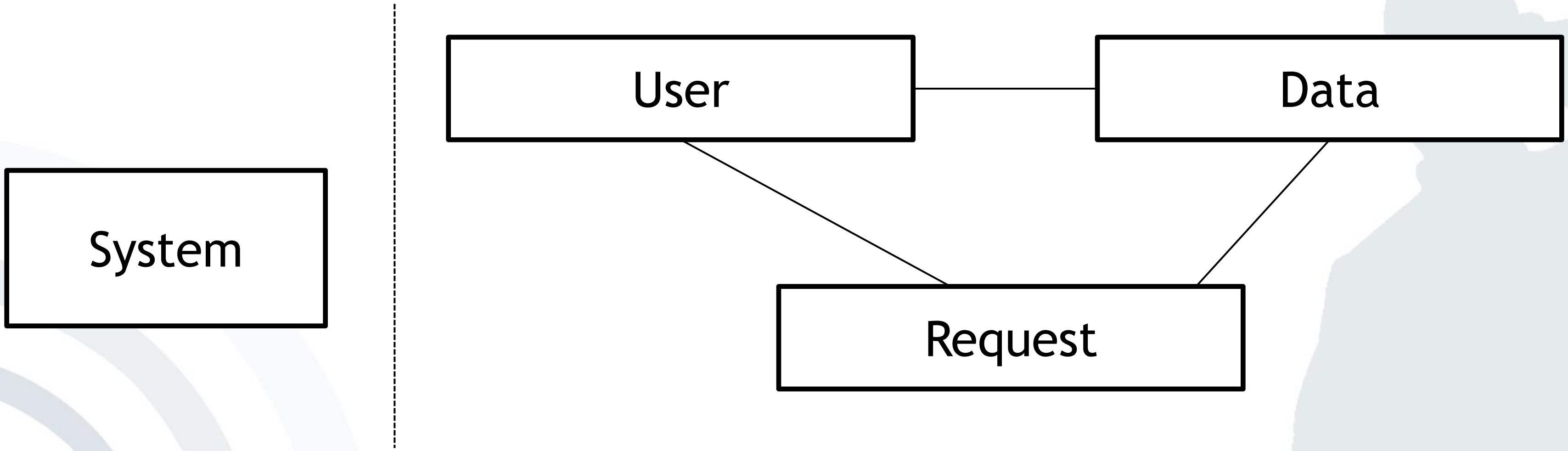
Model-driven Development (MDD)

- 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



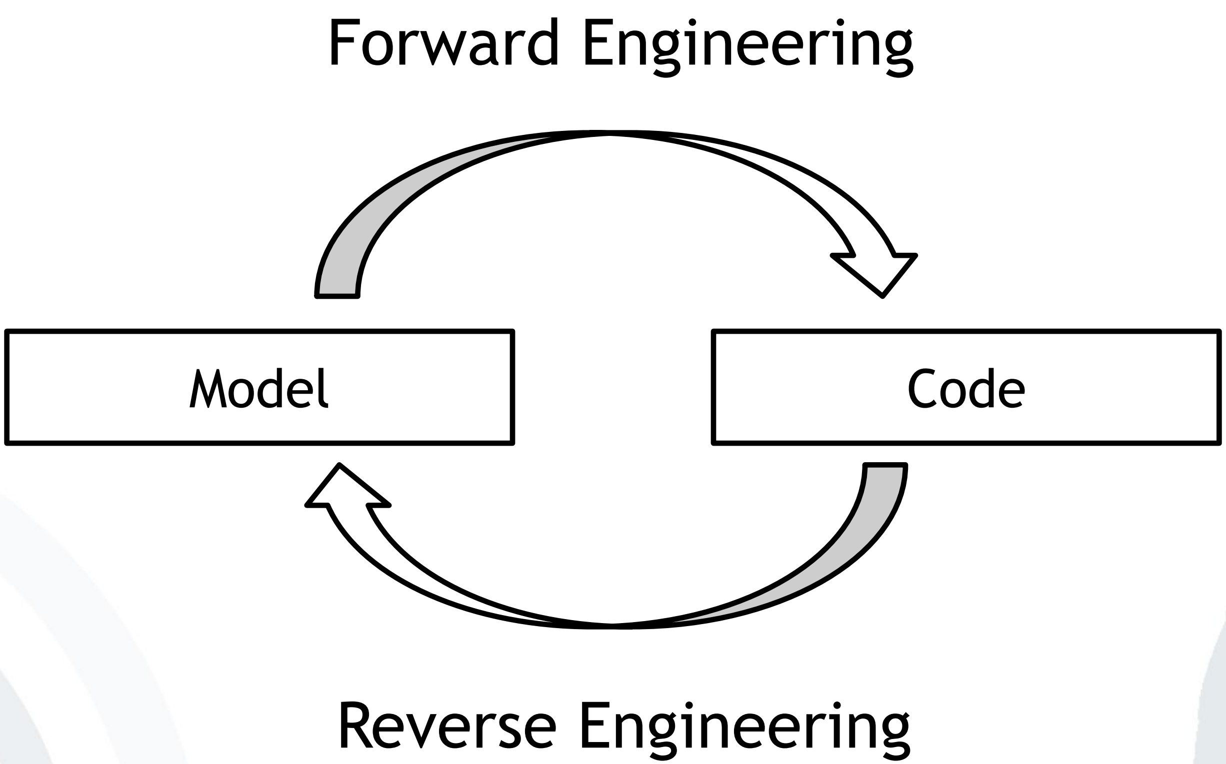
What is an abstract model?

- 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.



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

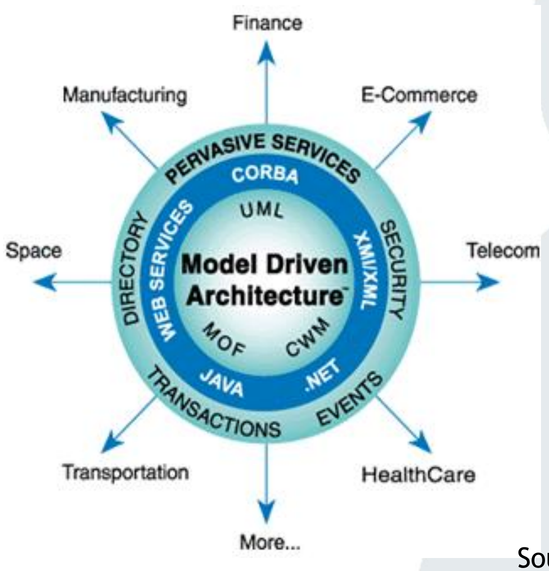
Benefits of MDD

- 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 more easily be adjusted
- Platform and programming language independence
- …

Source: Based on Scheier Software Engineering 2011

Model-Driven Architecture (MDA)

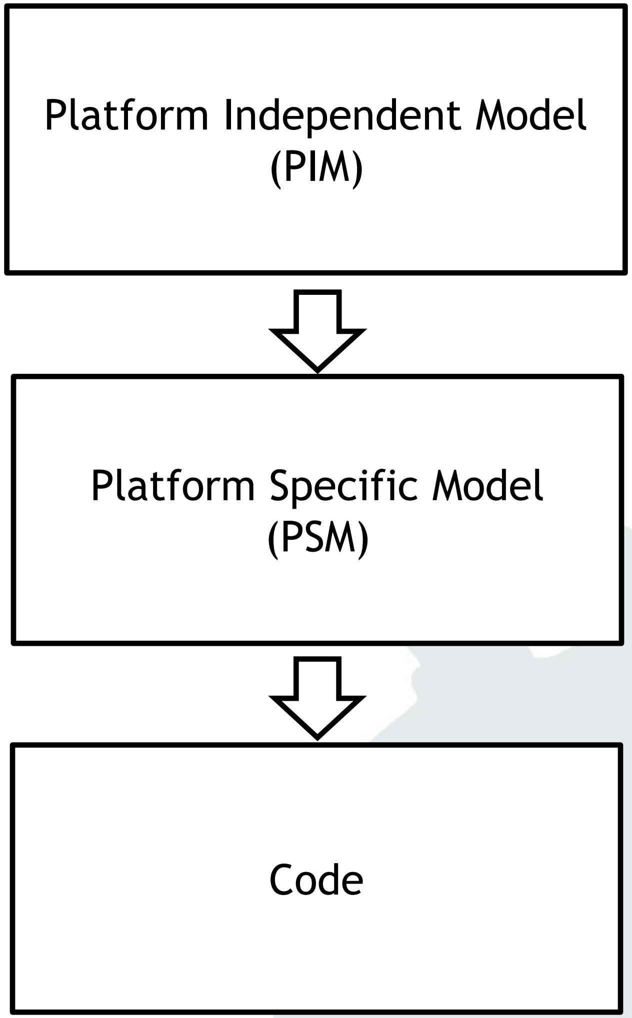
- MDA was introduced by the Object Management Group (OMG).
- MDA separates the business and application logic from the underlying implementation platform.
- MDA is a forward engineering approach where first abstract model diagrams are developed which are later transformed to code.
- The goal of MDA is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

Literature

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