02291: System Integration

Week 1

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Contents

Overview

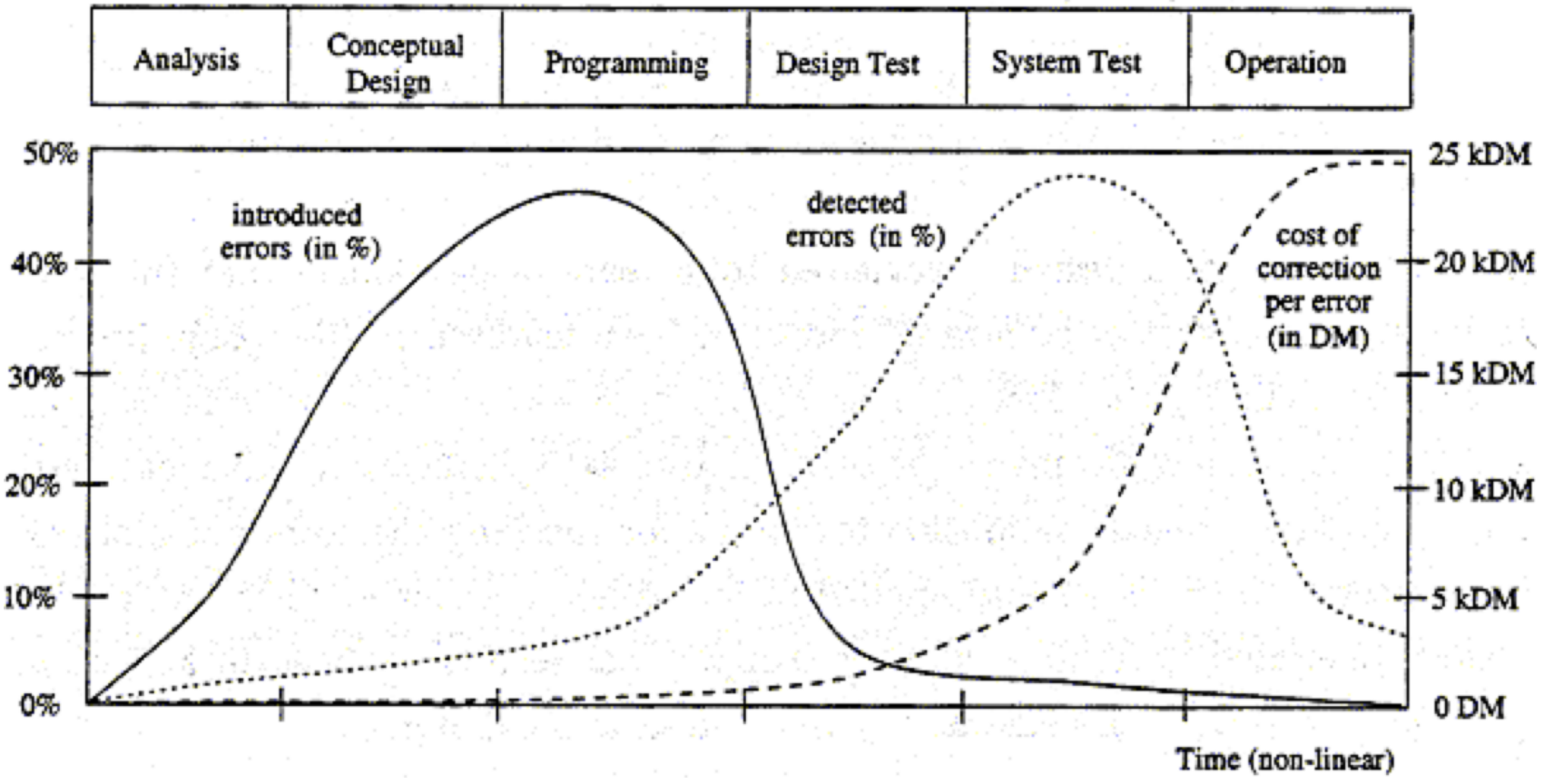
Introduction to UML

Practical Informations

System Integration

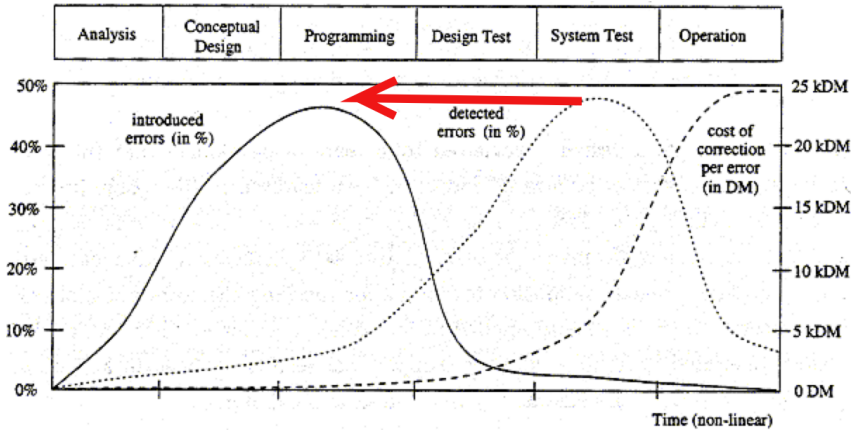
- Type
  - 5 ECTS Points
  - Audience: Masters / advanced Bachelor students
  - Lectures with exercises
  - Exam: modelling project with project presentation
- Time and Location
  - Lecture Wednesdays 10:15–12:00
  - Exercise session before the lecture 8:15–10:00
- How to reach me
  - huba@dtu.dk; office 303A/058
  - Teaching assistants: Constantina Ioannou and Wenhao Li
- Web Page
  - `http://www2.compute.dtu.dk/courses/02291`
  - Piazza

Problem in Software Engineering



- Liggesmeyer 1998

Why model?



- Abstraction is the key
  - → *Models* for the problem and the solution
  - → *Feedback* early
    - Model inspection
    - Automatic code generation
    - Analysis of models

Model (definition)

`http://en.wiktionary.org/wiki/model`

...

A simplified representation used to explain the workings of a real world system or event.

- ”The computer weather model did not correctly predict the path of the hurricane.”

A plane in a windtunnel

Clay model of a car

→ Abstraction

- Focus on some aspects only, e.g. air resistance
- Disregard the other aspects
- Aggregate details by introducing new concepts

Learning objectives:

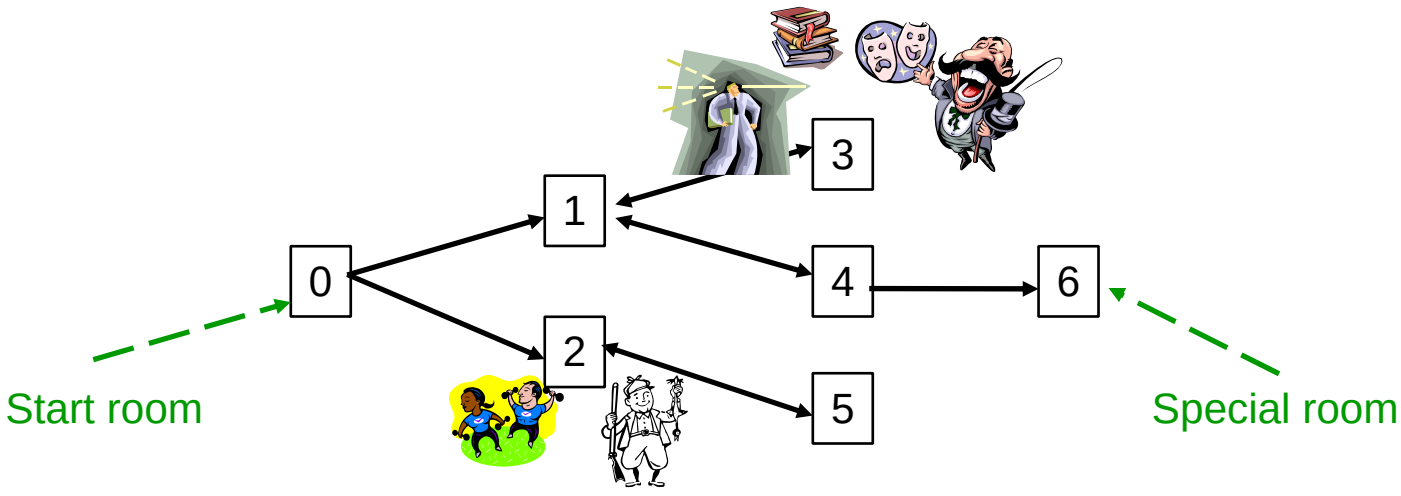
- Know about
  1. (Object-oriented) modelling languages: mainly UML
  2. Why model?
  3. How to model
  4. How to validate a model
- To be able to
  - *Model* larger systems
  - Use models for *understanding*, *designing*, *communication*, *analysing*, *verification*, and *creating* software
  - *Document* models
  - *Analyse* models
  - *Validate* models

Why model?

- Conjecture:
  - it suffices to communicate only key abstractions rather than the whole programm
  - it is easier to create a model of the system than to program it
  - a model of the system is easier to understand than the program itself

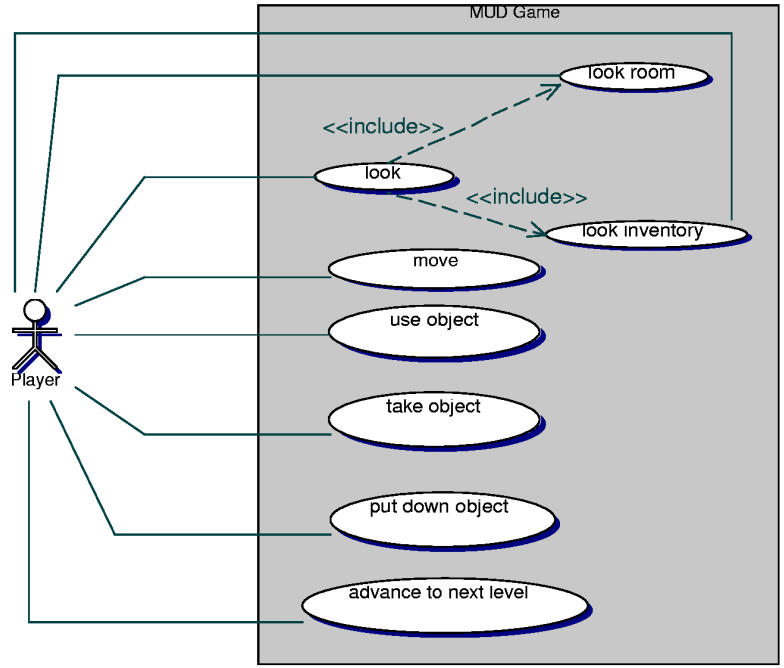
Example MUD

A Multi User Dungeon (MUD) game

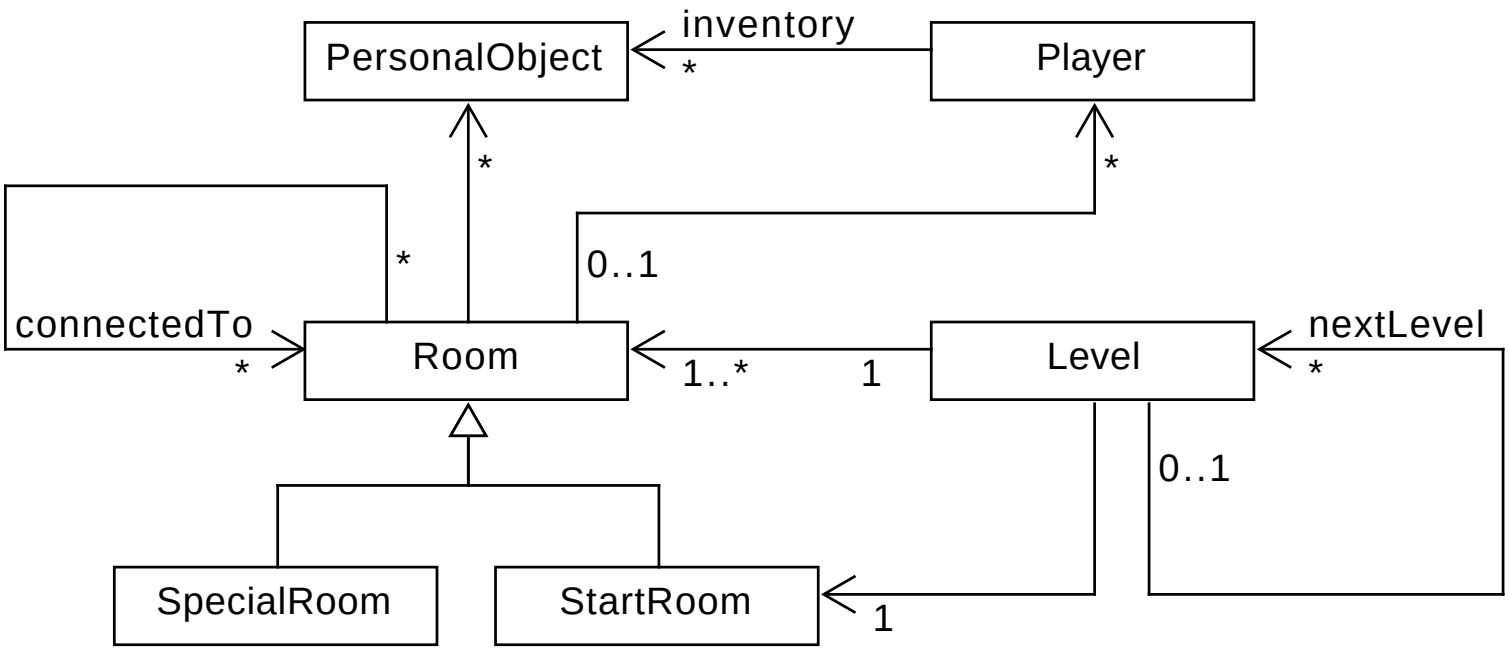


Abstraction: Focus on Functionality

Use Case Diagram for the MUD game

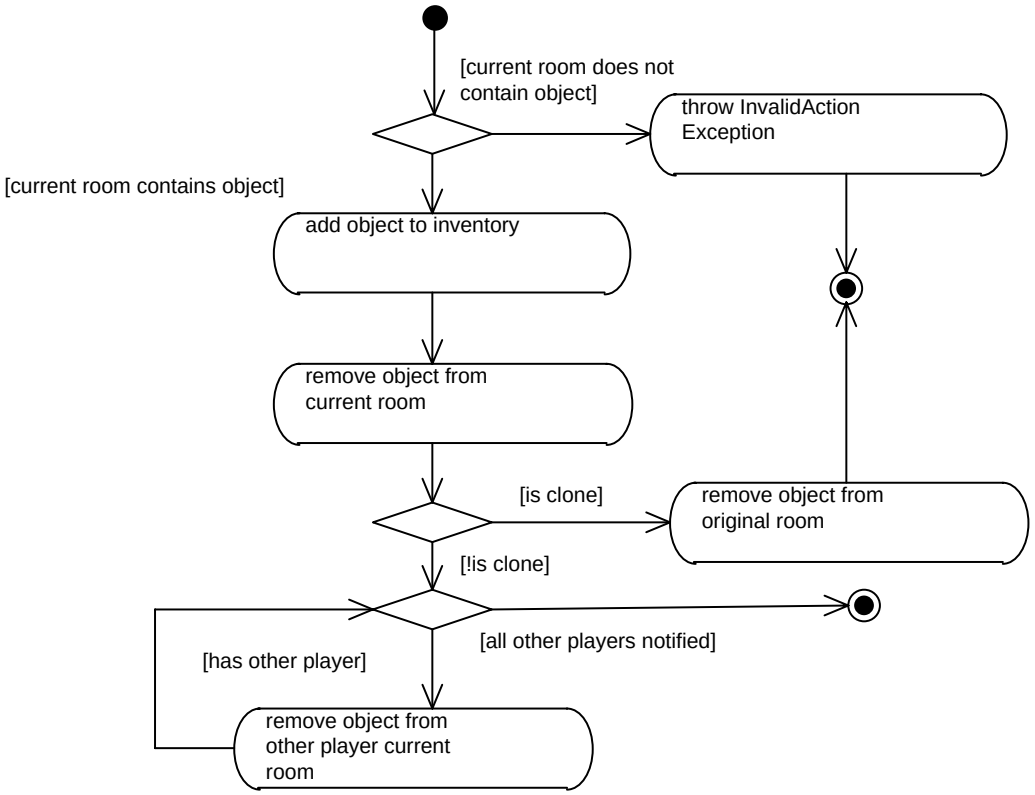


Abstraction: Focus on Structure



Abstraction: Focus on the Behaviour

Take object activity in the MUD game



Use of models

- informal
  - communication
  - $\rightarrow$ problem of ambiguity
  - drawings on a black board
- formal
  - verification / validation
  - simulation
  - code generation

Example for an informal model

Class Responsibility Collaboration (CRC) cards for the HotDraw editor

`http://www2.compute.dtu.dk/courses/02291/examples/draw.html`

How to model?

- Domain Driven Design
- CRC cards
- Model Driven Architecture
- Explorative Modelling
- Agile Modelling

Contents

Overview

Introduction to UML

Practical Informations

What is the UML?

- Unified Modelling Language (UML)
- Family of *graphical notations* for describing aspects of (object-oriented) software
  - ”A picture is more than a thousand words”
- Based on a *metamodel*
- Not a development process
- UML is an open standard and an ISO standard
  - managed by the Object Management Group (`www.omg.org`)
- Web resources
  - `http://www.uml.org`

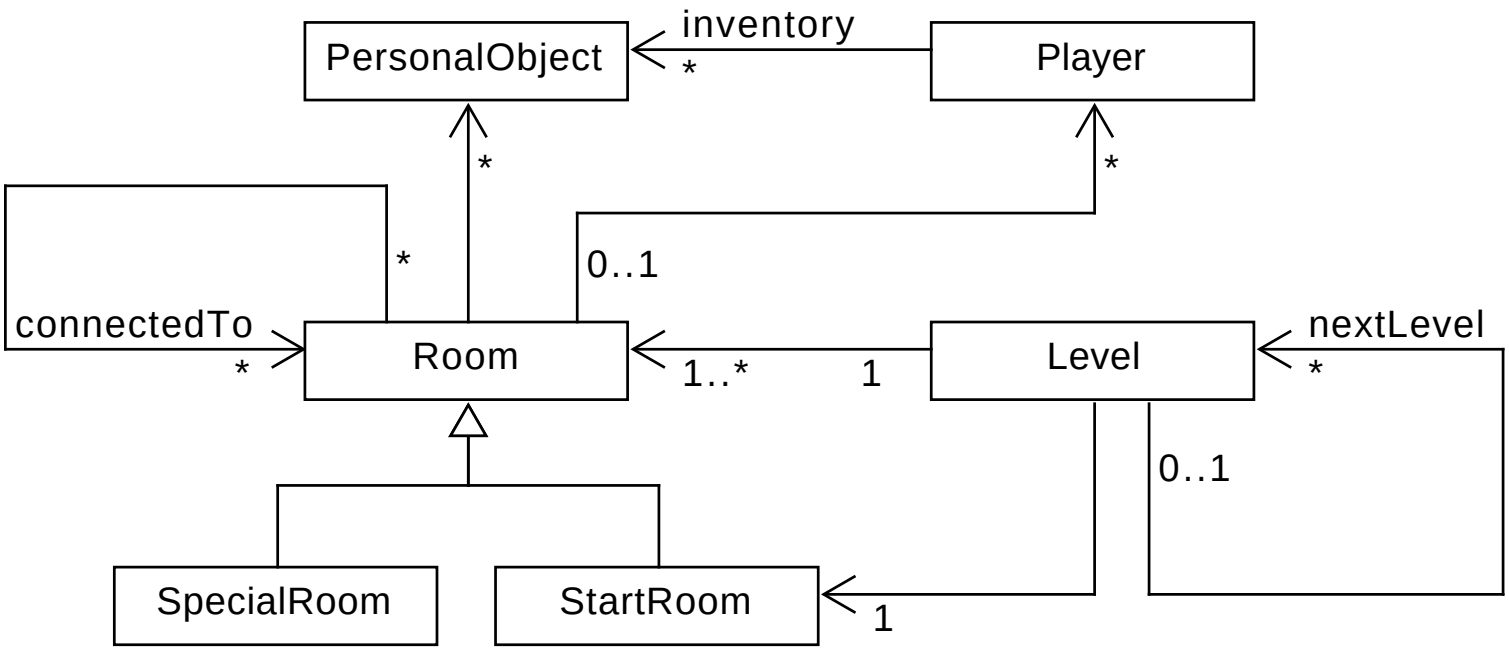
UML's history

- 1980s
  - Objects became main stream
  - OO methods and graphical notations
    - Grady Booch, Peter Coad, Ivar Jacobson, Jim Odell, Jim Rumbaugh, Sally Shlaer and Steve Mellor, Rebecca Wirfs-Brock, ...
- 1990s
  - Grady Booch, Ivar Jacobson and Jim Rumbaugh at Rational
  - First version of the UML (UML 0.8)
- 1996
  - The Object Management Group (OMG)
  - Driven by tool vendors!
    - Tool interoperability!
  - 1.x with 1.4 and 1.5 being widely used
- 2005
  - UML 2.0 ISO standard

Notations and Metamodels

- UML consists of
  - a set of graphical notations
  - and a single metamodel

Example of a class diagram



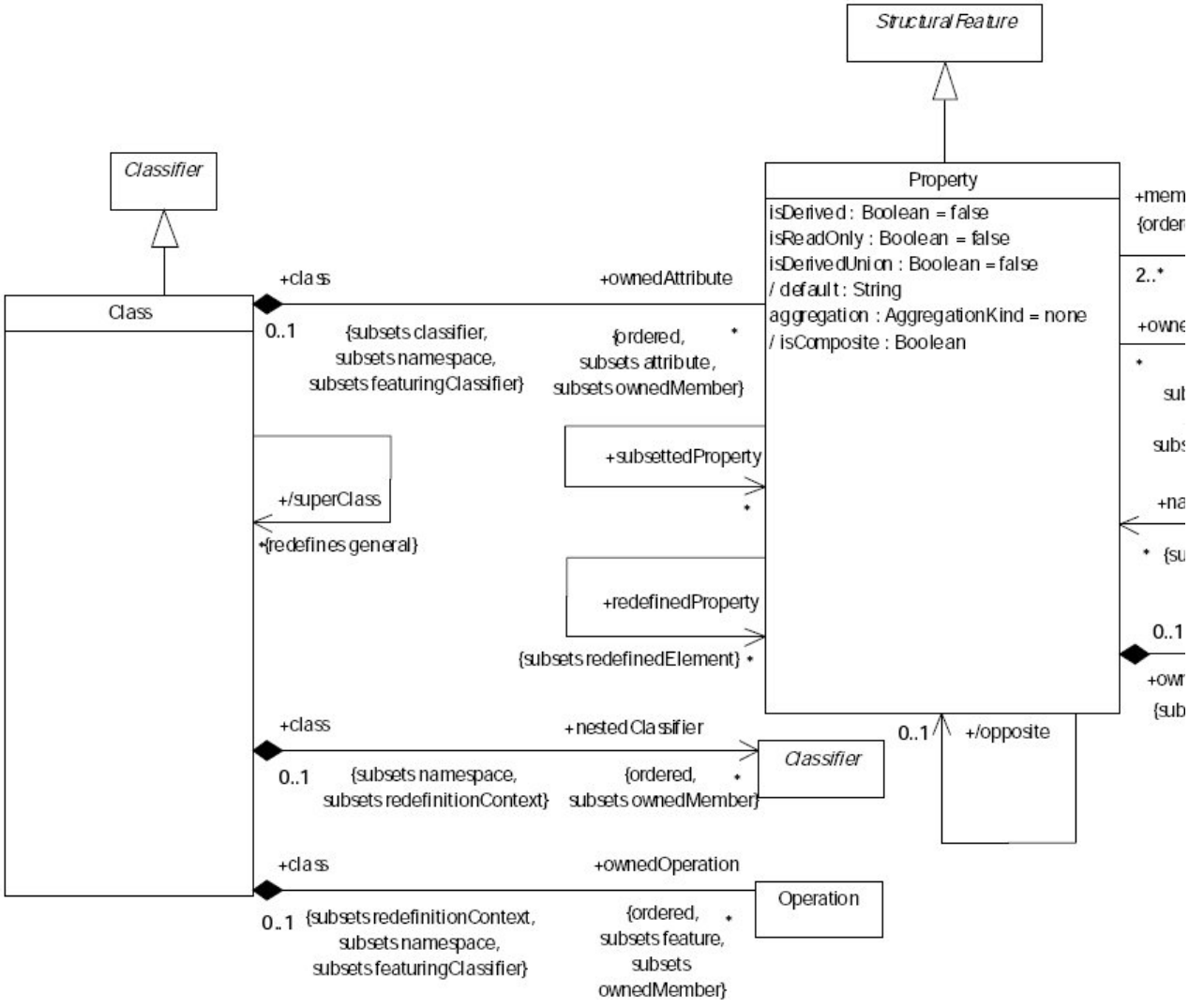
Metamodel

- Abstract syntax of UML diagrams
- Describes the *concepts* of UML elements
  - e.g. class, association, ...
- concepts are mapped to notations
  - e.g. the concept of a class is mapped to rectangle with subcompartments
- Metamodel written in MOF (Meta-Object Facility)
  - Basically *UML class diagrams*

  $\rightarrow$ MOF can be used to defined *ones own* modelling language

  $\rightarrow$ Course Software Engineering II (02162)
- The metamodel is important for model exchange
  - XMI (XML Metadata Interchange)

Metamodel Excerpt



The meaning of UML

- The abstract syntax / concepts: Ok
  - $\rightarrow$ metamodel
- The meaning of the concepts: not well-defined
  - Meaning of *class*?
  - Execution of *activity diagrams* and *state machines*
- Semantic variation points
  - Left open in the standard
  - Tool vendors choose meaning

Ways of using the UML

- Sketch
  - Informal use

  → Use of whiteboards, simple graphic editors

Ways of using the UML

- Sketch
  - Informal use
  - → Use of whiteboards, simple graphic editors
- Blueprint
  - Forward Engineering: e.g. create class stubs
  - → Use of CASE tools

Ways of using the UML

- Sketch
  - Informal use
  - → Use of whiteboards, simple graphic editors
- Blueprint
  - Forward Engineering: e.g. create class stubs
  - → Use of CASE tools
- Programming language
  - Executable UML
  - Problems
    - How to describe the behaviour?
  - → Use of CASE tools

UML is not enough

- UML is a general purpose modelling language
- UML can be extended
  - lightweight (UML profile)
  - heavy weight

$\rightarrow$ *Use the modelling language best suited for your purpose*

UML Diagrams (I)

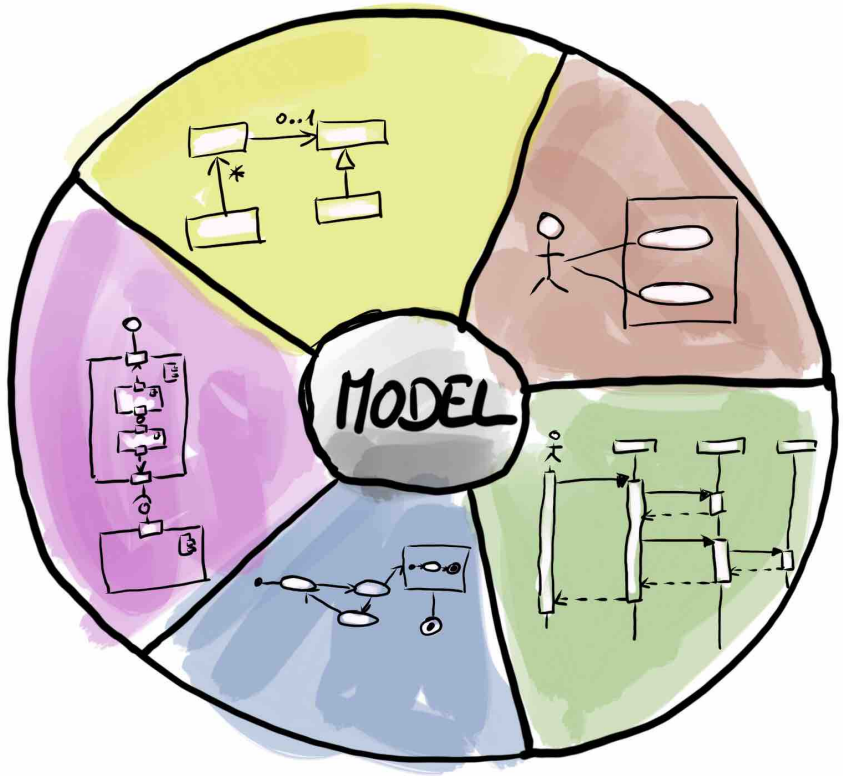
- Structure Diagrams
  - *Class Diagram*
    - Class, features, and relationships
  - *Object Diagram*
    - Example configuration of instances
  - *Package Diagram*
    - Hierarchical structure for models
  - *Component Diagram*
    - Structure and connections of components
  - Deployment Diagram
    - Deployment of artifacts to nodes
  - Composite Structure Diagram
    - Runtime decomposition of a class

UML Diagrams (II)

- Behaviour Diagrams
  - *Use-Case Diagram*
    - How users interact with a system
  - *Activity Diagram*
    - Procedural and parallel behaviour
  - *State Machine Diagram*
    - How events change an object over its life
  - Interaction Diagram
    - *Sequence Diagram*: Interaction between objects; emphasis on sequence
    - *Communication Diagram* (formerly called *collaboration diagram*): Interaction between objects; emphasis on links
    - Interaction Overview Diagram: Mix of sequence and activity diagram
    - Timing Diagram: Interaction between objects; emphasis on timing

Focus of the course

Many diagrams, but only *one model*

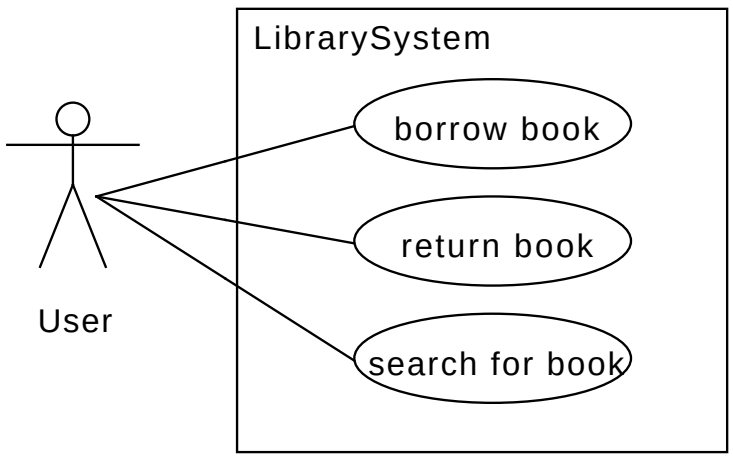


Different Views on the system

- Functionality: Use Case diagram, state machines, activity diagram, ...
- Structure: Component diagram, Class diagram
- Validation: Interaction diagram

Library Example: Detail of Use case *borrow book*

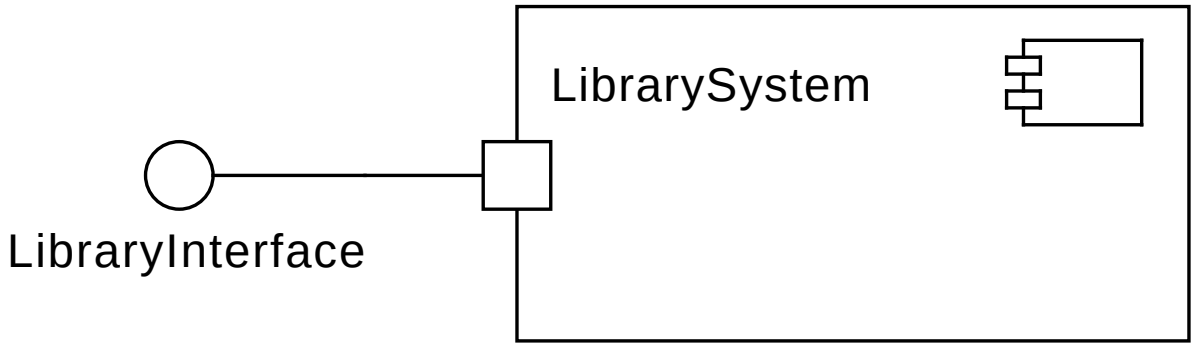
Use case diagram

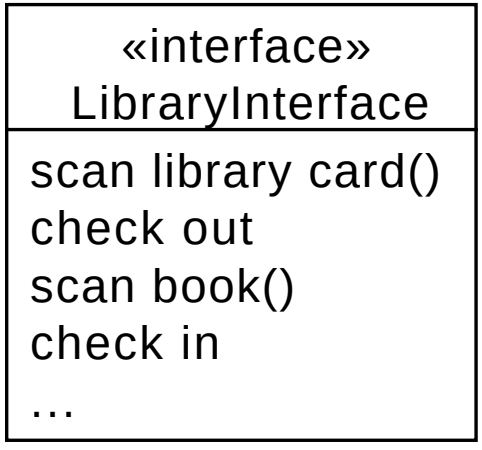


Use case *borrow book*
Basic course of events:

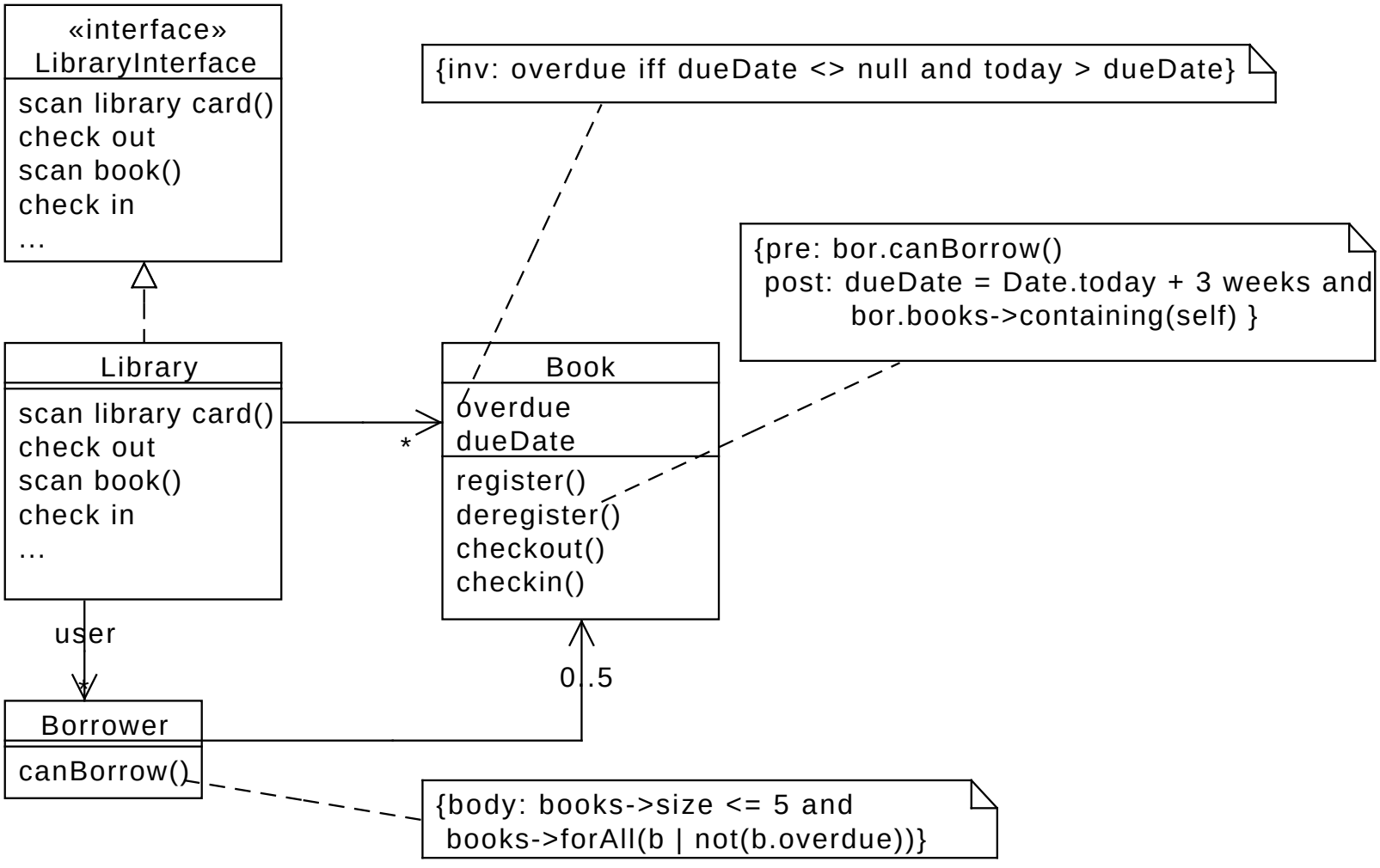
1. User scans his library card
2. User selects check out
3. User scans the book
4. System confirms loan

Implementation: Component Diagram

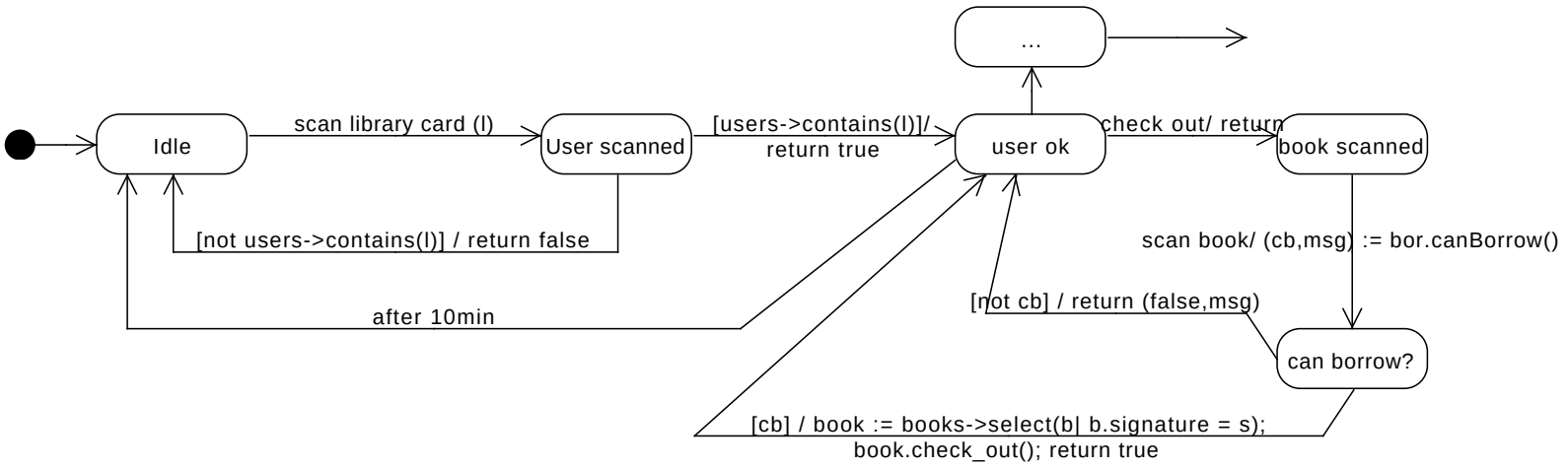




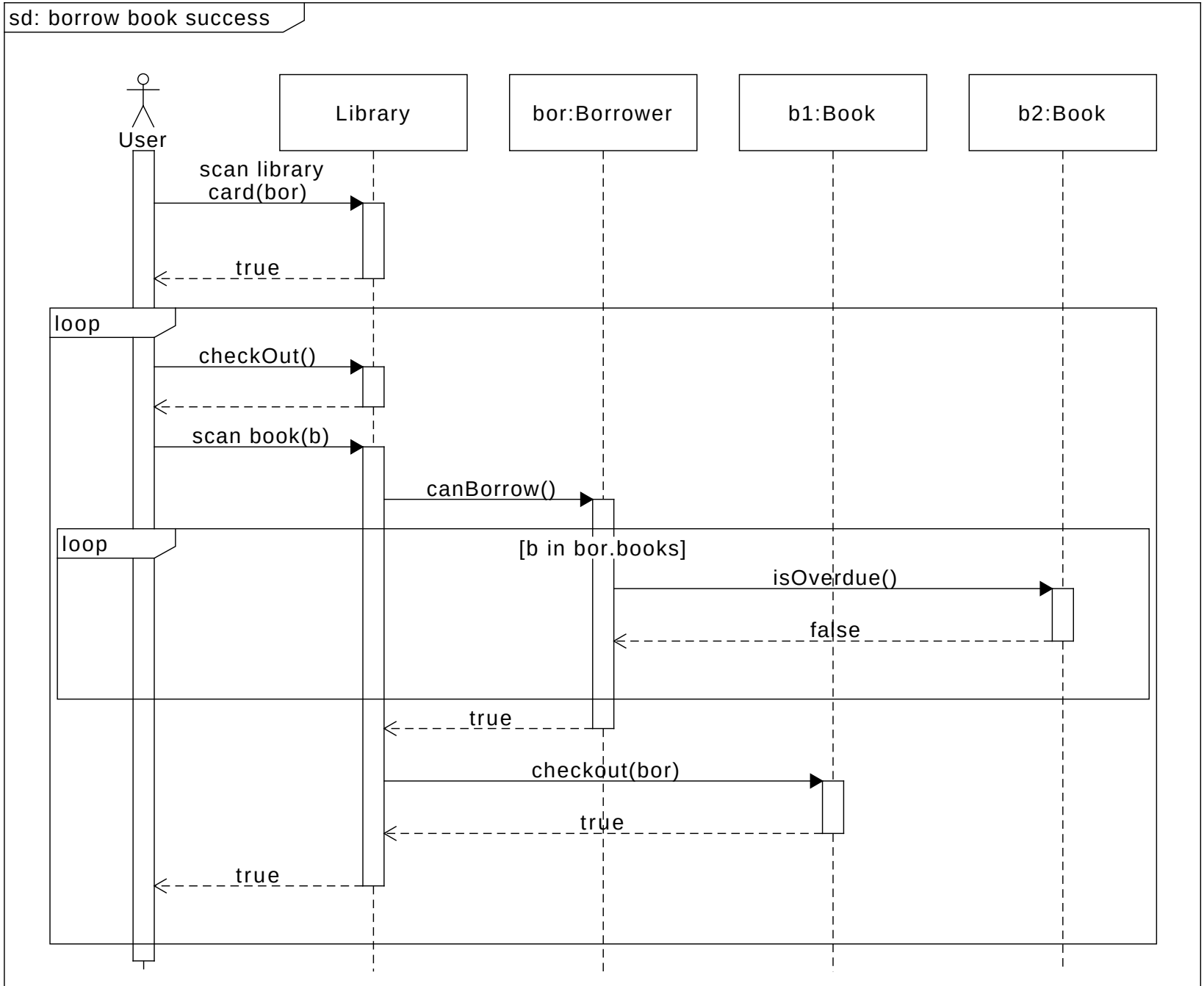
Implementation: Class Diagram



Library SM


...
Idle
scan library card (l)
User scanned
[users->contains(l)]/
return true
user ok
check out/ return
book scanned
[not users->contains(l)] / return false
scan book/ (cb,msg) := bor.canBorrow()
after 10min
[not cb] / return (false,msg)
can borrow?
[cb] / book := books->select(b| b.signature = s);
book.check_out(); return true

Use Case success scenario realisation



Use case *borrow book*: User interactions

Use case *borrow book*:
Basic course of events

1. User scans his library card
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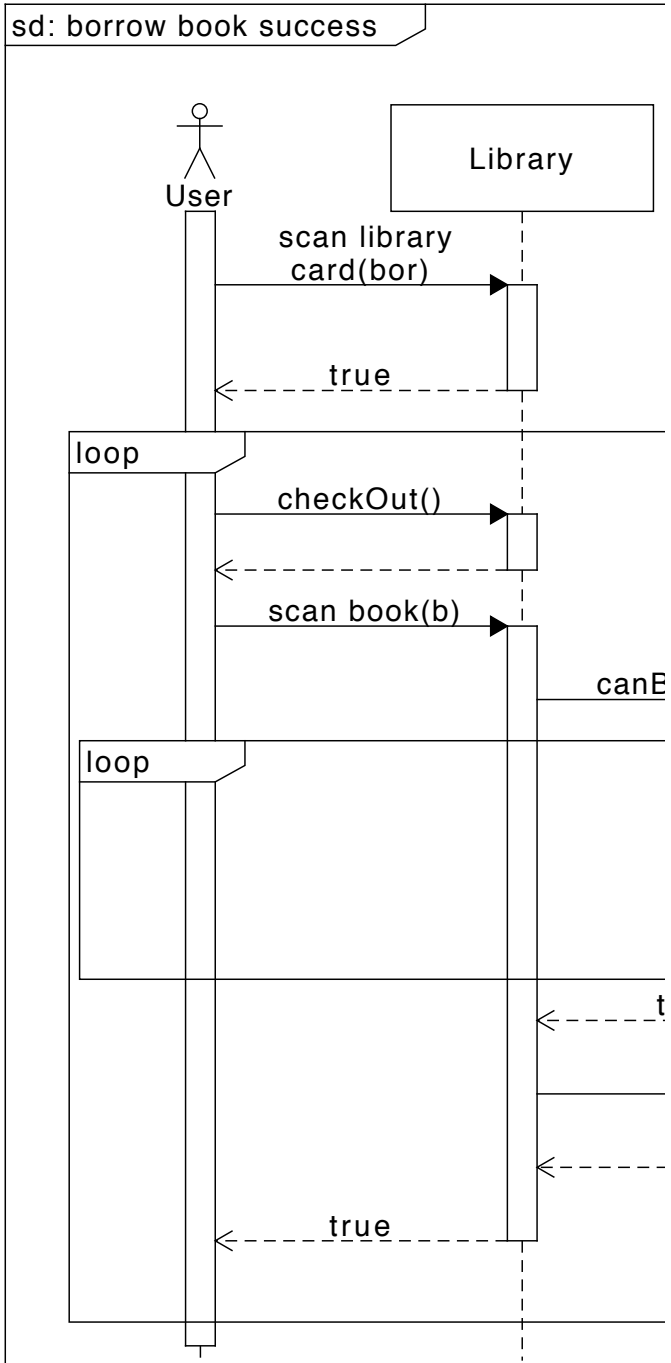
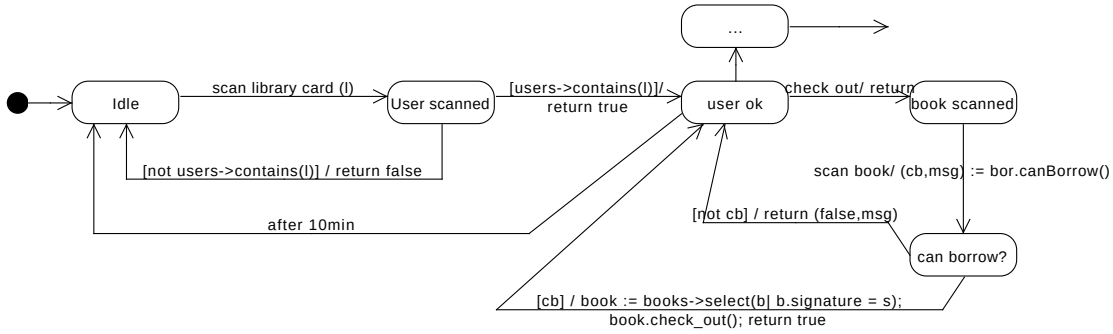
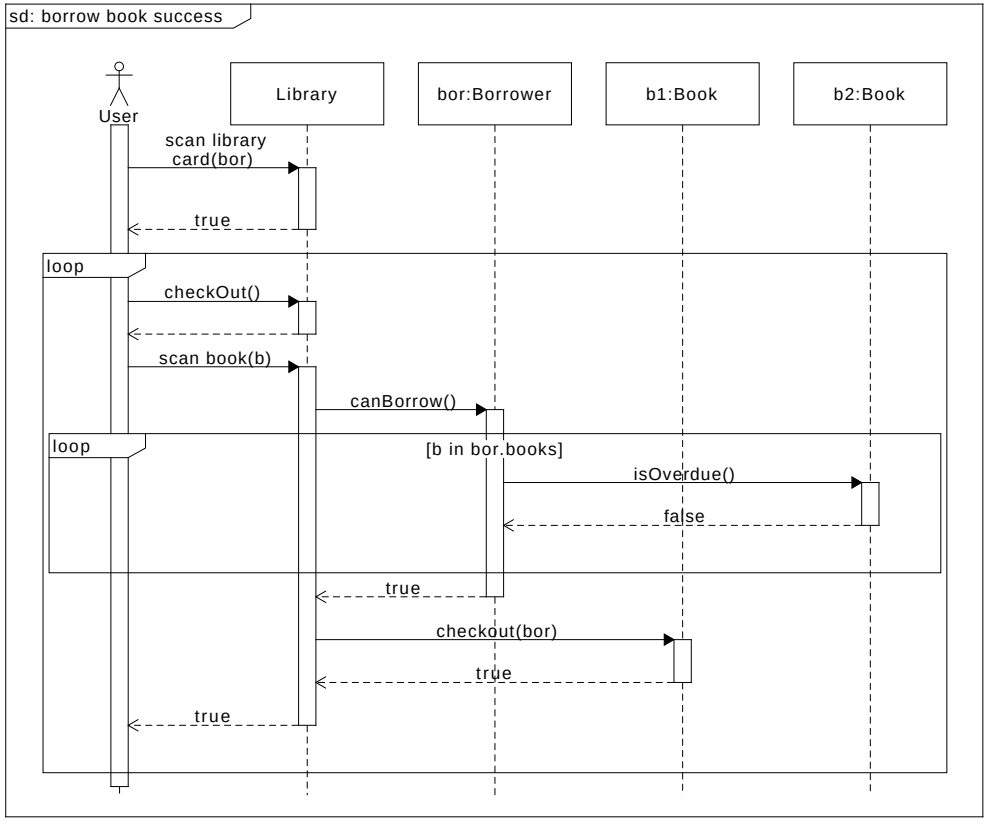


Library SM


...
Idle
scan library card (l)
User scanned
[users->contains(l)]/
return true
user ok
check out/ return
book scanned
[not users->contains(l)] / return false
scan book/ (cb,msg) := bor.canBorrow()
after 10min
[not cb] / return (false,msg)
can borrow?
[cb] / book := books->select(b| b.signature = s);
book.check_out(); return true


sd: borrow book success
User
Library
bor:Borrower
b1:Book
b2:Book
scan library
card(bor)
true
loop
checkOut()
scan book(b)
canBorrow()
loop
[b in bor.books]
isOverdue()
false
true
checkout(bor)
true
true

Contents

Overview

Introduction to UML

Practical Informations

Course Contents

- UML
  - Class-, Component-, Object- . . . diagrams
  - Activity-, Interaction- . . . diagrams
  - Object Constraint Language
- How to model
  - Agile modelling
  - CRC cards
  - Explorative Modelling
  - Domain Driven Design
  - Model Driven Design
- Validation / Verification
  - Acceptance tests
  - (UML) modelchecking
  - Use Case Realizations

Exam Project

- Project
  - Task is to model a larger system (*requirements*, *design*, *validation/verification*) so that programmers can implement the design
  - Duration 4 weeks at the end of the lecture
  - Written report
  - Groups: 4—6 people
- Project presentation
  - About the project
  - About the lecture
  - Dates: TBD (in the exam period)

Final project

- Steps
  - Model the requirements
    - Domain Model
    - Use Cases
    - Create a test model
    - ...
  - Build a design model
    - Component model
    - Class diagrams
    - OCL constraints
    - ...
  - Verify and validate the design
    - Use interaction diagrams to show that the use cases are realizable
    - ...
  - Reflect on the methods you use

Literature: UML

- Most books on UML will do. Make sure it deals with UML 2.x. Some options
- Grady Booch, James Rumbaugh, and Ivar Jacobson *The Unified Modeling Language User Guide (2nd Edition)* (Users manual from the creators of UML)
- Martin Fowler *UML Distilled. Third Edition* (Contains a *distilled* version of the most important UML diagrams)
- Perdita Stevens *Using UML* (A text book for teaching OO and UML)

Literature: OCL, Modeling

- OCL
  - Jos Warmer and Anneke Kleppe *The Object Constraint Language. Second Edition*
- Modeling
  - Scott Ambler *Agile Modeling*
  - Eric Evans *Domain-Driven Design*
  - Nancy Wiklinson *Using CRC Cards*
  - Anneke Kleppe, Jos Warmer, Wim Bast *MDA Explained*
- Further reading and Web resources will be given when coming to the relevant topics