



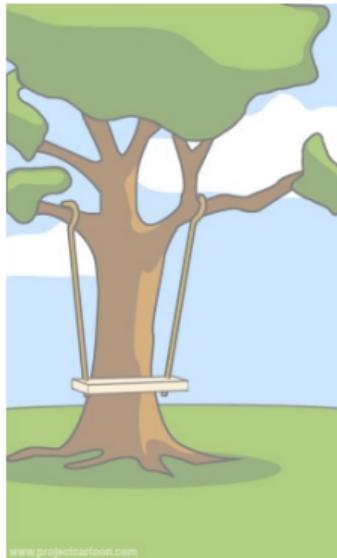
Software Engineering

2. Requirements | Matthias Tichy, Sabrina Böhm, Timo Zuccarello | October 16, 2024

Software Engineering Projects



how the customer
explained it



how the project leader
understood it



how the programmer
implemented it



how the business
consultant described it



what the customer
really needed

Lecture Overview – 2. Requirements

- 1. What are Requirements?**
- 2. How to Elicit Good Requirements?**
- 3. How to Document Requirements?**

2. Requirements

1. What are Requirements?

User Requirements

System Requirements

Functional Requirements

Non-Functional Requirements

Structure of a Requirements Document

Lessons Learned

2. How to Elicit Good Requirements?

3. How to Document Requirements?

User Requirements (Benutzeranforderungen)

User Requirement	[Sommerville]
<p>"User requirements are statements, in a natural language plus diagrams, of what services the system is expected to provide to system users and the constraints under which it must operate. The user requirements may vary from broad statements of the system features required to detailed, precise descriptions of the system functionality."</p>	<p>Example</p> <p>The Corona app should track contacts by means of random IDs and should store them locally for two weeks.</p>
<p>User Requirements Document (Lastenheft)</p> <p>System description from user's point of view. What? For what? (Was? Wofür?)</p>	<p>Example</p> <p>If a user has a positive test result, he or she can inform tracked contacts about their increased risk by means of a QR code.</p>



Tony Hoare (1969)

[Hoare 1969]

“The most important property of a program is whether it accomplishes the intention of its user.”

System Requirements (Systemanforderungen)

System Requirement

[adapted from Sommerville]

System requirements are more detailed descriptions of the software system's functions, services, and operational constraints. The system requirements document (aka. functional specification) should define exactly what is to be implemented. It may be part of the contract between the system buyer and the software developers.

System Requirements Document (Pflichtenheft)

System description from technical point of view.
How? Whereby? (Wie? Womit?)

Example

If two devices are within a distance of 2m for at least 15 minutes they exchange their IDs via Bluetooth.

Example

After IDs have been exchanged, they are stored for two weeks.

Example

A new ID is generated every 24 hours and old IDs are stored for two weeks.

Functional Requirements

Functional Requirement

[Sommerville]

"Functional requirements are statements of services the system should provide, how the system should react to particular inputs, and how the system should behave in particular situations. In some cases, the functional requirements may also explicitly state what the system should not do."

Non-Functional Requirements

Non-Functional Requirement

[Sommerville]

"Non-functional requirements are constraints on the services or functions offered by the system. They include timing constraints, constraints on the development process, and constraints imposed by standards. Non-functional requirements often apply to the system as a whole rather than individual system features or services."

Note

often more critical than functional requirements

Example

The app consumes less than 10MB of RAM.

Example

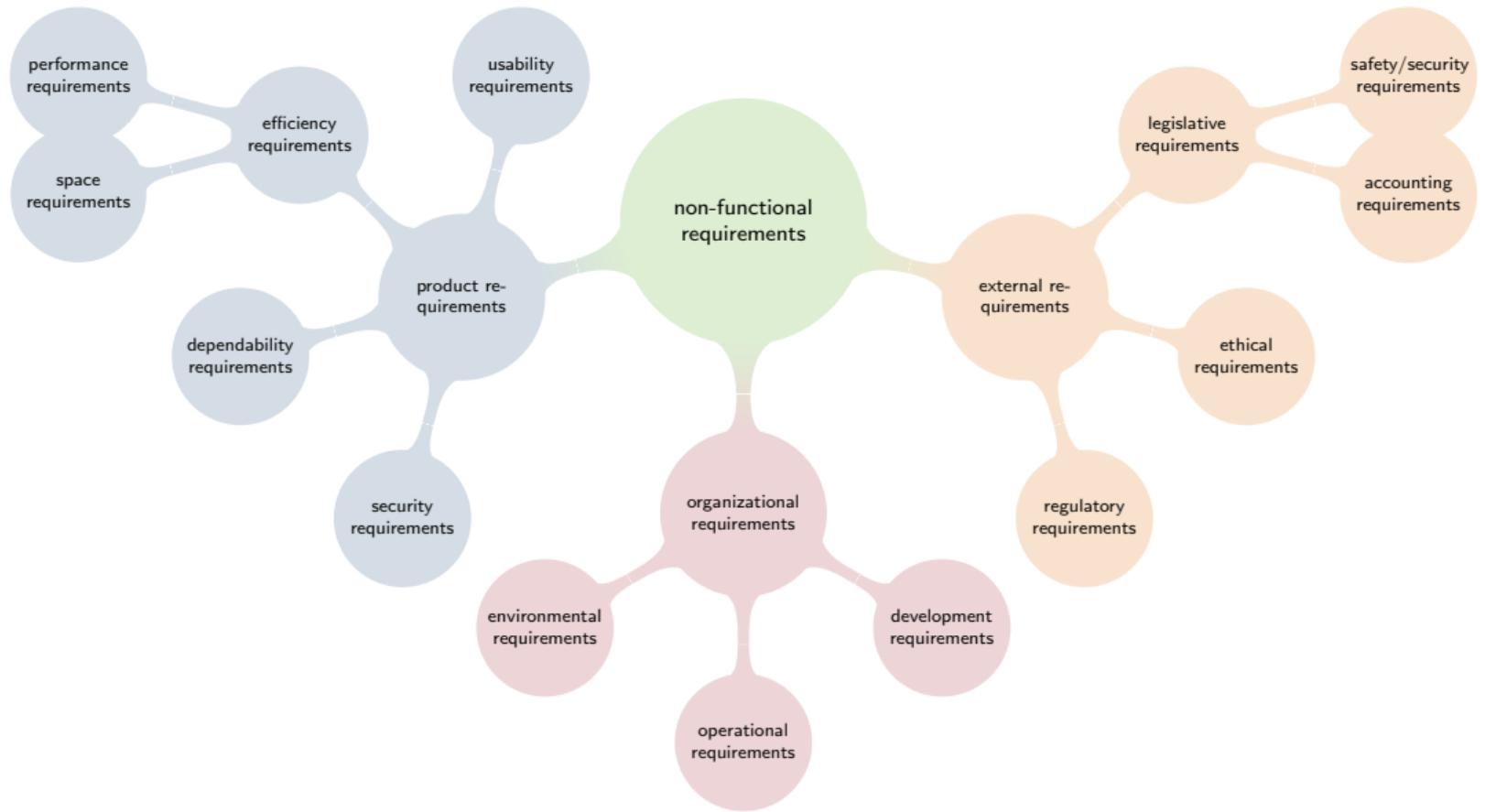
The app has no access to private data of the user.

Example

The app conforms to the GDPR. (DSGVO)

Example

The source code of the app is open source.



Structure of a Requirements Document

Typical Structure

[Sommerville]

Preface	expected readers, version history
Introduction	motivation/needs, collaboration with other system, strategic objectives
Glossary	technical terms
User Requirements Definition	functional and non-functional user requirements
System Architecture	distribution of functions across system modules, potential reuse
System Requirements Specification	detailed requirements, interfaces to other systems
System Models	graphical models illustrating the system with its environment
System Evolution	anticipated changes due to hardware evolution or changing needs
Appendices	hardware and database requirements, minimal/optimal system configuration
Index	index of diagrams/functions/terms/...

What are Requirements?

Lessons Learned

- What kind of requirements exist and why?
- User and System Requirements Document ([Lasten- und Pflichtenheft](#))
- Further Reading: [Sommerville](#), Chapter 2.2.1 (p. 54f), Chapter 4.1 (p. 101–111), Chapter 4.4.4 (p. 126–128)

Practice

1. Find at least one example for a functional, product, organizational, or external requirement
2. Classify each others requirements in groups of 2-3 students
3. Try to find an example for each category

2. Requirements

1. What are Requirements?

2. How to Elicit Good Requirements?

Imprecise Requirements

Complete and Consistent Requirements

Requirements Engineering Process

Why is Requirements Elicitation so Hard?

Example Dialog by Ludewig and Licher

Requirements Elicitation Techniques

Requirements Validation

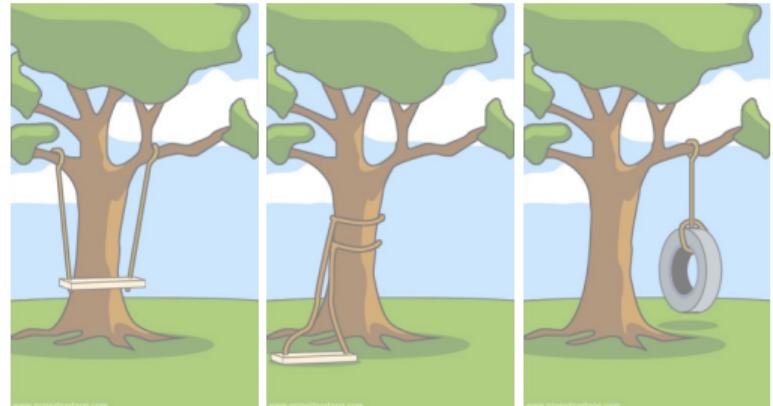
Lessons Learned

3. How to Document Requirements?

Imprecise Requirements

Sommerville:

"Imprecision in the requirements specification can lead to disputes between customers and software developers. It is natural for a system developer to interpret an ambiguous requirement in a way that simplifies its implementation. Often, however, this is not what the customer wants. New requirements have to be established and changes made to the system. Of course, this delays system delivery and increases costs."



how the project
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Complete and Consistent Requirements

Completeness and Consistency

[Sommerville]

"Ideally, the functional requirements specification of a system should be both complete and consistent. **Completeness** means that all services and information required by the user should be defined. **Consistency** means that requirements should not be contradictory."

Further Desired Properties

clear, easy to understand, unambiguous, correct, verifiable, prioritized, changeable, traceable

Often not Feasible in Practice

mistakes, omission, implicit knowledge, many stakeholders (**Akteure**) with different backgrounds / expectations / inconsistent needs



Fred Brooks (1931–2022)

[Brooks 1987]

“Much of the essence of building a program is in fact the debugging of the specification.”

Requirements Engineering Process

Requirements Elicitation and Analysis

Requirements elicitation and analysis is the process of deriving the system requirements through observation of existing systems, discussions with potential users, or development of prototypes. (Anforderungsermittlung und -analyse)

[adapted from Sommerville]

Requirements Specification

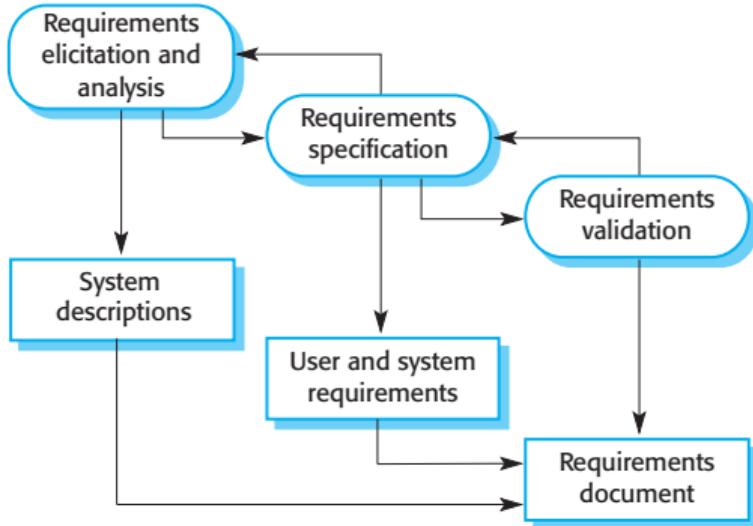
[Sommerville]

“Requirements specification is the process of writing down the user and system requirements in a requirements document (aka. requirements specification).” (Anforderungsspezifikation)

Requirements Validation

[Sommerville]

“Requirements validation is an activity that checks the requirements for realism, consistency, and completeness.” (Anforderungsvalidierung)



Why is Requirements Elicitation so Hard?

- Stakeholders have difficulties to articulate what they want
- Stakeholders don't know what is (not) feasible
- Implicit knowledge and jargon in the customer's domain
- Dynamic business environment (e.g., new stakeholders)

Example Dialog by Ludewig and Licher

- At the morning you unlock the door at the main entrance?
- Every morning?
- Even at the weekend?
- And during the plant shutdown?
- And if you are sick or in holidays?
- And if Mr. X is off?
- What does “morning” mean?
- Yes, as I said.
- Of course.
- No, at weekend the entrance remains closed.
- Clearly, it is then closed as well.
- Mr. X opens the door in this case.
- Then, a client knocks at the window to tell that the door is closed.
- ...

Source: Ludewig and Licher

Skit on Youtube (in German)

Requirements Elicitation Techniques

- Open interviews: talk to users what they do
- Closed interviews: stakeholders answer predefined questions
- Ethnography: observation of stakeholder's work
- Prototyping
- Feedback loops

Sommerville:

"You need to spend time understanding how people work, what they produce, how they use other systems, and how they may need to change to accommodate a new system."

In Practice

Combinations of numerous techniques used

Requirements Validation

Motivation: the later problems with requirements are detected, the more costly it will be

Validity checks do requirements (still) reflect real needs?

Consistency checks are there contradictory/redundant requirements?

Completeness checks are all functions and constraints documented?

Realism checks is it feasible within budget and schedule?

Verifiability can we test the requirements?

Checked by reviews, prototyping, and test-case creation

How to Elicit Good Requirements?

Lessons Learned

- What are desired and undesired properties for requirements?
- What is the requirements engineering process?
- What are techniques for requirements elicitation and why is it hard?
- Further Reading: [Sommerville](#), Chapter 4.2–4.3 (p. 111–119), Chapter 4.5 (p. 129f)

Practice

1. Think of some examples of bad requirements
2. Discuss improvements for some examples with your group (2–3 students)

2. Requirements

1. What are Requirements?

2. How to Elicit Good Requirements?

3. How to Document Requirements?

Natural Language Specification

Structured Specifications

CoronaWarnApp User Stories

Use Cases

Use Case Diagrams

Include and Extend Relationships

Lessons Learned

Natural Language Specification

- used since 1950s
- since programmer is not necessarily the user

Style Guidelines

- one or two short sentences of natural language
- one message per sentence
- use active voice (e.g., “the system …”)
- consistent use of language (i.e., avoid synonyms)
- use shall for mandatory and should for desirable requirements
- use text highlighting
- avoid jargon, abbreviations, acronyms
- provide a rationale

Pros

- expressive
- intuitive
- universal

Cons

- vague (*vage*)
- ambiguous (*mehrdeutig*)
- interpretation depends on reader's background

Rules for Natural Language Requirements [Ludewig and Licher]

Rule	Description
R1 Formulate every requirement in the active voice.	The actor is specified such that it's clear whether the system or the user does something.
R2 Express processes using full verbs.	Use full verbs like "reads," "generates," not "is" or "has," which require additional information (objects, complements) to describe the process.
R3 Identify incompletely specified process words ("verbs")	If there are missing terms (objects), then look for these terms to obtain complete statements.
R4 Identify incompletely specified conditions.	For "when-then-otherwise" conditions, both the "then" and "otherwise" cases must be described.
R5 Check universal quantifiers.	Are sentences with "never," "always," "every," "no," or "all" really universally valid, or are there restrictions?
R6 Check normalizations.	Nouns (e.g., "registration") often indicate a complex process that must be described. Use verbs instead.
R7 Recognize and specify indefinite nouns.	Often it remains unclear (e.g., "user," "message"), whether it's about a generic term or an actual object.
R8 Clarify responsibilities, possibilities, and necessities.	If in a requirement something is possible, impossible, can happen, may be allowed, must occur, then clarify who enforces this or prevents it.
R9 Recognize implicit assumptions.	Terms in the requirements that are not explained often indicate implicit assumptions.

Example [Ludewig and Licher]

Bad

It should be checked that, in addition to author and title of the document, the storage location is always entered as well.

Example [Ludewig and Licher]

Better

After the administrator has entered the document data record, the system checks whether the data record contains, in addition to (the single or first) author and title, also the storage location. If not, the system generates an error message and leaves the document data record unchanged.

Structured Specifications

- use of templates rather than free-form text
- distinguishes between function, description, input (origin), output (destination), pre- and postconditions, side effects, rationale, dependencies to other requirements, . . .
- or any subset thereof

Example

Function	Exchange of IDs
Description	Two devices send their IDs to each other.
Precondition	Devices have been within a distance of 2m for at least 15 minutes.
Postcondition	IDs are stored in the local database.
Rationale	Contact tracing requires to temporarily identify the device of contacts.

Pros

- expressive
- intuitive
- information easier to find
- less likely to forget certain information (e.g., rationale)

Cons

- vague
- ambiguous
- interpretation depends on reader's background
- same structure can be too restrictive
- multiple structures can be confusing

CoronaWarnApp User Stories

Show the number of stored keys in the local database #65

Closed

asidl12 opened this issue on May 31 · 1 comment



asidl12 commented on May 31

...

Feature description

The app receives keys from other smartphones via bluetooth and stores the keys for the last 14 days (IIRC) in the local database. Even though the app doesn't know if multiple keys in the local db correspond to one single person in real life, it would be nice to have this number as it could be used as a rough indicator if the app is working at all and give some transparency how well it is performing.

Also it could be helpful by providing some feedback to the user how well he is keeping distance to other people eg. by looking at the counter before and after going to the supermarket.

The counter could be put into a debug submenu to prevent confusing users with less technical knowledge.

Problem and motivation

As a technically interested person I would like to gain some insights und transparency how the app is performing.

Is this something you're interested in working on

No

CoronaWarnApp User Stories

Enhance Logging With Timber #24

Closed

Magoli1 opened this issue on May 30 · 1 comment



Magoli1 commented on May 30

...

Current Implementation

Currently the app uses the native android logging framework. To do that, every class holds a reference to a dedicated logging tag, which is given the logger, in case it is used. Example:

```
cwa-app-android/Corona-Warn-App/src/main/java/de/rki/coronawarnapp/receiver/ExposureStateUpdateReceiver.kt  
Line 38 in 43412bd
```

```
38     private val TAG: String? = ExposureStateUpdateReceiver::class.simpleName
```

Suggested Enhancement

There is a lightweight library called [Timber](#), which automatically sets the logging tags to the calling class. We suggest to change the implementation for all logging calls towards Timber.

Expected Benefits

Timber optimizes the developer experience in several cases, e.g. it automatically makes sure that the tag is at most 23 characters long (more details [here](#)). We could also get rid of the tag in every class that is currently hardcoded.

CoronaWarnApp User Stories

Do not log in production #235

Closed

IndianaDschnones opened this issue on Jun 7 · 4 comments



IndianaDschnones commented on Jun 7

Contributor ...

Current Implementation

The `release` build contains `Log`-statements of all levels.

Suggested Enhancement

A production build should not contain any `Log`-statements, see for example the [Android Prepare for release guide](#).

`Log` statements can be removed using ProGuard rules.

Expected Benefits

- Compliance to Android's suggestions for `release` builds
- Security: logs can contain sensitive data which should never be logged
- Behaves like the iOS application will do, see [corona-warn-app/cwa-app-ios#22](#)

Use Cases

Use Case (Anwendungsfall)

A sequence of interactions between an actor (or actors) and a system triggered by a specific actor, which produces a result for an actor. [Ludewig and Licher]

Example (1/2) [Ludewig and Licher]

Name	Authentication
Goal	The customer would like to have access to a BA42 ATM
Precondition	<ul style="list-style-type: none">• The machine is in operation, the welcome message is displayed• The customer's card and PIN are available
Postcondition in normal case	<ul style="list-style-type: none">• The customer has been accepted• The services of BA42 are available to the customer
Postcondition in alternative case	Access is denied, the card is either returned or retained, the welcome message is displayed
Normal process	<ol style="list-style-type: none">1. The customer inserts the card2. The BA42 reads the card and sends the data to the bank system for verification3. The banking system checks whether the card is valid4. The BA42 displays the request to enter the PIN5. The customer enters the PIN6. The BA42 reads the PIN and sends it to the bank system for verification7. The banking system checks the PIN8. The BA42 accepts the customer and displays the main menu

Example (2/2) [Ludewig and Licher]

Alternative process (2a) **The card cannot be read**

- 2a.1 The BA42 displays the message "Card cannot be read" (4s)
- 2a.2 The BA42 returns the card
- 2a.3 The BA42 shows the welcome message

Alternative process (2b) **The card is readable, but no BA42 card**

- 2b.1 The BA42 displays the message "Card not accepted" (4s)
- 2b.2 The BA42 returns the card
- 2b.3 The BA42 shows the welcome message

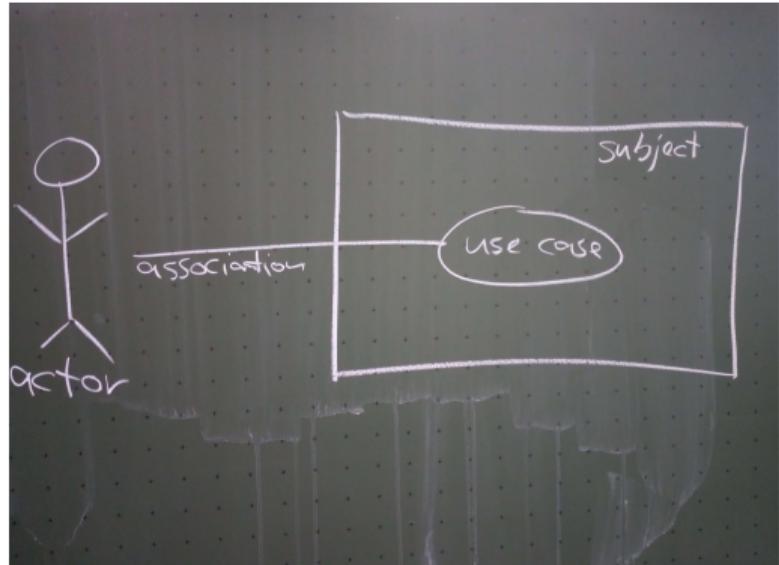
Use Case Diagrams (since 1993)

Use Case Diagram (Anwendungsfalldiagramm)

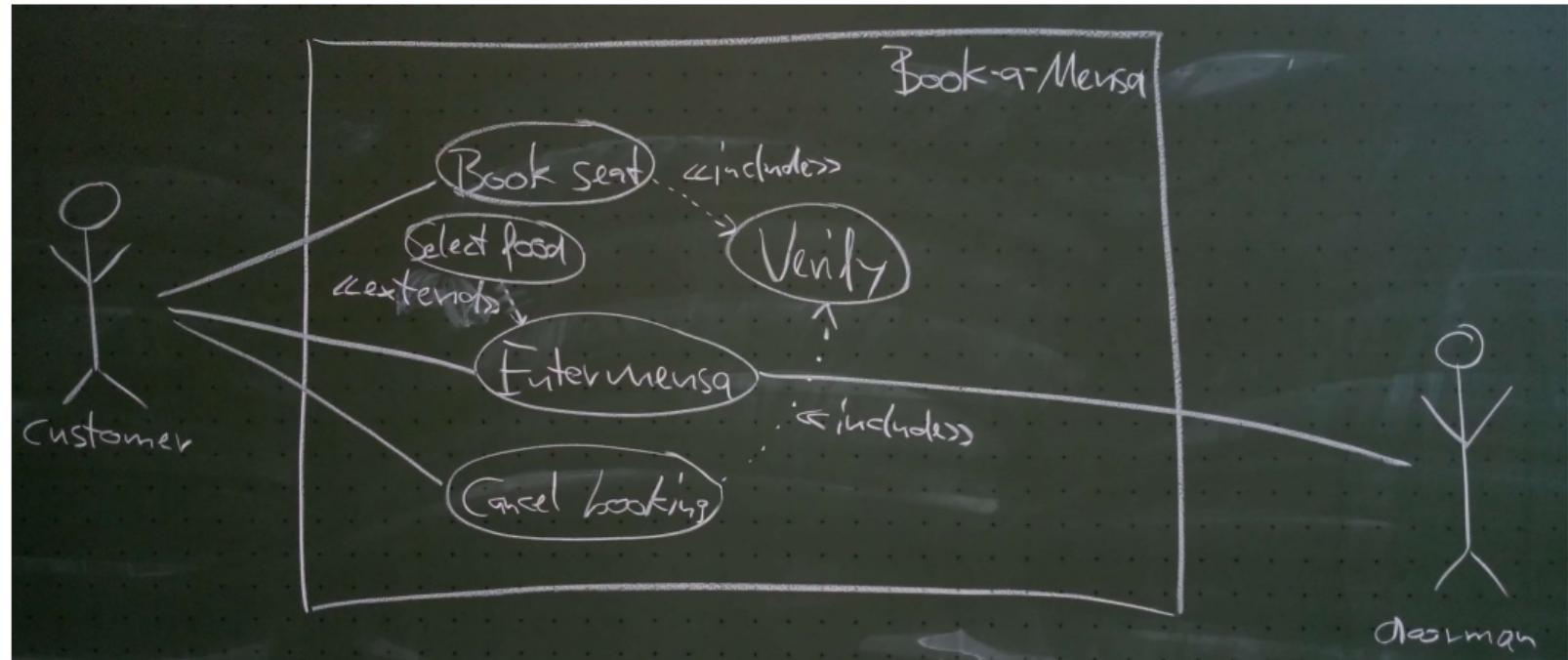
Use case diagrams are a means to capture the requirements of systems, i.e., what systems are supposed to do. The key concepts specified in this diagram are actors, use cases, and subjects:

- Each **subject** represents a system under consideration to which the use case applies. (**System**)
- Each users and any other system that may interact with a subject is represented as an **actor**. (**Akteur**)
- A **use case** is a specification of behavior in terms of verb and noun. (**Anwendungsfall**)

[adapted from UML 2.5.1]



Example



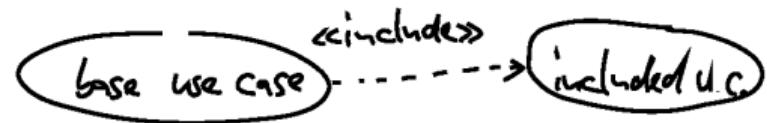
Include and Extend Relationships

Include Relationship

Motivation: make common parts of multiple use cases explicit

Relationship: a **base use case** may define an include relationship to an **included use case**

Meaning: included use case is always executed when the base use case is

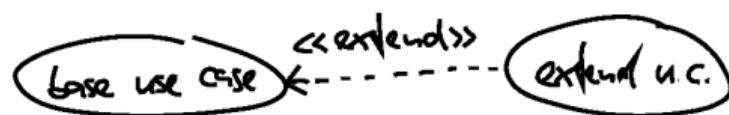


Extend Relationship

Motivation: make explicit that some use cases only happen under certain circumstances

Relationship: an **extend use case** may define an extend relationship to a **base use case**

Meaning: when the base use case is executed, the extend use case may or may not be executed





Edward V. Berard (1993)

[[wikiquote.org](#)]

“Walking on water and developing software from a specification are easy if both are frozen.”

How to Document Requirements?

Lessons Learned

- Natural language and structured specification of requirements
- Graphical specification with use case diagrams ([Anwendungsfalldiagramme](#))
- Further Reading: [Sommerville](#), Chapter 4.4 (p. 120–126) and Chapter 5.2.1 (p. 144–146)
- Further Reading: [UML 2.5.1](#), Chapter 18
- Next: How to model the system behavior in more detail?

Practice

1. Draw a use case diagram related to your requirements
2. Discuss with your group (2-3 students) whether your diagram is complete or if more (base/included/extend) use cases could be added