UNIVERSITÄT DUISBURG ESSEN

Offen im Denken

Requirements Engineering & Management

Core Activities – Documentation II

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Agenda

1. Requirements Specification Documents
2. Reference Structures for Requirements Specifications
3. Quality Criteria
4. Acceptance Criteria

1. Requirements Specification Documents

Requirements Documents vs. Requirements Specification (Documents)

- A **requirements specification document** typically requires **more strict documentation** of requirements as well as of additional information (compared with other documents used in RE).
- Typically, a specification document demands:
  - **Content**:
    - Only **requirements selected for the system** (release) are included.
    - The requirements are documented in **sufficient detail** (more detail than in most other documents).
    - Each requirement should be **fully specified**, i.e. **no information should be missing**.
  - **Format**:
    - Typically, more **formal representation** formats are used to facilitate (partial) automation and tool support in later development stages.
  - **Quality**:
    - More **rigorous quality** of both, the **overall**

Typical Types of Requirements Specification Documents

- **Stakeholder requirements specification (StRS)**: [ISO/IEC/IEEE 29148]
  Describes the motivation for developing or changing the system and how the system is used from a stakeholder's point of view.
- **System requirements specification (SyRS)**: [ISO/IEC/IEEE 29148]
  Defines the high-level requirements for the overall system, its goals, and includes information about interfaces to its context.
- **Software requirements specification (SRS)**: [ISO/IEC/IEEE 29148]
  Defines the requirements for a particular software (which may be part of a larger system) in detail by refining the relevant system requirements.
- **Lastenheft** (German-speaking countries) [DIN 69901-5 2009]
- **Pflichtenheft** (German-speaking countries) [DIN 69901-5 2009]

The Lastenheft

D The Lastenheft contains a definition of the **system vision** and a description of the **essential system goals** (functions and qualities). It names **important context objects** and constraints imposed by the requirements engineering context, and relates the context to the vision and the defined system goals.

- Typically created by the **client**.
- Contains **abstract descriptions** of the desired **functionalities** and **qualities** the system should provide.

The Pflichtenheft

D The Pflichtenheft **details the vision and the system goals** (abstract functionalities and qualities) described in the Lastenheft. If required, it **details the constraints** defined in the Lastenheft with regard to the intended technical **realization of the system**.

- Typically created by the **contractor**.
- Defines **all detailed requirements**.
- Typically contains **additional requirements** (requirements not stated in the Lastenheft), which are added during the creation of the Pflichtenheft.
- Often a Pflichtenheft also specifies the assignment of requirements to system components defined in an initial architecture

Detailed Requirements in the Pflichtenheft

Abstract Requirement in the Lastenheft:

R-L-12: The safety system shall offer user and access management.

Detailed Requirements in the Pflichtenheft:

R-8: The safety system shall differentiate between the administrator and user of the system.

…

R-14: The administrator shall be able to create new user accounts.

R-15: The system shall support the organization of user accounts in user groups.

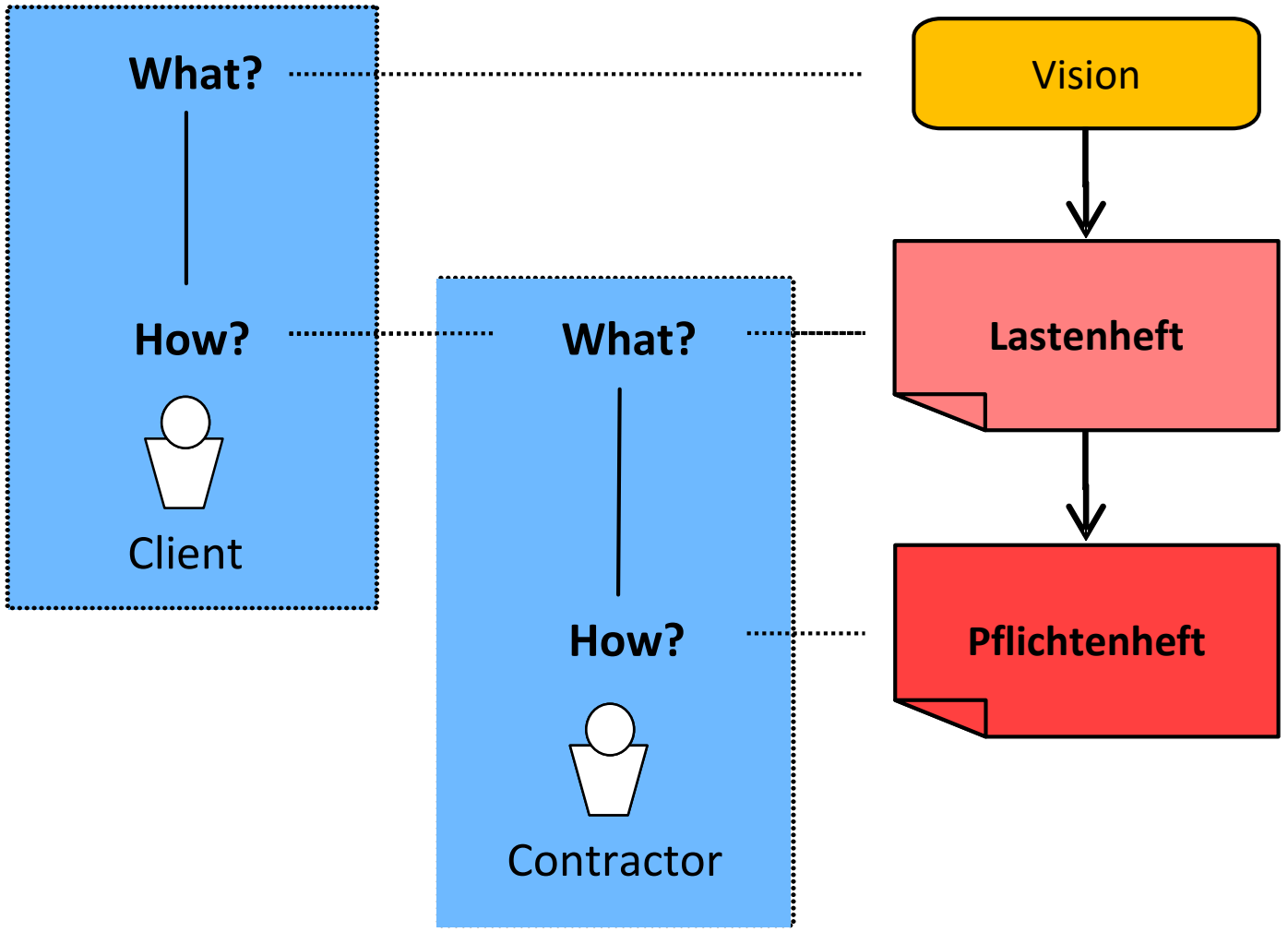
R-16: The administrator shall be able to assign and revoke access authorizations.

…

R-23: The user shall be able to change his/her personal access code.

…

Relations between Lastenheft and Pflichtenheft



2. Reference Structures for Requirements Specifications

Advantages

- In general (independent from the concrete reference structure), using a reference structure offers **significant advantages**:
  - Reflects **best practice experience**
  - Facilitates (checking for) **completeness**
  - Facilitates the documentation of the **same information** **at the same place**
  - Enables **tool support**, e.g., for generating documents from a requirements base or supporting the documentation based on templates
- However, there are **many reference structures** for requirements specifications, e.g., proposed by standards, domain specific, company specific, country specific, etc.. They **differ significantly.**

Reference Structure for SRS

According to ISO/IEC/IEEE Standard 29148

Exemplary high-level structure consisting of five parts:

1. Introduction
2. References
3. Specific Requirements
4. Verification
5. Appendices

The concrete structure for a specific system to be developed should be tailored and agreed upon by the stakeholders.

[ISO/IEC/IEEE 29148]

3. Quality Criteria

Motivation

- Quality should be **assessed objectively**, but is often **perceived subjectively**.
- To increase objectivity, **quality criteria** are used. Quality criteria
  - **define the quality expected** from documented or specified requirements (e.g. completeness or consistency)
  - **support quality assessment**
- Quality criteria should be defined
  - for **single requirements** and
  - for **sets of requirements** (documents).
- The quality of a set of requirements (document) depends on the fulfilment of the quality criteria defined for
  - **single requirements** contained in the document and
  - for the **set of requirements (document)**.

Quality Criteria for Single Requirements (1)

- **Agreed**: The relevant stakeholders established a sufficient agreement about the requirement – cf. agreement dimension of requirements engineering, Lecture "Requirements Engineering Framework"). based on [Pohl and Rupp 2011]
- **Atomic**: The requirement describes only a single, coherent fact.
  based on [ISO/IEC/IEEE 29148]
- **Complete**: The requirement adheres to the defined documentation and specification guidelines, does not omit any information relevant for some stakeholder, and does not need any further explanations.
  based on [ISO/IEC/IEEE 29148]
- **Comprehensible**: The content of the requirement is easy to understand for all stakeholders. based on [Pohl and Rupp 2011]
- **Consistent**: A requirement is consistent if the statements within the requirement do not contradict each other. In addition, the consistency of an entire set of requirements (document) as to be taken into account – cf. quality criteria for requirements specifications. based on [ISO/IEC/IEEE 29148; Pohl and Rupp 2011]
- **Correct**: The relevant stakeholders confirm that the specified or documented requirement is correct, and that the system shall realise the requirement. based on [IEEE Std 830-1998]
- **Feasible**: The requirement can be technically realised within the system constraints, and does not require major technological advancements. based on [ISO/IEC/IEEE 29148]

Quality Criteria for Single Requirements (2)

- **Identifiable**: The requirement can be uniquely distinguished from other requirements (e.g. by using a unique identifier).
- **Implementation free**: The requirement does not contain any unnecessary constraints regarding the architecture and its realization. based on [ISO/IEC/IEEE 29148]
- **Necessary**: The requirement defines a crucial system property. If it is missing, defects will occur that cannot be resolved by other capabilities. based on [ISO/IEC/IEEE 29148]
- **Rated**: The relevance, priority and stability of the requirement have been defined. based on [Pohl and Rupp 2011]
- **Traceable**: The source, evolution and use in later development phases of the requirement are identified and documented. based on [ISO/IEC/IEEE 29148]
- **Unambiguous**: The requirement only permits one valid interpretation. All readers arrive at the same understanding of the requirement. based on [ISO/IEC/IEEE 29148]
- **Verifiable**: The requirement allows proving whether the implemented system satisfies the requirement or not.
based on [ISO/IEC/IEEE 29148]

Verifiability is relevant for defining acceptance criteria for the system (see next section).

Consistency of Single Requirements

A single documented requirement is consistent if the **statements therein do not contradict each other**.

"R15-2: The system shall compute the report **in less than a second** in 90% of all potential situations and **prohibit response times >= 1 second**.

Quality Criteria for Requirements Specifications (1)

- **Affordable**: There exists a feasible solution that satisfies the complete set of requirements within the lifecycle constraints (e.g. cost, time, legal). based on [ISO/IEC/IEEE 29148]
- **Bounded**: The set of requirements is defined within the system scope, i.e. the requirements specification contains no “gold plating”. based on [ISO/IEC/IEEE 29148]
- **Clearly structured (comprehensible)**: The requirements specification supports selective reading and should thus be clearly structured and comprehensible. based on [Pohl and Rupp 2011]
- **Complete**: The requirements specification contains all relevant requirements, and each requirement is completely specified. No TBDs etc. are included.
  based on [ISO/IEC/IEEE 29148, IEEE 830-1998]

Quality Criteria for Requirements Specifications (2)

- **Consistent**: All single requirements are internally consistently defined. There are no contradictions between the requirements.
  based on [ISO/IEC/IEEE 29148]
- **Modifiable and extendable**: The requirements specification is easy to modify and extend. The document structure and style should support simple, complete and consistent modification. based on [Pohl and Rupp 2011, IEEE 830-1998]
- **Traceable**: The relationships between different versions of requirements specifications and other documents (e.g. business process models, architecture, test cases, user manuals, standards) should be traceable. based on [Pohl and Rupp 2011]
- **Unambiguous**: Each single requirement on its own, as well as the entire requirements specification allow only one valid interpretation.
  based on [Pohl and Rupp 2011]

Consistency of a Requirements Specification

- A requirements document is consistent if:
  - **each individual requirement** is (internally) consistently defined and if
  - there exist **no inconsistencies between the requirements** defined in the requirements document. [ISO/IEC/IEEE 29148]
- Three types of inconsistencies: [IEEE 830-1990]
  - Inconsistent **description of a real-world aspect/object**
  - Inconsistent **properties of a real-world aspect/object**
  - **Logical or temporal conflicts** between actions described in two or more requirements

"R12: Upon receipt of **any** incoming request, the system shall **store it** in the buffer memory."

...

"R23: **Invalid** order requests shall be **rejected without storing** them."

4. Acceptance Criteria

Definition

D An acceptance criterion defines verifiable and measurable **conditions for accepting a development artefact** (e.g. architecture, code).

- In **acceptance testing**, the implemented system will be verified **against** its **specified requirements**.
- How to determine **objectively** if a **requirement is satisfied**?
  - Acceptance criteria need to be **defined**, **documented** and **communicated**.
  - **Early definition of acceptance criteria** during requirements engineering empowers the developer to consider the criteria when developing the system.
  - To pass the acceptance test successfully, the implemented system has to fulfil all defined acceptance criteria.

Different Types of Acceptance Criteria

- **Acceptance criteria** for **requirements**:
  - single requirements
  - requirements specifications
- **Acceptance criteria** for **the implemented system**
  - realization of single functions and qualities
  - realization of entire system
- **Acceptance criteria** should be jointly defined by the **contractor** and the **client** as early as possible in the project for requirements and for the whole system.

for Single Requirements

Acceptance criteria for single requirements:

- define the **conditions a single requirement must meet** in order **to be accepted**.
- they typically refine **quality criteria** for single requirements as well as **documentation guidelines**.
- serve as basis for defining **checklists for validation** and **verification**, e.g., to validate requirements in an inspection.

Acceptance Criterion Req-1:

"Each requirements artefact must have a valid identifier. The identifier of a requirement must be unique and structured according to the scheme <Category>-<Number>."

Acceptance Criterion Req-2:

"At least one trigger must be specified for each function of the system. Valid trigger types are "user action", "time event" and "system-internal event".

for Requirement Specifications (Documents)

Acceptance criteria for requirement specification:

- define conditions under which a **requirements specification is accepted**.
- typically refine **quality criteria** for sets of requirements as well as **general documentation guidelines**.
- can include acceptance criteria for single requirements.

Acceptance Criterion Doc-1:
"At most **3% of the goals** documented **according to template T-G-003**, **but excluding** goals ranked as "high priority", may still contain gaps, i.e. may be not completely documented."

Acceptance Criterion Doc-2:
"**98% of the functional requirements** descriptions must have been **successfully accepted** according to the acceptance criteria for functional requirements."

for Realization of Single Functions and Qualities

Acceptance criteria for the realization of a single (functional or quality) requirement:

- define criteria the realization of **a single functional or quality requirements** must meet in order **to be accepted** during **acceptance test**.
- support **uncovering of potential defects** in the requirement, e.g., if a requirement is not verifiable.

for the Realization of Single Functions

Functional Requirement R1:

"When the emergency stop button is pushed, the control system must stop the elevator within 1 s."

Acceptance Criterion 1:

"The fulfilment of requirement R1 has to be proven by an **acceptance test** executed in the **real operational environment**. The acceptance test must be performed with the **maximum load** allowed and at the maximum vertical speed.
At least 30 test runs have to be performed. In at least 25 of the 30 test runs, the elevator **must stop within 0.9 s**. In at most 5 test runs, the system is allowed to take longer than 1 s to stop the elevator, but not more than 1.3 s."

for the Realization of Single Qualities

Quality Requirement R142:

"The system responds to a user input within 1 s."

Acceptance Criterion 1:

"At an average load of 50 user requests per second, the system shall **respond to 98% of all requests within 1 s** and to the remaining **2% within 1.5 s**."

Acceptance Criterion 2:

"**When 1 000 users are logged in**, the validation of the log-in information for an **additional user** shall **not take longer than 2s**."

for the Realization of an Entire System

Acceptance criteria for the entire system (or system components):

- define the **conditions** under which the **client will accept the system**.
- may be **based on acceptance criteria for single requirements**.

Acceptance Criterion Sys-1:

"For a successful acceptance test, 98% of all required test cases (see **acceptance criteria A-1 to A-38**) must be performed without errors classified as serious error."

Acceptance Criterion Sys-2:

"The input-output pairs defined in the files IN-OUT-1 to IN-OUT-12 **must be used for acceptance testing**. The system has to produce the specified outputs **in all cases**."

Acceptance Criterion Sys-3:

"**All acceptance tests** must be performed in the **environment** defined in the document **Env-Config-001** as well as in the environment defined in the document **Env-Config-007**."

Summary

- There are five commonly used types of requirements specification documents.
- Reference structures for specification documents reflect best practices for organising the content of documents.
- Quality criteria serve as a reference for objectively determining and communicating the quality of single requirements and a requirements specification.
- Acceptance criteria for requirements are often based on quality criteria (for single requirements and/or requirements specification documents).
- Acceptance criteria for the realisation of requirements determine the conditions under which the client will accept the system.

Literature

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[IEEE Std 830-1998] Institute of Electrical and Electronics Engineers: IEEE Recommended Practice for Software Requirements Specification (IEEE Std 830-1998). IEEE Computer Society, New York, 1998.

[ISO/IEC/IEEE 29148] ISO/IEC/IEEE: Systems and software engineering —Life cycle processes — Requirements engineering. International Standard 29148, First edition, 2011.

[Wiegers 2003] K.E. Wiegers: Software Requirements. 2nd edition, Microsoft Press, Redmond, 2003.

[Pohl and Rupp 2011] K. Pohl and Chris Rupp: Requirements Engineering Fundamentals – A Study Guide for the Certified Professional for Requirements Engineering Exam. Rocky Nook, 2011.

Image References

[1] Licensed by http://www.iconshock.com/

[2] Provided by Microsoft Office

Legend

Definition

Example

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Vielen Dank für Ihre Aufmerksamkeit

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