Software Requirements

l Descriptions and specifications of a system

Software Requirements Overview

l **Requirements** set out what the system should do and define constraints on its operation and implementation

l **User requirements** are high-level statements of what the system should do, from the user's perspective

l **System requirements** communicate the system services and constraints

- **Functional requirements** set out the services the system should provide
- **Non-functional requirements** constrain the system being developed or the development process

l A **software requirements document** or specification is an agreed statement of the system requirements

Requirements engineering

l The process of establishing the services that the customer requires from a system and the constraints under which it operates and is developed

l The requirements themselves are the descriptions of the system services and constraints that are generated during the requirements engineering process

What is a requirement?

l It may range from a high-level abstract statement of a service or of a system constraint to a detailed mathematical functional specification

l This is inevitable as requirements may serve a dual function

- May be the basis for a bid for a contract - therefore must be open to interpretation
- May be the basis for the contract itself - therefore must be defined in detail
- Both these statements may be called requirements

Requirements abstraction (Davis)

"If a company wishes to let a contract for a large software development project, it must define its needs in a sufficiently abstract way that a solution is not pre-defined. The requirements must be written so that several contractors can bid for the contract, offering, perhaps, different ways of meeting the client organisation's needs. Once a contract has been awarded, the contractor must write a system definition for the client in more detail so that the client understands and can validate what the software will do. Both of these documents may be called the *requirements document* for the system."

Types of requirement

l User requirements

- Statements in natural language plus diagrams of the services the system provides and its operational constraints. Written for customers

l System requirements

- A structured document setting out detailed descriptions of the system services. Written as a contract between client and contractor

l Software specification

- A detailed software description which can serve as a basis for a design or implementation. Written for developers
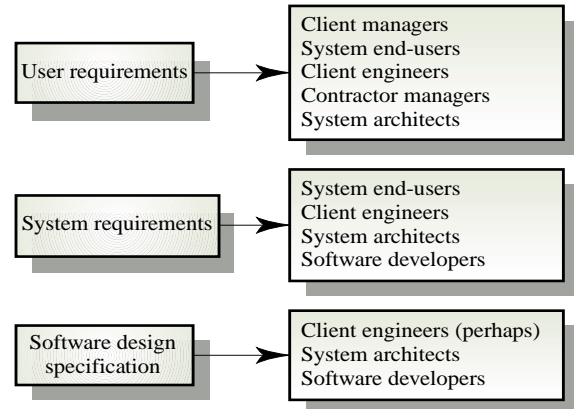
Definitions and specifications

Requirements definition

1. The software must provide a means of representing and accessing external files created by other tools.

Requirements specification

1.1 The user should be provided with facilities to define the type of external files.
1.2 Each external file type may have an associated tool which may be applied to the file.
1.3 Each external file type may be represented as a specific icon on the user's display.
1.4 Facilities should be provided for the icon representing an external file type to be defined by the user.
1.5 When a user selects an icon representing an external file, the effect of that selection is to apply the tool associated with the type of the external file to the file represented by the selected icon.

Requirements readers

User requirements →
Client managers
System end-users
Client engineers
Contractor managers
System architects

System requirements →
System end-users
Client engineers
System architects
Software developers

Software design specification →
Client engineers (perhaps)
System architects
Software developers

User requirements

- Should describe functional and non-functional requirements so that they are understandable by system users who don't have detailed technical knowledge
- User requirements are defined using natural language, tables and diagrams

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Problems with natural language

- Lack of clarity
  - Precision is difficult without making the document difficult to read
- Requirements confusion
  - Functional and non-functional requirements tend to be mixed-up
- Requirements amalgamation
  - Several different requirements may be expressed together

Database requirement

.A.5 The database shall support the generation and control of configuration objects; that is, objects which are themselves groupings of other objects in the database. The configuration control facilities shall allow access to the objects in a version group by the use of an incomplete name.

Editor grid requirement

.6 Grid facilities To assist in the positioning of entities on a diagram, the user may turn on a grid in either centimetres or inches, via an option on the control panel. Initially, the grid is off. The grid may be turned on and off at any time during an editing session and can be toggled between inches and centimetres at any time. A grid option will be provided on the reduce-to-fit view but the number of grid lines shown will be reduced to avoid filling the smaller diagram with grid lines.

Requirement problems

- Database requirements includes both conceptual and detailed information
  - Describes the concept of configuration control facilities
  - Includes the detail that objects may be accessed using an incomplete name
- Grid requirement mixes three different kinds of requirement
  - Conceptual functional requirement (the need for a grid)
  - Non-functional requirement (grid units)
  - Non-functional UI requirement (grid switching)

Structured presentation

> **2.6 Grid facilities**
> **2.6.1   The editor shall provide a grid facility where a matrix of horizontal and vertical lines provide a background to the editor window.** This grid shall be a p assive grid where the alignment of entities is the user's responsibility.
> *Rationale*: A grid helps the user to create a tidy diagram with well-spaced entities. Although an active grid, where entities 'snap-to' grid lines can be useful, the positioning is imprecise. The user is the best person to decide where entities should be positioned.
> *Specification*: ECLIPSE/WS/Tools/DE/FS Section 5.6

Detailed user requirement

> **3.5.1 Adding nodes to a design**
> 3.5.1.1   **The editor shall provide a f acility for users to add nodes of a specified type to their design.**
> 3.5.1.2   The sequence of actions to add a node should be as follows:
> 1. The user should select the type of node to be added.
> 2. The user should move the cursor to the approximate node position in the diagram and indicate that the node symbol should be added at that point.
> 3. The user should then drag the node symbol to its final position.
> *Rationale*: The user is the best person to decide where to position a node on the diagram. This approach gives the user direct control over node type selection and positioning.
> *Specification*: ECLIPSE/WS/Tools/DE/FS. Section 3.5.1

Guidelines for writing requirements

- Adopt a standard format and use it for all requirements
- Use language in a consistent way. Use "will" for mandatory requirements, "should" for desirable requirements
- Use text highlighting to identify key parts of the requirement
- Use computer jargon sparingly

System Requirements:
Functional and non-functional requirements

- Functional requirements
  - Statements of services the system should provide, how the system should react to particular inputs and how the system should behave in particular situations.
- Non-functional requirements
  - constraints on the services or functions offered by the system such as timing constraints, constraints on the development process, standards, etc.
- Domain requirements
  - Requirements that come from the application domain of the system and that reflect characteristics of that domain

Functional requirements

- Describe functionality or system services
- Depend on the type of software, expected users and the type of system where the software is used
- Functional user requirements may be high-level statements of what the system should do but functional system requirements should describe the system services in detail

Examples of functional requirements

- The user shall be able to search either all of the initial set of databases or select a subset from it.

- The system shall provide appropriate viewers for the user to read documents in the document store.

- Every order shall be allocated a unique identifier (ORDER_ID) which the user shall be able to copy to the account's permanent storage area.

Requirements imprecision

- Problems arise when requirements are not precisely stated

- Ambiguous requirements may be interpreted in different ways by developers and users

- How would you interpret the phrase "appropriate viewers" if you saw it in an SRS?
  - User intention - special purpose viewer for each different document type
  - Developer interpretation - Provide a text viewer that shows the contents of the document

Requirements completeness and consistency

- In principle requirements should be both complete and consistent
- Complete
  - They should include descriptions of all facilities required
- Consistent
  - There should be no conflicts or contradictions in the descriptions of the system facilities
- In practice, it is impossible to produce a complete and consistent requirements document
- Do you agree? Why or why not?

Non-functional requirements

- Define system properties and constraints e.g. reliability, response time and storage requirements. Constraints are I/O device capability, system representations, etc.
- Process requirements may also be specified mandating a particular CASE system, programming language or development method
- Non-functional requirements may be more critical than functional requirements. If these are not met, the system is useless

Non-functional classifications

- Product requirements
  - Requirements which specify that the delivered product must behave in a particular way e.g. execution speed, reliability, etc.
- Organisational requirements
  - Requirements which are a consequence of organisational policies and procedures e.g. process standards used, implementation requirements, etc.
- External requirements
  - Requirements which arise from factors which are external to the system and its development process e.g. interoperability requirements, legislative requirements, etc.

Non-functional requirement types
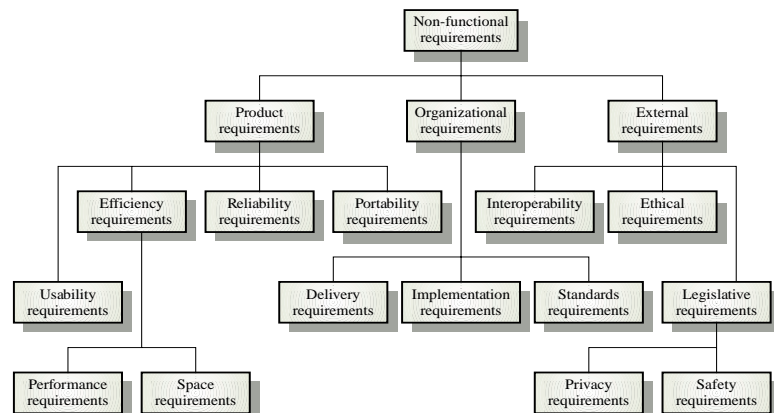
on-functional requirements examples

₁ Product requirement
  • 4.C.8 It shall be possible for all necessary communication between the APSE and the user to be expressed in the standard Ada character set

₁ Organisational requirement
  • 9.3.2 The system development process and deliverable documents shall conform to the process and deliverables defined in XYZCo-SP-STAN-95

₁ External requirement
  • 7.6.5 The system shall not disclose any personal information about customers apart from their name and reference number to the operators of the system

Goals and requirements

₁ Non-functional requirements may be very difficult to state precisely and imprecise requirements may be difficult to verify.

₁ Goal
  • A general intention of the user such as ease of use

₁ Verifiable non-functional requirement
  • A statement using some measure that can be objectively tested

₁ Goals are helpful to developers as they convey the intentions of the system users

Examples

₁ **A system goal**
  • The system should be easy to use by experienced controllers and should be organised in such a way that user errors are minimised.

₁ **A verifiable non-functional requirement**
  • Experienced controllers shall be able to use all the system functions after a total of two hours training. After this training, the average number of errors made by experienced users shall not exceed two per day.

Requirements measures

Property	Measure
Speed	Processed transactions/second User/Event response time Screen refresh time
Size	K Bytes Number of RAM chips
Ease of use	Training time Number of help frames
Reliability	Mean time to failure Probability of unavailability Rate of failure occurrence Availability
Robustness	Time to restart after failure Percentage of events causing failure Probability of data corruption on failure
Portability	Percentage of target dependent statements Number of target systems

Requirements interaction

₁ Conflicts between different non-functional requirements are common in complex systems

₁ Spacecraft system
  • To minimise weight, the number of separate chips in the system should be minimised
  • To minimise power consumption, lower power chips should be used
  • However, using low power chips may mean that more chips have to be used. Which is the most critical requirement?

Domain requirements

₁ Derived from the application domain and describe system characteristics and features that reflect the domain

₁ May be new functional requirements, constraints on existing requirements or define specific computations

₁ If domain requirements are not satisfied, the system may be unworkable

Library system domain requirements

- There shall be a standard user interface to all databases which shall be based on the Z39.50 standard.

- Because of copyright restrictions, some documents must be deleted immediately on arrival. Depending on the user's requirements, these documents will either be printed locally on the system server for manually forwarding to the user or routed to a network printer.

Train protection system

- The deceleration of the train shall be computed as:

  - $D_{train} = D_{control} + D_{gradient}$

  where $D_{gradient}$ is $9.81ms^2$ * compensated gradient/alpha and where the values of $9.81ms^2$ /alpha are known for different types of train.

Domain requirements problems

- Understandability
  - Requirements are expressed in the language of the application domain
  - This is often not understood by software engineers developing the system

- Implicitness
  - Domain specialists understand the area so well that they do not think of making the domain requirements explicit
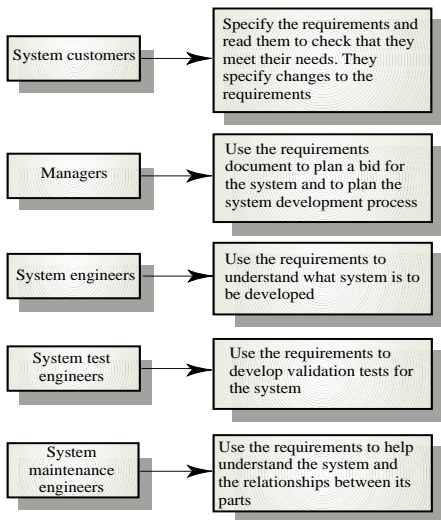
System requirements

- More detailed than user requirements
- Serve as a basis for the design document
- May be used as part of the system contract
- System requirements may be expressed using system models discussed in Chapter 7

Requirements and design

- In principle, requirements should state what the system should do and the design should describe how it does this

- In practice, requirements and design are inseparable
  - A system architecture may be designed to structure the requirements
  - The system may inter-operate with other systems that generate design requirements
  - The use of a specific design may be a domain requirement

The system requirements document

- Also known as the SRS (systems requirement specification)
- The requirements document is the official statement of what is required of the system developers
- Should include both a definition and a specification of requirements
- It is NOT a design document. As far as possible, it should set of WHAT the system should do rather than HOW it should do it

System customers	Specify the requirements and read them to check that they meet their needs. They specify changes to the requirements
Managers	Use the requirements document to plan a bid for the system and to plan the system development process
System engineers	Use the requirements to understand what system is to be developed
System test engineers	Use the requirements to develop validation tests for the system
System maintenance engineers	Use the requirements to help understand the system and the relationships between its parts

Users of a requirements document

equirements document requirements

- Specify external system behaviour
- Specify implementation constraints
- Easy to change
- Serve as reference tool for maintenance
- Record forethought about the life cycle of the system i.e. predict changes
- Characterise responses to unexpected events

IEEE requirements standard

- Introduction
- General description
- Specific requirements
- Appendices
- Index
- This is a generic structure that must be instantiated for specific systems

Requirements document structure

- Introduction
- Glossary
- User requirements definition
- System architecture
- System requirements specification
- System models
- System evolution
- Appendices
- Index

Key points

- Requirements set out what the system should do and define constraints on its operation and implementation
- Functional requirements set out services the system should provide
- Non-functional requirements constrain the system being developed or the development process
- User requirements are high-level statements of what the system should do

Key points

- User requirements should be written in natural language, tables and diagrams
- System requirements are intended to communicate the functions that the system should provide
- A software requirements document is an agreed statement of the system requirements