Requirements and specifications

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Expectations

vs reality

From specifications, to requirements

Specifications are a **contract** between us and the customer

- At a first step, we define what the system must do, and we derive a set of requirements
  - Specification requirements
  - We speak of software functionalities

Then, for each phase of the development flow, we create a more detailed/tech set of requirements

- System specs&reqs
- Module/component specs&reqs
- From each of them, we create tests

These are agreed between designers and developers, the customer has nothing to do with this!

- Unless he has some constraint / expertise in the field
- Beware: often, the customer thinks that SW development is easy!
- *"Lo fa anche ammiocuggino"*

What vs How

Specs tells us **what** the system should do

- So, functional requirements do

Implementation tells us **how** the system does things

- So, system/module/component requirements do
- Typically, start with a top-down (*divide-et-impera*) approach, and include existing modules, if necessary

Every step of the development process defines a contract between its sub-parts

- This contract can be, e.g., a Middleware protocol in the system design phase, or Java interfaces of the sub-modules of a single module/component

..and so on, and so on…

- The deeper we go in the process, the more in detail we go with technology

What vs How: example

What: users shall authenticate in the system

How

- Users shall enter their data in a form
- Design: is it a custom webform? Is it a google form?

More deeper

- Users shall enter the password in an obfuscated field in the webform, and click “submit”

Even more deeper

- The data shall be transmitted to a webservice that returns 400 in case age is null

…and so on, and so on…

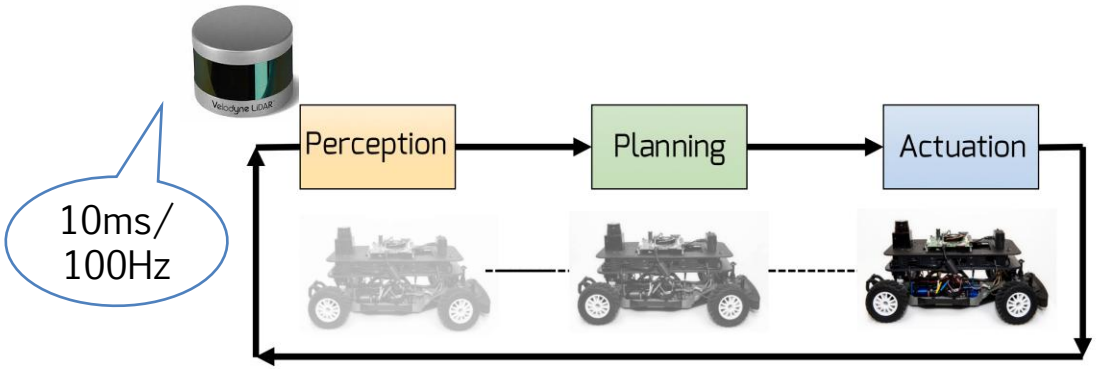
Highest-level: system requirements

Requirements describe of system functionalities

- Every requirement describes a specific use-case / scenario
- Functional requirements to describe how the system reacts to input, which output it produces and how its state changes (e.g., a DB)
- Non-functional requirements describe properties such as performance, reliability, etc

Domain-specific requirements

- Often, implicit, and the customer won't tell you!
- Ex: Real-time systems, deal with worst case execution time, not with average case exection time, and it is a **functional** requirement



FURPS model

Requirements are classified in:

- Functionality
- Usability
- Reliability
- Performance
- Supportability

Communicating the requirements

"The hardest single part of building a software system is deciding precisely what to build" (Fred Brooks)

- Often, not even customers know what they want

Specifications must be

- Clear, non-ambiguous
- Consistent among them
- Complete
- Incrementally build with customer

Communicating the requirements

We use formalism

- E.g., Finite State Machines, Use-case charts, E/R diagrams
- Might depend on the specific application domain (e.g., FSM are good for RT systems)
- We'll see them later on….

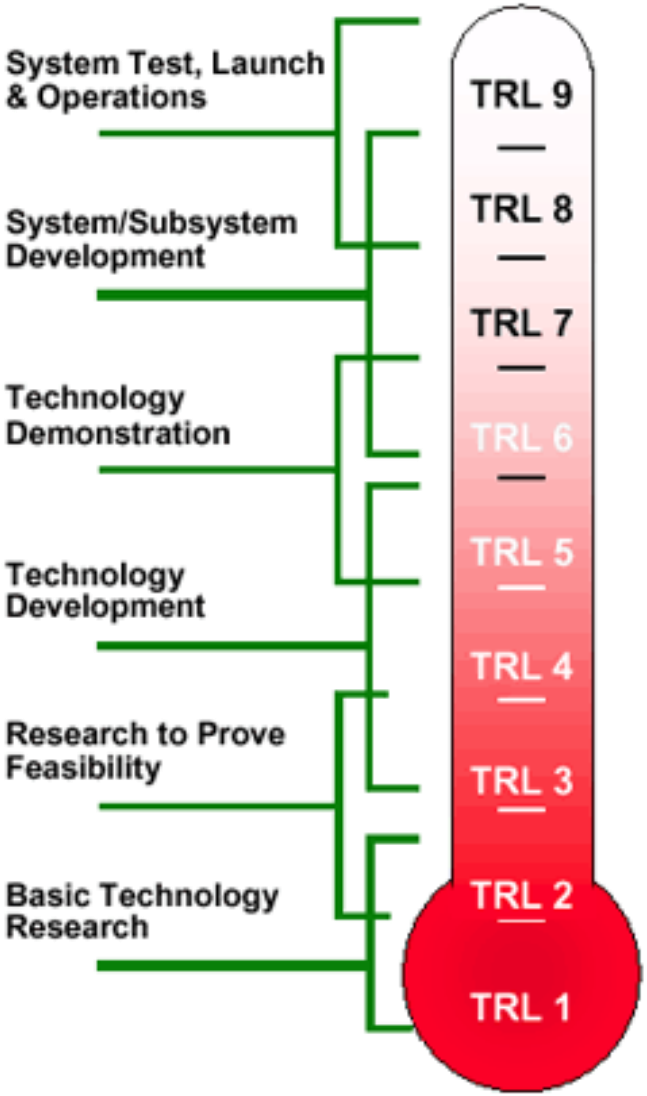
Specifications can be

- Operational: what the system shall do
  - "The system must record users' age"
- Descriptional: how the system is made
  - "We store users' data, such as age, in a DB" – "We expose a web server"
- Tech: how the system is implemented
  - Typically, due to existing applications/legacy codebase

TRL – Technology readiness level

A Number from 1 to 9 estimating the maturity of a technology

› Developed by NASA in 1970s for the space missions



Assessing TRL of SW

TRL	NASA usage[4]	European Union[5]
1	Basic principles observed and reported	Basic principles observed
2	Technology concept and/or application formulated	Technology concept formulated
3	Analytical and experimental critical function and/or characteristic proof-of concept	Experimental proof of concept
4	Component and/or breadboard validation in laboratory environment	Technology validated in lab
5	Component and/or breadboard validation in relevant environment	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
6	System/subsystem model or prototype demonstration in a relevant environment (ground or space)	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
7	System prototype demonstration in a space environment	System prototype demonstration in operational environment
8	Actual system completed and "flight qualified" through test and demonstration (ground or space)	System complete and qualified
9	Actual system "flight proven" through successful mission operations	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

› Always remember: it depends on the Operational Scenario! F1/10 example…

Software Requirement Specification (SRS)

Software Requirement Specification (SRS)

IEEE 830 standard (circa 1998)

- Used only for requirements, does not speak of implementation, nor about quality of code

It must be:

- Correct
- Unambiguous
- Complete
- Consistent
- Orders requirement by their priority/level of abstraction
- Verifiable
- Modifiable
- Traceable

Software Requirement Specification (SRS)

Correct

› To correctly model system behaviour

Unambiguous

› Has the right notations, terminology and Data Dictionary (DD)

› No ambiguity in language: use **must/not** and **shall/not**

› Based on the concept of entity, process, behaviour

Complete

› Covers all requirements, functional and non-functional

› Defines a response for every possible state/input of the system (spoiler: FSMs do)

› Enhanced with figures

Software Requirement Specification (SRS)

Consistent

- No conflicts might arise
- Typically, because multiple contributors to the document don't speak each other!!!
- Defining a syllabus / DD is the first step

Orders requirement by their priority/level of abstraction

- Assign an identifier, and a priority
- Describe the requisite in details
- E.g., Failure Mode and Effects Analysis (FMEA) for electronic devices

Verifiable

- Assign metrics and Key Performance Indicators to requirements
- «Response time under 7 secs [in 90% of cases]»

Software Requirement Specification (SRS)

Modifiable

- Often, requirements change
- The document must be well organized, and requirements should not be redundant

Traceable

- We shall understand where each requirements come from
- High level (e.g., functional) requirements must be approved by the customer
- Tech requirements are typically agreed between the dev team

Example of requirements for svc/db modules

- Functional requirement

ID	Description	Parents
USR_568	The user must be able to modify his/her birth date in DB	

- SVC component requirement

ID	Description	Parents	Siblings
WEBSVC_11	~~The web services returns 400 if age is null~~ The web services handle null value errors in DB returning 400	USR_568, …	DBMS_49784, …

- DBMS component requirement

ID	Description	Parents	Siblings
DBMS_49784	DB shall throw an exception if age is null	USR_568, WEBSVC_11, …	

Structure of a SRS

1. Introduction
    - 1.1 Purpose document
    - 1.2 Scope of the document
    - 1.3 Definitions, acronyms and abbreviations
    - 1.4 [References]
    - 1.5 Overview / document structure
2. General description
    - 2.1 Product perspective
    - 2.2 Product functions
    - 2.3 User characteristics
    - 2.4 General constraints
    - 2.5 Assumptions and dependencies
    - 2.6 Apportioning of requirements
3. Requirements
    - 3.1 System interface and frontend
    - 3.2 Functional requirements
    - 3.3 Non-functional requirements

Appendix / [References]

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1. Introduction

1.1 Purpose of the document

- What is our goal (remember: customer might not have a complete idea, so better clarifying everything!)
- Audience (tech people? Non tech people?)

1.2 Scope of the document

- Name of the product
- Goals
- Benefits
- What we plan to do/solve
- What we don't plan to do/solve now
- What we might plan to do/solve in the future

1. Introduction

1.3 Definitions, acronyms and abbreviations

› Typically, a list + table for acronyms

1.4 References

› Can also be in appendix

1.5 Overview / document structure

› Briefly and concisely, go through every section

› In case of migrations, typically they are split in *as-is* + *to-be*

2. General description

Main features of our system, and main rules constraints it shall adhere to

- Not yet the real requirements..

2.1 Product perspective – similar products

- 2.1.1 System interface
  - Are we using a framework/middleware? Which Web server?
- 2.1.2 User interface
  - WebApi? WebForm?
- 2.1.3 Hardware interface
  - How to configure it
- 2.1.4 Software interface
  - Which libraries to use
  - Interface towards other systems and services (e.g., an existing DB)

2.1 Product perspective (cont'd)

- 2.1.5 Communication interface
  - TCP/IP? MQTT? ROS2?
- 2.1.6 Memory requirements
  - Remember that I work in embedded systems…
- 2.1.7 Initialization, backup and recovery
  - ….
- 2.1.8 Installation and configuration
  - In case of micro-services, for instance, we deploy auth and comm bus first…
  - What is the security level? Do we need to set up a DMZ? An application gateway?

2. General description

2.2 Product functions

- What do the system do?
- Not too many details…

2.3 User characteristics

- Newbie, experts in the domain, tech vs. non-tech
- Will they require a training to use the system? If so, we must provide a cost entry for this in quotation!

2.4 General constraints

- Functional and performance, when interacting with other systems
- Parallel/concurrent system? I.e., a web server
- Any criticality

2. General description

2.5 Assumptions and dependencies

› Existing system, knowledge base, licenses

2.6 Apportioning of requirements

› We are not omniscient! We cannot know everything (especially at this stage ☺)

› Specify which are these aspects, and **who** shall work on them

3. (Func and non-func) requirements

3.1 System interface / frontend

- Refines what's in 2.1 and 2.2
- Input and output data formats, and protocols

3.2 Functional requirements

- Every requirements has a dedicated table/sheet, or/and a row in a table
- Intro: specifies the context, the functionality, and the entities/actors involved
- Input and output
- Description:
  - Validation /format of data
  - Operations that will be performed
  - What happens in case of errors?
  - What output should we expect?
  - Etc..

3.2 Functional requirement: example

NOTE this is just *a possible representation*. As soon as you are clear, complete, etc, you can devise your own!

USR_568	User account	Update birth date
Input	User ID, the new birth date	
Description	User wants to update the birth date with a new one; the system updates it, and, in case user does not exist, it creates a new user with empty fields	
Error messages	In case birth date is a future date, or it is empty, an error with a meaningful message is shown. The error is shown in user language, as described in requirement LOCAL_45	
Output	Information is updated in the persistent storage; all views that contain the datum are automatically updated, or get the fresh new datum when manually updated.	

› (Possible additional) compact representation

ID	Description	Parents
USR_568	The user must be able to modify his/her birth date in DB	

3.2 Functional requirement: example

NOTE this is just *a possible representation*. As soon as you are clear, complete, etc, you can devise your own!

ID | Area | Short desc

USR_568	User account	Update birth date
Input	User ID, the new birth dat	
Description	User wants to update the birth da with a new one; the system updat it, and, in case user does not exist, it creates a new user with empty fields	
E	~~in case birth date~~ is a future date, or it is empty, an error with a meaningful message is shown. The error is shown in user language, as described in requirement LOCAL_45	
Output	Information is updated in the persistent storage; all views that contain the datum are automatically updated, or get the fresh new datum when manually updated.	

Explicitly declaring additional (sub) functionalities

Refer to other req

Non-tech language

Here, we also assume that other modules/areas have different optional functionalities

› (Possible additional) compact rep

ID	Description	Parents
USR_568	The user must be able to modify his/her birth date in DB	

3.3 Non-functional requirements

3.3.1 Performance requirements

- How many concurrent accesses?
- How many users shall we store?
- How many concurrent asynchronous workflows shall we have in-place?

3.3.2 Database / storage

- Do we have any tech constraint?

3.3.3 General constraints

- Shall we adhere to standards?
- Do we have HW limitations / OS constraint?
- Shall we use some specific language?
- ....

3.3.4 System attributes

Reliability / dependability

› Down time, faults we can/shall/must tolerate…

Accessibility

› Checkpoints, backup, recovery time under faults…

Security

Mantainability

Portability

3.3.5. Other requirements

Development / staging / production software lines

- CI/CD pipelines
- Possible public releases

User groups, visibility rules, access rules

Scalability

- Performance: “up” and “out” (replicas)
- Number of users
- Cost/pricing of scalability

Appendix / index

Everything that is non-essential should go in appendix

- Ex: we use AWS. It is useful to know its structure and protocol, because we might interact with it. But we shouldn't embed a full guide to AWS in our Section 2!!!
- Also, typically references are here

Index

- Index of sections
- Index of terms..?
- …

References

Course website

- http://hipert.unimore.it/people/paolob/pub/ProgSW/index.html

Book

- I. Sommerville, "Introduzione all ingegneria del software moderna", Pearson
- Chapter 6-7-8 for requirements and system analysis

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