LTAT.05.003
Software Engineering

Lecture 02:
Requirements Engineering – Part 1

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Fall 2020
Schedule of Lectures

Week 01: Introduction to SE

Week 02: Requirements Engineering I

Week 03: Requirements Engineering II

Week 04: Analysis

Week 05: Development Infrastructure

Week 06: Continuous Development and Integration

Week 07: Project Estimation / Architecture and Design I

Week 08: Architecture and Design II

Week 09: Verification and Validation I

Week 10: Verification and Validation II

Week 11: Refactoring (and TDD)

Week 12: Agile/Lean Methods

Week 13: Industry Guest Lecture

Week 14: Course wrap-up, review and exam preparation

Week 15: Reserve time slot (no lecture scheduled as of today)
Goal of this Lecture:
To give answers to the following questions ...

What is ‘Requirements Engineering’?
Why is RE important?
Why is RE difficult?
Who is involved in RE?
What are ‘Requirements’?
What types of requirements exist?
What levels of requirements exist?

What activities are involved in RE?
How to elicit requirements?
How to represent/document requirements?
How to use requirements for project planning?
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To give answers to the following questions ...

What is ‘Requirements Engineering’?
Why is RE important?
Why is RE difficult?
Who is involved in RE?
What are ‘Requirements’?
What types of requirements exist?
What levels of requirements exist?
What activities are involved in RE?
How to elicit requirements?
How to represent/document requirements?
How to use requirements for project planning?

to be continued next week
Structure of Lecture 02

- Recap from last week: User Stories
- The Nature of Requirements Engineering (RE)
- The Nature of Requirements
- The Process of RE
Comparison of Basic Process Types

Functionality

Time

Requirements

Design

Implementation

Testing

Waterfall

Incremental, e.g. RUP

Agile - XP

RUP = Rational Unified Process
XP = Extreme Programming
Lab 1 Assignment

Joostes Marss AS

Customer: Home Improvement International (HII)

POS System

To do:
- Interviews to identify roles and requirements (user stories)
- List of 20 functional user stories
- List of 10 non-functional user stories (performance & usability)
Lab 1 Assignment

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Customer: Home Improvement International (HII)

POS System

To do:
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- List of 20 functional user stories
- List of 10 non-functional user stories (performance & usability)

Have a look at the videos on the course wiki:
→ YouTube videos by Lars Bilde (Kaj Car Rental Service)
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Lectures

Note: The following schedule is still subject to possible alterations in the second half of the semester.

- Lecture 1 (06-Sep-2019) - Introduction to Software Engineering
  - Course Organization: (pdf-2019-1)
  - Overview of Software Engineering: (pdf-2019-2)
  - Homework Assignment 1: (pdf-2019-3)
  - Video: (video-2018)

- Lecture 2 (13-Sep-2019) - Requirements Engineering I
  - Slides: (pdf-2019)
  - Video:
    - Lean requirements (by Atlassian)
    - INVEST in good Stories, and SMART Tasks (by Bill Wake)
    - Hints on how to write testable requirements
    - Balsamiq - A tool for developing wireframes (Mockups)
  - A series of YouTube videos by Lars Bilde explaining the steps from first interviews with stakeholders to user stories, tasks, and sprint planning (note: these videos promote the use of the commercial tool ScrumWise - any other backlog management and sprint planning tool may be used instead):
    - Initial user stories extracted from interview
    - First backlog items (user stories)
    - Finding more User Stories from existing User Stories (e.g., by splitting up)
    - Splitting User Stories into Tasks?
    - General remarks about the right level of backlog planning detail
    - Planning the first (or next) sprint
    - Time tracking with the Task Board
    - Sprint Burndown Chart
User Stories

As a tenant | I can lock the doors | to protect my apartment.

role (benefactor) capability (action/means) business-value (motivation/rationale/end)

who - what - why

• Similar to NL requirements, but focus on the user benefits, instead on system characteristics (alone).

• Unfortunately, third element (business-value) is often omitted

• Preferred technique in agile methods.
User Story:

As a tenant | I can lock the doors | to protect my apartment.

- role (benefactor)
- capability (action/means)
- business-value (motivation/rationale/end)

... to make sure my child (or my pet) cannot get out unexpectedly
... to make sure I don’t forget my keys when I leave again

- Similar to NL requirements, but focus on the user benefits, instead on system characteristics (alone).
- Unfortunately, third element (business-value) is often omitted
- Preferred technique in agile methods.
‘Normal’ User Story

<Actor/Role>  As a tenant
...  

<Action>  I can lock the doors
...  

<Value>  to protect my apartment (from burglars)

A good User Story is:
- Independent
- Negotiable
- Valuable
- Estimable
- Small
- Testable

INVEST
‘Normal’ User Story – Independent

<Actor/Role>   As a tenant

...  

<Action> I can lock the doors

... 

<Value> to protect my apartment (from burglars)

INDEPENDENT: 
- Does not overlap with or subsume concepts occurring in other user stories
- Can be scheduled and implemented in any order
‘Normal’ User Story – Negotiable

<Actor/Role>  As a tenant

...  

<Action>  I can lock the doors  

...  

<Value>  to protect my apartment (from burglars)  

NEGOTIABLE:
- It is not an explicit contract for features; rather, details will be co-created by the customer and programmer during development.

Note: A good user story captures the essence, not the details.
‘Normal’ User Story – Valuable

<Actor/Role> As a tenant

... I can lock the doors

... to protect my apartment (from burglars)

VALUABLE:
- The user story is valuable to the customer

NOTE: We are mainly interested in value for the customer; if the role in a user story is not the customer, then we should still be able to explain it’s value for the customer
‘Normal’ User Story – Estimable

<Actor/Role> As a tenant

... 

<Action> I can lock the doors 

... 

<Value> to protect my 
apartment (from 
burglars) 

---

ESTIMABLE
- No exact estimate needed, just enough to rank and schedule the user story’s implementation

Note: Being estimable is partly a function of
- being negotiable
- size (small is easier to estimate)
- team’s experience
‘Normal’ User Story – Small

<Actor/Role>  As a tenant

...  

<Action>  I can lock the doors

... 

<Value>  to protect my apartment (from burglars)

Note:
- User stories typically should represent at most a few person-days worth of work
- Smaller user stories are easier to estimate
‘Normal’ User Story – Testable

<Actor/Role> As a tenant
...

<Action> I can lock the doors
...

<Value> to protect my apartment (from burglars)

TESTABLE: Writing a good user story carries an implicit promise: “I understand what I want well enough that I could write a test for it.”
‘Normal’ User Story – Testable

<Actor/Role> As a tenant

... I can lock the doors

... to protect my apartment (from burglars)

Acceptance test (1):

Given that the door has not been locked (state='unlocked' or 'open'):
Check whether the door can be locked with correct key.

Pass: door changes state to 'locked'
Fail: door doesn’t change state to 'locked'
‘Normal’ User Story – Testable

<Actor/Role> As a tenant
...

<Action> I can lock the doors
...

<Value> to protect my apartment (from burglars)

Acceptance test (2):

Given that the door has not been locked (state='unlocked' or 'open'):
Check whether the door can be locked {without key / with incorrect key}

Pass: door doesn’t change state to 'locked'
Fail: door changes state to 'locked'
‘Normal’ User Story – Testable

<Actor/Role> As a tenant

... 

<Action> I can lock the doors

... 

<Value> to protect my apartment (from burglars)

Acceptance test (3):

Given that the door has been locked (state='locked'):
Check whether the attempt to lock triggers the expected behaviour.

Pass: message ’door is already locked’ is issued’ and state unchanged.
Fail: door changes state | no message
Bad User Story Example /1

<Actor/Role> As a system user
<Action> I want to send and receive emails
<Value> to ...

What is bad?
Bad User Story Example /1

<Actor/Role> As a system user
<Action> I want to send and receive emails
<Value> to …

-----------------------------------------------

<Actor/Role> As a system user
<Action> I want to send and reply to emails
<Value> to …

NOT independent:
US1 overlaps with US2

Better:
US1: … send [new] email ...
US2: ... receive emails ...
US3: ... reply to emails …
Bad User Story Example /2

<Actor/Role> As a fulfilment clerk
<Action> I want to get a note telling which items to send, from which shelf to pick the items, how to write the receipt, and where to deliver …
<Value> to …

What is bad?
Bad User Story Example /2

<Actor/Role> As a fulfilment clerk
>Action> I want to get a note
telling which items to
send, from which shelf
to pick the items, how
to write the receipt, and
where to deliver …
<Value> to …

NOT negotiable:
US gives too much
implementation detail.

Better to start with:
US: As a fulfilment
clerk, I can send a
book and receipt, to …

The details of how to
do this (i.e., what and
how to automate the
process can be
negotiated)
Bad User Story Example /3

<Actor/Role> As an end user
<Action> I want to see error messages in any language I want
<Value> --

What is bad?
Bad User Story Example /3

<Actor/Role> As an end user
<Action> I want to see error messages in any language I want
<Value> --

NOT valuable:
Value depends on what we try to achieve, e.g.:
- Increase revenue
- Avoid cost
- Improve service
- Meet requirements
- Build reputation
- Create options
- Generate data

… for our stakeholders
Bad User Story Example /4

<Actor/Role> As a fulfillment clerk
<Action> I want to send a book and receipt
<Value> to …

What is bad?
Bad User Story Example /4

<Actor/Role> As a fulfillment clerk
<Action> I want to send a book and receipt
<Value> to …

NOT estimable:
The user story is too vague and still needs to be negotiated and broken up into several more specific user stories.

Note: We often want to estimate a story before it is fully understood; ‘negotiable’ – ‘size’ – and ‘estimable’ are related and typically change over time.
Bad User Story Example /5

<Actor/Role>  As a system user
<Action>     I want to send emails to all my relatives
<Value>      to …

What is bad?
Bad User Story Example /5

<Actor/Role> As a system user
<Action> I want to send emails
to all my relatives
<Value> to …

NOT testable:
The user story is contains elements of ambiguity and subjectivity which make it hard to test

Typical words that signal problems with testability are: all, always, just, only, any, right, suitable, appropriate, best, worst, fast, shortest, longest, …
Structure of Lecture 02

• Recap from last week: User Stories
• The Nature of Requirements Engineering (RE)
• The Nature of Requirements
• The Process of RE
Definition: Requirements Engineering

RE is the process of establishing

- the **services** that the customer requires from a system

and

- the **constraints** under which it operates and is developed.

RE means to ...

... **dig up**, understand, write down, check, prioritize, select, follow up on ...

... the **functions and properties** of (software) products
The Goal of RE

- What the Customer wants
- What the Customer needs
- What the Software (to-be) does

Application Domain (User Requirements)

System Domain (System Requirements)
Why is RE important?

Requirements (Specification) are central for development and verification / validation.

From: Soren Lauesen: Software Requirements © Pearson / Addison-Wesley 2002
Economic Consequences of RE Problems

![Graph showing cost of correcting a problem in different phases: Req, Design, Coding, System Testing, Acceptance Testing, Operation. Cost increases significantly during Operation.]

[Davis, 1992]
RE is difficult, because …

- It typically involves **many stakeholders**.
- Stakeholders (often) **don’t know** what they really want.
- Stakeholders **express requirements in their own terms** (might be imprecise, ambiguous).
- Different stakeholders may have **conflicting requirements**.
- **Organisational and political factors** may influence the system requirements.
- **New stakeholders** may emerge and the **business environment change**.
- The requirements **change during the analysis process**.
Stakeholders in SE

External:
- Customers
  - Those who pay for the software
- Users
  - Those who use the software

Internal:
- Software Developers
- Development (Project) Managers
- Product Managers
- ...

Example of a Real World Situation (Mobile Phones)

Where do all requirements come from?

... find the right person to talk to ...

... get the deep domain knowledge ...
Example: Ambiguous Requirement

The tiny word ’only’

Version 1:
• *The spam filter* **only delivers** the e-mail that the user wants.

Version 2:
• *The spam filter* **delivers only** the e-mail that the user wants.

Same meaning? If not, what’s the difference?
Example: Ambiguous Requirement

The tiny word ‘only’

Version 1:
- The spam filter **only delivers** the e-mail that the user wants.

Version 2:
- The spam filter **delivers only** the e-mail that the user wants.

(Unfortunately, Version 2 is not considered correct English in the UK. The word ‘only’ must always go before the main verb.)
Example: Ambiguous Requirement

• Requirement: ‘As a user of the Library Information System (LIS) I shall be able to search the recent publications lists for all libraries.’
Example: Ambiguous Requirement

- Requirement: ‘As a user of the Library Information System (LIS) I shall be able to search the recent publications lists for all libraries.’

- Consider the term ‘search … for all’:
Example: Ambiguous Requirement

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- Consider the term ‘search … for all’:
Example: Ambiguous Requirement

- Requirement: ‘As a user of the Library Information System (LIS) I shall be able to search the recent publications lists for all libraries.’

- Consider the term ‘search … for all’: 

\[\text{User intention: search for a publication across all recent publications lists in all libraries;}
\]
\[\text{Developer interpretation: search for a publication in an individual recent publications list. User first chooses library then searches list.}
\]

Imprecise (ambiguous) requirements may be interpreted in different ways by developers and users.
Example: Ambiguous Requirement

- Requirement: ‘As a user of the Library Information System (LIS) I shall be able to search the recent publications lists for all libraries.’

- Consider the term ‘search … for all’:
  - User intention: search for a publication across all recent publications lists in all libraries;
  - Developer interpretation: search for a publication in an individual recent publications list. User first chooses library then searches list.

- Imprecise (ambiguous) requirements may be interpreted in different ways by developers and users.
Example: Conflicting Requirements

• A performance requirement may indicate that
  • a core system must be updated in real time
  but
  • the size and scope of the system (as defined by other requirements) may preclude this.
  Updating such a large system may not be possible in real time.

• Need to apply conflict resolution procedures (→ negotiation with stakeholders)
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Functional vs. Non-Functional Requirements

**Functional reqs:**

- What the system shall do
- Often intended to be implemented as a whole or else not implemented at all
- Often regards input/output **data** and **functions** that process the input data to produce the output

**Non-functional reqs (NFR), Quality Requirements, (extra-functional reqs):**

- How good the system shall do it
- Often measured on a scale
- Often put constraints on the system (or the development process)
- Often cross-cutting, may impact many functions

- Performance
- Reliability
- Usability
- Safety, Security
- Interoperability
- Maintainability
- ...

*But the division is not black and white...*
What non-functional (=quality) requirements do you expect from a Student Information System (SIS)?
SW Product Quality -> ISO 9126 (now ISO 25000)

Efficiency = Performance

Software Quality Model
(ISO 9126 – Part 1)
Example – Efficiency Requirements

Performance requirements:

R1: Product shall be able to process 100 payment transactions per second in peak load.

R2: Product shall be able to process one alarm in 1 second, 1000 alarms in 5 seconds.

R3: In standard work load, CPU usage shall be less than 50% leaving 50% for background jobs.

R4: Scrolling one page up or down in a 200 page document shall take at most 1 s. Searching for a specific keyword shall take at most 5 s.

R5: When moving to the next field, typing must be possible within 0.2 s. When switching to the next screen, typing must be possible within 1.3 s. Showing simple report screens, less than 20 s. (Valid for 95% of the cases in standard load)

R6: A simple report shall take less than 20 s for 95% of the cases. None shall take above 80s. (UNREALISTIC)

Cover all product functions?

From: Soren Løniesen. Software Requirements
© Pearson / Addison-Wesley 2002

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## Example – Usability Requirements

<table>
<thead>
<tr>
<th>Problem counts</th>
<th>Task time</th>
<th>Keystroke counts</th>
<th>Opinion poll</th>
<th>Score for understanding</th>
<th>Design-level reqs</th>
<th>Product-level reqs</th>
<th>Guideline adherence</th>
<th>Development process reqs</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1: At most 1 of 5 novices shall encounter critical problems during tasks Q and R. At most 5 medium problems on list.</td>
<td>R2: Novice users shall perform tasks Q and R in 15 minutes. Experienced users tasks Q, R, S in 2 minutes.</td>
<td>R3: Recording breakfast shall be possible for any guest. No mouse.</td>
<td>R4: 80% of users shall find system easy to use and recommend system to others.</td>
<td>R5: Show 5 users 10 common error messages large. Ask for the cause. 80% of the time users find them large.</td>
<td>R6: System shall use screen pictures in app. xx, buttons work as app. yy.</td>
<td>R7: For all code fields, user shall be able to select value from drop-down list.</td>
<td>R8: System shall follow style guide zz. Menus shall have at most three levels.</td>
<td>R9: Three prototype versions shall be made and usability tested during design.</td>
</tr>
</tbody>
</table>
From Goal to Design

Requirements can be formulated at various levels:

- **Goal-level requirement**
  - R1. Our pre-calculations shall hit within 5%

- **Domain-level requirement**
  - R2. Product shall support cost recording and quotation with experience data
  - R3. Product shall have recording and retrieval functions for experience data

- **Product-level requirement**
  - R4. System shall have screen pictures as shown in app. xx

- **Design-level requirement**

Underlying purpose, business, goals, expected/intended improvements

Context, how user and system-to-be-developed collaborate in order to achieve the goals

Externally visible functions and properties of the system

Precise description of data, functions, user-interfaces, etc.

From: Søren Lauesen: Software Requirements
© Pearson / Addison-Wesley 2002
From Goal to Design

• Requirements can be formulated at various levels:

  - **Goal-level requirement**: Underlying purpose, business, goals, expected/intended improvements
  - **Domain-level requirement**: Context, how user and system-to-be-developed collaborate in order to achieve the goals
  - **Product-level requirement**: Externally visible functions and properties of the system
  - **Design-level requirement**: Precise description of data, functions, user-interfaces, etc.

  - **R1. Our pre-calculations shall hit within 5%**
  - **R2. Product shall support cost recording and quotation with experience data**
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  - **R4. System shall have screen pictures as shown in app. xx**

From: Soren Lauesen: Software Requirements © Pearson / Addison-Wesley 2002
Structure of Lecture 02

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- The Nature of Requirements Engineering (RE)
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RE Activities

Requirements gathering (= Requirements elicitation)
- Interacting with stakeholders to discover their requirements:
  - What is to be accomplished?
  - How the system will fit into the needs of the business?
  - How the system will be used on a day-to-day basis?

Requirements analysis
- Refining, classifying/clustering, structuring, prioritizing, and modifying the gathered requirements

Requirements specification
- Documenting the (system) requirements in a semiformal or formal manner to ensure clarity, consistency, and completeness

Requirements validation
- Checking the requirements
RE Activities: Iteration & Concurrency

- Initial information
- Scope
- Constraints

- Analyze
  - classify,
  - organize,
  - prioritize,
  - negotiate

- Elicit

- Validate

- Specify

- Model

+ Requirements traced back to their source

- Requirements Management

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To be continued next week
Elicitation Techniques

- Analyzing existing documents & data
- “Brainstorming” possible requirements
  - within the dev. Team
- Interviews (one-on-one)
  - This is what you need to do for Lab 1…
- Focus groups or workshops (one-on-many)
  - useful for larger projects
- Prototyping/mockups
- Meetings with the customer/users
  - E.g. for checkpoints, or showing prototypes

...
Analyzing documents & data

Sources of information:

- company reports, organization charts, policy manuals, job descriptions, reports, documentation of existing systems, etc.

Advantages:

- Helps the analyst to get an understanding of the organization before meeting the people who work there
- Helps to prepare for other types of fact finding
e.g. by being aware of the business objectives of the organization.
- may provide detailed requirements for the current system

Disadvantages:

- written documents often do not match up to reality
- Can be long-winded with much irrelevant detail
Meetings

• Used for summarization and feedback
  • E.g. meet with stakeholders towards the end of each stage:
• Every meeting should have a clear objective:
  • E.g. presentation, problem solving, conflict resolution, progress analysis, gathering and merging of facts, training, planning,...
• Plan the meeting carefully:
  • Schedule the meeting and arrange for facilities
  • Prepare an agenda and distribute it well in advance
  • Keep track of time and agenda during the meeting
  • Follow up with a summary to be distributed to meeting participants
Next Lecture

• Date/Time:
  • Friday, 18-Sep, 10:15-12:00

• Topic:
  • Requirements Engineering II
    • Representation styles
    • Planning based on requirements

• For you to do:
  • Get started with homework assignment 1!
  • Go to labs next week: assessment of intermediate results for homework assignment 1
Acknowledgements

Textbooks:

(http://www.softwareengineering-9.com/)

Ivan Marsic: Software Engineering, 2012
(http://www.ece.rutgers.edu/~marsic/books/SE/book-SE_marsic.pdf)

Sören Lauesen: Software Requirements - Styles and Techniques, Pearson Education, 2002

Lectures on RE:

Prof. Björn Regnell, Lund University, Sweden

Prof. Steve Easterbrook, University of Toronto, Canada