LTAT.05.003
Software Engineering

Lecture 03:
Requirements Engineering – Part 2

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email: dietmar.pfahl@ut.ee

Fall 2018
ICS Day 2018 – Friday, 05 October

When? – 14:15
Where? – Paabel (Ülikooli 17)
What? –
  To bring together students and academic/research staff
  To introduce interesting research directions that are carried out in the institute
  To network and find topics for Bachelor's and Master's theses

More info:
# Schedule of Lectures

<table>
<thead>
<tr>
<th>Week 01: Introduction to SE</th>
<th>Week 10: <em>Continuous Development</em> and <em>Integration</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 02: Requirements Engineering I</td>
<td>Week 11: Refactoring (and TDD)</td>
</tr>
<tr>
<td><strong>Week 03: Requirements Engineering II</strong></td>
<td>Week 12: Agile/Lean Methods</td>
</tr>
<tr>
<td>Week 04: Analysis</td>
<td>Week 13: no lecture</td>
</tr>
<tr>
<td>Week 05: <em>Development Infrastructure I</em></td>
<td>Week 14: <em>Software Craftsmanship</em></td>
</tr>
<tr>
<td>Week 06: <em>Development Infrastructure II</em></td>
<td>Week 15: Course wrap-up, review and exam preparation</td>
</tr>
<tr>
<td>Week 07: Architecture and Design</td>
<td></td>
</tr>
<tr>
<td>Week 08: Verification and Validation I</td>
<td></td>
</tr>
<tr>
<td>Week 09: Verification and Validation II</td>
<td></td>
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</table>
Homework 1 Submission

Make sure you submit your Homework 1 solution on time via your team project wiki on Bitbucket!

(double-check YOUR submission deadline: it’s at midnight before your lab takes place)

Penalties apply for late submission!
No exceptions will be allowed!
Labs Next Week

Lab 2 Assignment:

1. Project Planning
   - Refinement of User Stories into Tasks
   - Prioritization of Tasks (P1, P2, P3, P4)
   - Responsibility assignment
   - Effort estimation

2. Five Use Case Descriptions

3. (Initial) Domain Model
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 process steps are involved in RE?
- How to get started with RE?
- How to elicit requirements?
- How to represent/document requirements?
- How to use requirements for project planning?
Acknowledgements

Textbooks/Slides:

Representation Styles

- Natural language (plus supporting tables and graphs)
- Structured natural language / Scenarios
  - e.g., user stories, use case descriptions, CRC cards, ...
- Semi-formal notations
  - e.g., UML diagrams (use case diagrams, class diagrams, state diagram, sequence charts, etc.)
- Formal notations (with formal semantics)
  - e.g., abstract model-based (VDM, Larch, B, ...) or algebraic (OBJ, EJB, ACT-ONE, ...)

Not covered in this course
Example: Home Access Control

Objective: Design an electronic system for:

- Home access control
- Locks and lighting operation
- Intrusion detection and warning

Please read:
Ch 1.2 / 1.3.1 / 2.2
# Example NL Requirements

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"shall": mandatory (?)

"should": optional (?)
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Test?
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| REQ4       | 4        | For REQ3, the customer may suggest these test cases:  
• Test with the valid key of a current tenant on his or her apartment (pass)  
• Test with the valid key of a current tenant on someone else's apartment (fail)  
• Test with an invalid key on any apartment (fail)  
• Test with the key of a removed tenant on his or her previous apartment (fail)  
• Test with the valid key of a just-added tenant on his or her apartment (pass)  |
| REQ5       | 2        | |
| REQ6       | 2        | |
| REQ7       | 2        | |
| REQ8       | 1        | The system should allow filing inquiries about “suspicious” accesses. This function shall be available over the Web. |
| REQ9       | 1        | |
User Stories

As a tenant, I can unlock the doors to enter my apartment.

- Similar to NL requirements, but focus on the user benefits, instead on system characteristics (alone).
- Unfortunately, third element (business-value) is often ommitted
- Preferred tool in agile methods.
NL Requirements vs. User Stories

Traditional requirement – “shall” statements:
• “The system shall provide a user configurable interface for all user and system manager functions”
• “The user interface shall be configurable in the areas of:
  • Screen layout
  • Font
  • Background and text color

Corresponding “User Story”:
• “As a system user or system manager, …
• … I want to be able to configure the user interface for screen layout, font, background color, and text color, …
• … so that I can use the system in the most efficient manner”

who - what - why
# Example User Stories

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<td>ST-1</td>
<td>As an authorized person (tenant or landlord), I can keep the doors locked at all times. (… so I am safe)</td>
</tr>
<tr>
<td>ST-2</td>
<td>As an authorized person (tenant or landlord), I want the lock be automatically locked after a defined period of time.</td>
</tr>
<tr>
<td>ST-3</td>
<td>As an authorized person (tenant or landlord), I can lock the doors on demand.</td>
</tr>
<tr>
<td>ST-4</td>
<td>As an authorized person (tenant or landlord), I can unlock the doors. (Test: Allow a small number of mistakes, say three.)</td>
</tr>
<tr>
<td>ST-5</td>
<td>As a landlord, I can at runtime manage authorized persons.</td>
</tr>
<tr>
<td>ST-6</td>
<td>As an authorized person (tenant or landlord), I can view past accesses.</td>
</tr>
<tr>
<td>ST-7</td>
<td>As a tenant, I can configure the preferences for activation of various devices.</td>
</tr>
<tr>
<td>ST-8</td>
<td>As a tenant, I can file complaint about “suspicious” accesses.</td>
</tr>
</tbody>
</table>

Note: ‘Why’ part is missing in the examples above.
Time Estimation with User Story Points

- Points assigned to individual user stories
- Total work size estimate:
  \[ \text{Total size} = \sum \text{points-for-story } i \quad (i = 1..N) \]
- Velocity (= Productivity) estimated from experience
- Estimate the work duration:
  \[ \text{Project duration} = \frac{\text{Total size}}{\text{Velocity}} \quad \text{[time unit]} \]
Time Estimation with User Story Points

• Points assigned to individual user stories
• How?

Team estimates based on experience

30 User Stories

1 day
2 days
0.5 days

Beware: Time vs. Effort!
Time Estimation with User Story Points

- Points assigned to individual user stories
- How?

30 User Stories

Planning Poker Cards
Time Estimation with User Story Points

- Points assigned to individual user stories
- Total work size estimate:
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# Example User Stories

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<td>As an authorized person (tenant or landlord), I can keep the doors locked at all times.</td>
<td>4 points</td>
</tr>
<tr>
<td>ST-2</td>
<td>The lock should be automatically locked after a defined period of time.</td>
<td>3 pts</td>
</tr>
<tr>
<td>ST-3</td>
<td>As an authorized person (tenant or landlord), I can lock the doors on demand.</td>
<td>6 pts</td>
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</table>
| ST-4       | As an authorized person (tenant or landlord), I can unlock the doors.  
  (Test: Allow a small number of mistakes, say three.)                                                                                              | 9 pts |
| ST-5       | As a landlord, I can at runtime manage authorized persons.                                                                                                                                                   | 10 pts |
| ST-6       | As an authorized person (tenant or landlord), I can view past accesses.                                                                                                                                       | 6 pts |
| ST-7       | As a tenant, I can configure the preferences for activation of various devices.                                                                                                                               | 6 pts |
| ST-8       | As a tenant, I can file complaint about “suspicious” accesses.                                                                                                                                                | 6 pts |
Example User Stories

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Sum: 50 User Story Points (USP)

Team: 3 persons

How long will it take?
Example Estimation

- Points assigned to individual user stories
- Total work size estimate:
  \[ \text{Total size} = \sum \text{points-for-story} \ i \quad (i = 1..N) \]
- Velocity (= Productivity) estimated from experience
- Estimate the work duration:
  \[ \text{Project duration} = \frac{\text{Total size}}{\text{Velocity}} \quad \text{[time unit]} \]

- Average Team Size: 6 persons
- Average Project Size: 600 USPs
- Average Project Duration: 30 days
- Average Velocity (6 pers): 20 USP/day
  \[ = 3.33 \text{ USP/person-day} \]

50 US Points & 3 Pers. Team:
Duration: \(\frac{50}{(3*3.33)} = 5 \text{ days}\)
Agile Project Estimation/Planning

Work backlog

1) ST-4: Unlock  2.7 day  (9pts)
2) ST-2: Auto-Lock  0.9 day  (3pts)
3) ST-1: Keep locked  1.2 day  (4pts)
...
(...)
5) ST-5: Manage Users  3 day  (10pts)
6) ST-6: View History  1.8 day  (6pts)
...

Estimated work duration

assumes that 1 person works fulltime on this task without interruption

Items pulled by the team into an iteration

List prioritized by the customer

Priority

Estimated completion date

20 days

5 days (40 hours)

Time

1st iteration
2nd iteration
n-th iteration

List prioritized by the customer
User Stories versus Tasks

How to split User Stories into Tasks:
https://www.youtube.com/watch?v=gZ4uLafsxAk

User Story = Point of view of system user (What?)
Task = Point of view of system developer (How?)
SMART Tasks

- Specific
- Measurable
- Attainable (Achievable, Actionable, Appropriate)
- Realistic
- Time-bound (Timely, Traceable)

Note: The SMART analysis may also be applied to requirements!

Source: http://jessica80304.wordpress.com/2008/08/04/smart-requirements/
SMART Tasks

Counter-example (i.e., not SMART):

‘Implement the UI of system xyz so it looks nice to all users and make sure the response time to inquiries is as fast as the speed of light’

S Specific
M Measurable
A Attainable (Achievable, Actionable, Appropriate)
R Realistic
T Time-bound (Timely, Traceable)
Counter-example:

'Make the user interface of system xyz look nice to all users and make sure the response time to inquiries is as fast as the speed of light'

Not specific:
- Compound (3 reqs – 1 F & 2 NF)

Not measurable:
- What is ’nice’?

Not attainable:
- It is not probable (unrealistic) that ’all’ users will find that the UI looks nice / ’UI’ is too unspecific

Not realistic:
- Speed of light cannot be achieved

Time-bound/Timely:
- To check this we would need to know the project plan and the planned date when the required function shall be available

Traceable:
- Would need other documents to be able to check whether the req is traceable (BUT: since it is a compound, there is already some potential complication of traceability)
Counter-example

'Make the user interface of system xyz look nice to all users and make sure the response time to inquiries is as fast as the speed of light'

AND:

The task is a mix of functional and non-functional aspects.

Implementation tasks are typically related to functionality.

What about the non-functional requirements, then?

S  Specific
M  Measurable
A  Attainable (Achievable, Actionable, Appropriate)
R  Realistic
T  Time-bound (Timely, Traceable)
Counter-example:

'Make the user interface of system xyz look nice to all users and make sure the response time to inquiries is as fast as the speed of light'

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AND:

The task is a mix of functional and non-functional aspects.

Implementation tasks are typically related to functionality.

What about the non-functional requirements, then?

Answer:
- Don’t forget the tasks related to creating tests!
- You might implement tests that check the non-functional requirements!
SMART Tasks

• **Specific**
  A good task is specific and not generic. It should not be open to misinterpretation when read by others.
  • Avoid using conjunctions (and, or, but)
  • Avoid indeterminate amounts of time (soon, fast, later, immediately)
  • Etc.

• **Measurable**

• **Attainable (Achievable, Actionable, Appropriate)**

• **Realistic**

• **Time-bound (Timely, Traceable)**

Source: http://jessica80304.wordpress.com/2008/08/04/smart-requirements/
SMART Tasks

• **Specific**
  This answers whether you will be able to verify the completion of the project. You should avoid signing up for any task that cannot be verified as complete.
  • These are especially risky when you use non-quantitative terms (best, optimal, fastest) for acceptance criteria.

• **Measurable**

• **Attainable** (Achievable, Actionable, Appropriate)

• **Realistic**

• **Time-bound** (Timely, Traceable)

Source: http://jessica80304.wordpress.com/2008/08/04/smart-requirements/
SMART Tasks

• Specific
  
  This intends to ensure that the Task is physically and logically possible to be achieved given existing circumstances. There is arguably overlap between attainable and realistic.
  
  • Reserve attainable to check the likelihood that it will be possible to implement the task

• Measurable

• **Attainable** (Achievable, Actionable, Appropriate)

• Realistic

• Time-bound (Timely, Traceable)

Source: http://jessica80304.wordpress.com/2008/08/04/smart-requirements/
SMART Tasks

- Specific
- Measurable
- Attainable (Achievable, Actionable, Appropriate)
- Realistic
- Time-bound (Timely, Traceable)

Source: http://jessica80304.wordpress.com/2008/08/04/smart-requirements/

This intends to ensure that the task is realistic to implement when considering other constraints of the project and requirements.
SMART Tasks

• Specific
• Measurable
• Attainable (Achievable, Actionable, Appropriate)

Where appropriate each task should be time-bound or specify by *when* or *how fast* a required function needs to be completed or executed.

In software engineering, you may see the “T” in SMART being used to mark whether a task is “traceable”, which is a separate but important topic in developing software.

• Realistic
• **Time-bound** (Timely, Traceable)

Source: http://jessica80304.wordpress.com/2008/08/04/smart-requirements/
Use Cases

• For Functional Requirements Analysis and Specification

• A **use case** is a description of how a user will use the system-to-be to achieve business goals
  
  • Detailed use cases are usually written as usage **scenarios** or **scripts**, listing a specific sequence of actions and interactions between the actors and the system
Scenarios

- Scenario = real-life example of how a system can be used
- They should include
  - A description of the starting situation (state)
  - A description of the normal flow of events
  - A description of what can go wrong
  - Information about other concurrent activities
  - A description of the state when the scenario finishes
Use Case Diagrams and Descriptions

Use Case Description:
Name of Use Case
Actors associated with Use Case
Pre-conditions
Post-conditions
Normal Flow of Events (Basic Scenario)
Alternative Flow of Events (Alternative Scenarios)
...
Types of Actors

• **Initiating actor** (also called *primary actor* or “user”): initiates the use case to achieve a goal

• **Participating actor** (also called *secondary actor*): participates in the use case but does not initiate it:
  • **Supporting actor**: helps the system-to-be to complete the use case
  • **Offstage actor**: passively participates in the use case, i.e., neither initiates nor helps complete the use case, but may be notified about some aspect of it (e.g., for keeping records)
Identifying Actors

- **Ask the following questions:**
  - Who will be a primary user of the system? (primary actor)
  - Who will need support from the system to do her daily tasks?
  - Who will maintain, administrate, keep the system working? (secondary actor)
  - Which hardware devices does the system need?
  - With which other systems does the system need to interact with?
  - Who or what has an interest in the results that the system produces?

- **Look for:**
  - the users who directly use the system
  - also others who need services from the system
Finding Use Cases

• For each actor, ask the following questions:
  • Which functions does the actor require from the system?
  • What does the actor need to do?
  • Does the actor need to read, create, destroy, modify, or store some kinds of information in the system?
  • Does the actor have to be notified about events in the system?
  • Does the actor need to notify the system about something?
  • What do those events require in terms of system functionality?
  • Could the actor’s daily work be simplified or made more efficient through new functions provided by the system?
# Deriving Use Cases from System Requirements

REQ1: Keep door locked and auto-lock  
REQ2: Lock when “LOCK” pressed  
REQ3: Unlock when valid key provided  
REQ4: Allow mistakes but prevent dictionary attacks  
REQ5: Maintain a history log  
REQ6: Adding/removing users at runtime  
REQ7: Configuring the device activation preferences  
REQ8: Inspecting the access history  
REQ9: Filing inquiries

<table>
<thead>
<tr>
<th>Actor</th>
<th>Actor's Goal (what the actor intends to accomplish)</th>
<th>Use Case Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landlord</td>
<td>To disarm the lock and enter, and get space lighted up.</td>
<td>Unlock (UC-1)</td>
</tr>
<tr>
<td>Landlord</td>
<td>To lock the door &amp; shut the lights (sometimes?).</td>
<td>Lock (UC-2)</td>
</tr>
<tr>
<td>Landlord</td>
<td>To create a new user account and allow access to home.</td>
<td>AddUser (UC-3)</td>
</tr>
<tr>
<td>Landlord</td>
<td>To retire an existing user account and disable access.</td>
<td>RemoveUser (UC-4)</td>
</tr>
<tr>
<td>Tenant</td>
<td>To find out who accessed the home in a given interval of time and potentially file complaints.</td>
<td>InspectAccessHistory (UC-5)</td>
</tr>
<tr>
<td>Tenant</td>
<td>To disarm the lock and enter, and get space lighted up.</td>
<td>Unlock (UC-1)</td>
</tr>
<tr>
<td>Tenant</td>
<td>To lock the door &amp; shut the lights (sometimes?).</td>
<td>Lock (UC-2)</td>
</tr>
<tr>
<td>Tenant</td>
<td>To configure the device activation preferences.</td>
<td>SetDevicePrefs (UC-6)</td>
</tr>
<tr>
<td>LockDevice</td>
<td>To control the physical lock mechanism.</td>
<td>UC-1, UC-2</td>
</tr>
<tr>
<td>LightSwitch</td>
<td>To control the lightbulb.</td>
<td>UC-1, UC-2</td>
</tr>
<tr>
<td>[to be identified]</td>
<td>To auto-lock the door if it is left unlocked for a given interval of time.</td>
<td>AutoLock (UC-2)</td>
</tr>
</tbody>
</table>

(Actors are often given, if working from user stories instead of ‘shall/should’-statements.)
## Traceability Matrix

### Mapping: System requirements to Use cases

- **Req't**: Requirement
- **PW**: Priority Weight

### Purpose:
- Check all REQs are covered by UCs
- Check no UC is added that doesn’t have a REQ
- Prioritize UCs

<table>
<thead>
<tr>
<th>Req't</th>
<th>PW</th>
<th>UC1</th>
<th>UC2</th>
<th>UC3</th>
<th>UC4</th>
<th>UC5</th>
<th>UC6</th>
<th>UC7</th>
<th>UC8</th>
</tr>
</thead>
<tbody>
<tr>
<td>REQ1</td>
<td>5</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQ2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQ3</td>
<td>5</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>REQ4</td>
<td>4</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>REQ5</td>
<td>2</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>REQ6</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>REQ7</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>REQ8</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>REQ9</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Max PW**

<table>
<thead>
<tr>
<th>UC1</th>
<th>UC2</th>
<th>UC3</th>
<th>UC4</th>
<th>UC5</th>
<th>UC6</th>
<th>UC7</th>
<th>UC8</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>9</td>
<td>5</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total PW**

<table>
<thead>
<tr>
<th>UC1</th>
<th>UC2</th>
<th>UC3</th>
<th>UC4</th>
<th>UC5</th>
<th>UC6</th>
<th>UC7</th>
<th>UC8</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PW = Priority Weight**

- UC1: Unlock
- UC2: Lock
- UC3: AddUser
- UC4: RemoveUser
- UC5: InspectAccessHistory
- UC6: SetDevicePrefs
- UC7: AuthenticateUser
- UC8: Login
Use Case Diagram: Device Control

First tier use cases

- UC1: Unlock
- UC2: Lock

Second tier use cases

- UC3: AddUser
- UC4: RemoveUser
- UC5: InspectAccessHistory
- UC6: SetDevicePrefs
- UC7: AuthenticateUser
- UC8: Login

System boundary

- Tenant
- Landlord
- LockDevice
- LightSwitch
- Timer

Communication:

- «initiate»
- «participate»
- «include»
- «initiate + participate»
Use Case Diagrams and Descriptions

Use Case Description:
Name of Use Case
Actors associated with Use Case
Pre-conditions
Post-conditions
Normal Flow of Events (Basic Scenario)
Alternative Flow of Events (Alternative Scenarios)
...

Use Case Model

Actors
Use Cases
Use-Case Descriptions

...
# Schema for Use Case Description

<table>
<thead>
<tr>
<th><strong>Use Case UC-#</strong>:</th>
<th>Name / Identifier</th>
<th>[verb phrase]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Related Requirements:</strong></td>
<td>List of the requirements that are addressed by this use case</td>
<td></td>
</tr>
<tr>
<td><strong>Initiating Actor:</strong></td>
<td>Actor who initiates interaction with the system to accomplish a goal</td>
<td></td>
</tr>
<tr>
<td><strong>Actor's Goal:</strong></td>
<td>Informal description of the initiating actor's goal</td>
<td></td>
</tr>
<tr>
<td><strong>Participating Actors:</strong></td>
<td>Actors that will help achieve the goal or need to know about the outcome</td>
<td></td>
</tr>
<tr>
<td><strong>Preconditions:</strong></td>
<td>What is assumed about the state of the system before the interaction starts</td>
<td></td>
</tr>
<tr>
<td><strong>Postconditions:</strong></td>
<td>What are the results after the goal is achieved or abandoned; i.e., what must be true about the system at the time the execution of this use case is completed</td>
<td></td>
</tr>
</tbody>
</table>

**Flow of Events for Main Success Scenario:**

→ 1. The initiating actor delivers an action or stimulus to the system (the arrow indicates the direction of interaction, to- or from the system)

← 2. The system's reaction or response to the stimulus; the system can also send a message to a participating actor, if any

→ 3. ...

**Flow of Events for Extensions (Alternate Scenarios):**
What could go wrong? List the exceptions to the routine and describe how they are handled

→ 1a. For example, actor enters invalid data

← 2a. For example, power outage, network failure, or requested data unavailable

...  

The arrows on the left indicate the direction of interaction: → Actor's action; ← System's reaction
Use Case 1: Unlock

<table>
<thead>
<tr>
<th>Use Case UC-1: Unlock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Related Requirem’ts:</strong></td>
</tr>
<tr>
<td><strong>Initiating Actor:</strong></td>
</tr>
<tr>
<td><strong>Actor’s Goal:</strong></td>
</tr>
<tr>
<td><strong>Participating Actors:</strong></td>
</tr>
</tbody>
</table>

**Preconditions:**
- The set of valid keys stored in the system database is non-empty.
- The system displays the menu of available functions; at the door keypad the menu choices are “Lock” and “Unlock.”

**Postconditions:**
The auto-lock timer has started countdown from autoLockInterval.

**Flow of Events for Main Success Scenario:**

1. **Tenant/Landlord** arrives at the door and selects the menu item “Unlock”
2. **include::AuthenticateUser** (UC-7)
3. **System** (a) signals to the **Tenant/Landlord** the lock status, e.g., “disarmed,” (b) signals to **LockDevice** to disarm the lock, and (c) signals to **LightSwitch** to turn the light on
4. **System** signals to the **Timer** to start the auto-lock timer countdown
5. **Tenant/Landlord** opens the door, enters the home [and shuts the door and locks]
# Use Case UC-7: 
**AuthenticateUser** (sub-use case)

<table>
<thead>
<tr>
<th>Related Requirements:</th>
<th>REQ3, REQ4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiating Actor:</td>
<td>Any of: Tenant, Landlord</td>
</tr>
<tr>
<td>Actor’s Goal:</td>
<td>To be positively identified by the system (at the door interface).</td>
</tr>
<tr>
<td>Participating Actors:</td>
<td>AlarmBell, Police</td>
</tr>
</tbody>
</table>
| Preconditions:         | • The set of valid keys stored in the system database is non-empty.  
                        | • The counter of authentication attempts equals zero. |
| Postconditions:        | None worth mentioning. |

**Flow of Events for Main Success Scenario:**

1. System prompts the actor for identification, e.g., alphanumeric key  
2. **Tenant/Landlord** supplies a valid identification key  
3. System (a) verifies that the key is valid, and (b) signals to the actor the key validity

**Flow of Events for Extensions (Alternate Scenarios):**

2a. **Tenant/Landlord** enters an invalid identification key  

1. System (a) detects error, (b) marks a failed attempt, and (c) signals to the actor  
2. System (a) detects that the count of failed attempts exceeds the maximum allowed number, (b) signals to sound **AlarmBell**, and (c) notifies the **Police** actor of a possible break-in  
3. Same as in Step 3 above
Use Case Diagram: Account Management

- UC1: Unlock
- UC2: Lock
- UC3: AddUser
- UC4: RemoveUser
- UC5: InspectAccessHistory
- UC6: SetDevicePrefs
- UC7: AuthenticateUser
- UC8: Login

Account Management Subsystem

Landlord

Tenant

UC3: AddUser
UC4: RemoveUser
UC5: InspectAccessHistory
UC6: SetDevicePrefs
UC8: Login
Use Case Diagram: Account Management

UC1: Unlock
UC2: Lock
UC3: AddUser
UC4: RemoveUser
UC5: InspectAccessHistory
UC6: SetDevicePrefs
UC7: AuthenticateUser
UC8: Login

Account Management Subsystem

Tenant
- UC3: AddUser
- UC4: RemoveUser
- UC5: InspectAccessHistory
- UC6: SetDevicePrefs
- UC8: Login

Landlord
- UC1: Unlock
- UC2: Lock
- UC3: AddUser
- UC4: RemoveUser
- UC5: InspectAccessHistory
- UC6: SetDevicePrefs
- UC7: AuthenticateUser
- UC8: Login

Why secondary?
Novice developers frequently identify user login as a use case. Expert developers argue that login is not a use case in its own right.

Recall that use case is motivated by user’s goal; The user initiates interaction with the system to achieve a certain goal. You are not logging in for the sake of logging in—you are logging in to do some work, and this work is your use case.
Optional Use Cases: «extend»

Example optional use cases:

- UC6: SetDevicePrefs
- UC5: InspectAccessHistory
- ManageAccount
- UC6: SetDevicePrefs

Key differences between «include» and «extend» relationships

<table>
<thead>
<tr>
<th></th>
<th>Included use case</th>
<th>Extending use case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is this use case optional?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Is the base use case complete without this use case?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Is the execution of this use case conditional?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Does this use case change the behavior of the base use case?</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Where do we want to take you?  
(by the end of this course)

Sample student software projects (Fall 2015)

• [https://github.com/vladislavivanistsev/SuperCap/](https://github.com/vladislavivanistsev/SuperCap/)

• [https://github.com/alajal/license-management/](https://github.com/alajal/license-management/)
Project Estimation

with

Use Cases
Use Case Points

For the sum of all Use Cases:

- UCP equation is composed of four variables:
  - Unadjusted Use Case Point (UUCP)
  - The Technical Complexity Factor (TCF)
  - The Environment Complexity Factor (ECF)

(adjusted) \[ UCP = UUCP \times TCF \times ECF \]

- UUCP is the sum of Unadjusted Actor Weight (UAW) and Unadjusted Use Case Weight (UUCW).

\[ UUCP = UAW + UUCW \]
# Unadjusted Actor Weight

<table>
<thead>
<tr>
<th>Actor Type</th>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple</td>
<td>Communicates to system through API</td>
<td>1</td>
</tr>
<tr>
<td>Average</td>
<td>Interacts with the system through some protocol (HTTP, FTP, or probably some user defined protocol), or Are data stores (Files, DBMS)</td>
<td>2</td>
</tr>
<tr>
<td>Complex</td>
<td>Interacts through HCI (GUI)</td>
<td>3</td>
</tr>
</tbody>
</table>

\[
UAW = (\text{Total No. of Simple actors} \times 1) + (\text{Total No. Average actors} \times 2) + (\text{Total No. Complex actors} \times 3)
\]
## Unadjusted Use Case Weight

<table>
<thead>
<tr>
<th>Use Case Type</th>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple</td>
<td>1 to 3 transactions</td>
<td>5</td>
</tr>
<tr>
<td>Average</td>
<td>4 to 7 transactions</td>
<td>10</td>
</tr>
<tr>
<td>Complex</td>
<td>8 or more transactions</td>
<td>15</td>
</tr>
</tbody>
</table>

\[
UUCW = \text{(Total No. of Simple Use Cases } \times 5) + \text{(Total No. Average Use Case } \times 10) + \text{(Total No. Complex Use Cases } \times 15)
\]
## Technical Complexity Factor – TCF

<table>
<thead>
<tr>
<th>Technical Factor</th>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>TF(1)</td>
<td>Distributed System</td>
<td>2</td>
</tr>
<tr>
<td>TF(2)</td>
<td>Performance</td>
<td>1</td>
</tr>
<tr>
<td>TF(3)</td>
<td>End User Efficiency</td>
<td>1</td>
</tr>
<tr>
<td>TF(4)</td>
<td>Complex Internal Processing</td>
<td>1</td>
</tr>
<tr>
<td>TF(5)</td>
<td>Reusability</td>
<td>1</td>
</tr>
<tr>
<td>TF(6)</td>
<td>Installability</td>
<td>0.5</td>
</tr>
<tr>
<td>TF(7)</td>
<td>Usability</td>
<td>0.5</td>
</tr>
<tr>
<td>TF(8)</td>
<td>Portability</td>
<td>2</td>
</tr>
<tr>
<td>TF(9)</td>
<td>Modifiability</td>
<td>1</td>
</tr>
<tr>
<td>TF(10)</td>
<td>Concurrency</td>
<td>1</td>
</tr>
<tr>
<td>TF(11)</td>
<td>Includes special security requirements</td>
<td>1</td>
</tr>
<tr>
<td>TF(12)</td>
<td>Provides direct access by third parties</td>
<td>1</td>
</tr>
<tr>
<td>TF(13)</td>
<td>Special User training facilities are required</td>
<td>1</td>
</tr>
</tbody>
</table>

Each TF(i) can have a value from 0 (factor is irrelevant) to 5 (factor is essential).

\[
\text{TCF} = 0.6 + \frac{\text{TF}}{100} \quad \text{with} \quad \text{TF} = \sum_{i=1}^{13} (\text{TF}(i) \times \text{Weight}(i))
\]
Environmental Complexity Factor - ECF

<table>
<thead>
<tr>
<th>Factor Number</th>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF(1)</td>
<td>Familiarity with system development process in use</td>
<td>1.5</td>
</tr>
<tr>
<td>EF(2)</td>
<td>Application experience</td>
<td>0.5</td>
</tr>
<tr>
<td>EF(3)</td>
<td>Object-oriented experience</td>
<td>1.0</td>
</tr>
<tr>
<td>EF(4)</td>
<td>Lead analyst capability</td>
<td>0.5</td>
</tr>
<tr>
<td>EF(5)</td>
<td>Motivation</td>
<td>1.0</td>
</tr>
<tr>
<td>EF(6)</td>
<td>Requirements stability</td>
<td>2.0</td>
</tr>
<tr>
<td>EF(7)</td>
<td>Part time staff</td>
<td>-1.0</td>
</tr>
<tr>
<td>EF(8)</td>
<td>Difficulty of programming language</td>
<td>-1.0</td>
</tr>
</tbody>
</table>

Each EF(i) can have a value from 0 (no experience) to 5 (expert)

Complexity increases, the smaller EF(1) to EF(6) and the greater EF(7) & EF(8)

ECF = 1.4 + (-0.03*EF) with EF = ∑_{i=1}^{8}(EF(i) * Weight(i))
Use Case Points

For the sum of all Use Cases:

- UCP equation is composed of four variables:
  - Unadjusted Use Case Point (UUCP)
  - The Technical Complexity Factor (TCF)
  - The Environment Complexity Factor (ECF)

\[
UCP = UUCP \times TCF \times ECF
\]

- UUCP is the sum of Unadjusted Actor Weight (UAW) and Unadjusted Use Case Weight (UUCW).

\[
UUCP = UAW + UUCW
\]
Use Case Points

For the sum of all Use Cases:

- UCP equation is composed of four variables:
  - Unadjusted Use Case Point (UUCP)
  - The Technical Complexity Factor (TCF)
  - The Environment Complexity Factor (ECF)
  - The Productivity Factor (PF)

\[
\text{Effort (UCP)} = \text{UUCP} \times \text{TCF} \times \text{ECF} \times \text{PF}
\]

- UUCP is the sum of Unadjusted Actor Weight (UAW) and Unadjusted Use Case Weight (UUCW).

\[
\text{UUCP} = \text{UAW} + \text{UUCW}
\]
Use Case Points: Project Effort

For the sum of all Use Cases:

- UCP equation is composed of four variables:
  - Unadjusted Use Case Point (UUCP)
  - The Technical Complexity Factor (TCF)
  - The Environment Complexity Factor (ECF)
  - The Productivity Factor (PF)

\[ \text{Eff}(UCP) = UUCP \times TCF \times ECF \times PF \text{ [person-hours]} \]

- UUCP is the sum of Unadjusted Actor Weight (UAW) and Unadjusted Use Case Weight (UUCW).

\[ UUCP = UAW + UUCW \]

Either 20 person-hours/UCP or 28 person-hours/UCP
Productivity Factor - PF

If sum of [(number of factors E1 through E6 assigned value < 3) and (number of factors E7 and E8 assigned value > 3)] ≤ 2

PF = 20 ph/UCP

Else
If sum of [(number of factors E1 through E6 assigned value < 3) and (number of factors E7 and E8 assigned value > 3)] = 3 or 4
PF = 28 ph/UCP

Else:  Rethink project; it has too high a risk of failure

Example: http://en.wikipedia.org/wiki/Use_Case_Points

Complexity increases, the smaller EF(1) to EF(6) and the greater EF(7) & EF(8)

EF values: 0, 1, 2, 3, 4, 5
Next Lecture

- Date/Time:
  - Friday, 28 Sep, 10:15-12:00
- Topic:
  - Analysis

- For you to do:
  - Make sure you submit your Lab Task1 solution on time (double-check submission deadlines!)
  - Go to next lab → Second HW Assignment