• Observe the system context to detect context changes
• Manage the execution of requirements engineering activities
• Manage the requirements artefacts
Lecture Goals

- Define the goals of requirements management
- Introduce principles of requirements prioritisation
- Present the AHP method

Management goals

- Managing Requirements Artefacts
- Observing system context
- Managing Requirements Engineering Activities
Management goals

• Managing Requirements Artefacts
  – Definition of requirements attribute scheme
  – Requirements traceability
  – Requirements change management
  – Requirements configuration management
  – Requirements prioritisation

• Observing system context

• Managing Requirements Engineering Activities

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  – A new technology or new competing product emerges
  – A law or standard changes
  – Evolution of stakeholder goals
  – Involvement of additional stakeholders
  – Changes of an organisational policy
  – Changes in the way that external actors (stakeholders or systems) use the system

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• Managing Requirements Engineering Activities
  – Phase-oriented approach
    • Same sequence of activities is applied to all requirements artefacts
  – Situative approach
    • Activities to be executed next based on assessment of current status of the existing requirements artefacts

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Basics of Prioritisation

→ **Need to select what to implement**
  - Customers (usually) ask for way too much
  - Balance time-to-market with amount of functionality
  - Decide which features go into the next release

→ **For each requirement/feature, ask:**
  - How important is this to the customer?
  - How much will it cost to implement?
  - How risky will it be to attempt to build it?

→ **Perform Triage:**
  - Some requirements *must* be included
  - Some requirements should definitely be excluded
  - That leaves a pool of “nice-to-haves”, which we must select from.
A Cost-Value Approach

→ Calculate return on investment
  - Assess each requirement’s importance to the project as a whole
  - Assess the relative cost of each requirement
  - Compute the cost-value trade-off:

![Diagram showing cost-value trade-off]

→ Two approaches:
  - **Absolute scale (e.g. dollar values)**
    - Requires much domain experience
  - **Relative values (e.g. less/more; a little, somewhat, very)**
    - Much easier to elicit
    - Prioritization becomes a sorting problem
Some complications

→ **Hard to quantify differences**
  - easier to say “x is more important than y”…
  - …than to estimate by how much.

→ **Not all requirements comparable**
  - E.g. different level of abstraction
  - E.g. core functionality vs. customer enhancements

→ **Requirements may not be independent**
  - No point selecting between X and Y if they are mutually dependent

→ **Stakeholders may not be consistent**
  - E.g. If X > Y, and Y > Z, then presumably X > Z?

→ **Stakeholders might not agree**
  - Different cost/value assessments for different types of stakeholder

---

Hierarchical Prioritisation

→ **Group Requirements into a hierarchy**
  - e.g. A goal tree

→ **Only make comparisons between branches of a single node:**
Analytic Hierarchy Process (AHP)

Source: Adapted from Karlsson & Ryan 1997

→ Create n x n matrix (for n requirements)
  - For element \((x, y)\) in the matrix enter:
    - 1 - if \(x\) and \(y\) are of equal value
    - 3 - if \(x\) is slightly more preferred than \(y\)
    - 5 - if \(x\) is strongly more preferred than \(y\)
    - 7 - if \(x\) is very strongly more preferred than \(y\)
    - 9 - if \(x\) is extremely more preferred than \(y\)
  - (use the intermediate values, 2, 4, 6, 8 if compromise needed)
  - ...and for \((y, x)\) enter the reciprocal.

→ Estimate the eigenvalues:
  - E.g. "averaging over normalized columns"
  - Calculate the sum of each column
  - Divide each element in the matrix by the sum of it’s column
  - Calculate the sum of each row
  - Divide each row sum by the number of rows

→ This gives a value for each requirement:
  - ...giving the estimated percentage of total value of the project

AHP example - estimating costs

<table>
<thead>
<tr>
<th></th>
<th>Req1</th>
<th>Req2</th>
<th>Req3</th>
<th>Req4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req1</td>
<td>1</td>
<td>1/3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Req2</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Req3</td>
<td>1/2</td>
<td>1/5</td>
<td>1</td>
<td>1/3</td>
</tr>
<tr>
<td>Req4</td>
<td>1/4</td>
<td>1/3</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Normalise columns

<table>
<thead>
<tr>
<th></th>
<th>Req1</th>
<th>Req2</th>
<th>Req3</th>
<th>Req4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req1</td>
<td>0.21</td>
<td>0.18</td>
<td>0.18</td>
<td>0.48</td>
</tr>
<tr>
<td>Req2</td>
<td>0.63</td>
<td>0.54</td>
<td>0.45</td>
<td>0.36</td>
</tr>
<tr>
<td>Req3</td>
<td>0.11</td>
<td>0.11</td>
<td>0.09</td>
<td>0.04</td>
</tr>
<tr>
<td>Req4</td>
<td>0.05</td>
<td>0.18</td>
<td>0.27</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Sum the rows

<table>
<thead>
<tr>
<th></th>
<th>sum</th>
<th>sum/4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req1</td>
<td>1.05</td>
<td>0.26</td>
</tr>
<tr>
<td>Req2</td>
<td>1.98</td>
<td>0.50</td>
</tr>
<tr>
<td>Req3</td>
<td>0.34</td>
<td>0.09</td>
</tr>
<tr>
<td>Req4</td>
<td>0.62</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Result

Req1 - 26% of the cost
Req2 - 50% of the cost
Req3 - 9% of the cost
Req4 - 16% of the cost
Plot ROI graph

Repeat AHP process twice:
1. Once to estimate relative value
2. Once to estimate relative cost

Other selection criteria
Security Risk Management in Airline Turnaround Sector

→ Check-in passenger information
- Risk 1: Blacklisted passenger presents fake document, gets checked-in because personnel could be bribed
- Risk 2: Attacker uses phishing email to extract passenger booking number and uses it to check-in to the flight

→ Luggage information
- Risk 3: The personnel records values lower than actual weight of luggage and ground operations uses the information in the loading of the aircraft
- Risk 4: The personnel accepts luggage and adds contraband items to a passenger’s luggage

✧ Fuel slip
- Risk 5: A malicious insider with access to the computer that stores the fuel slip performs changes to the data contained in the fuel slip
- Risk 6: The attacker intercepts the fuel slip, changes the data contained and sends it to the supplier

✧ Cargo assignment
- Risk 7: A malicious insider with access rights performs changes to the cargo assignment document before it is sent to a service provider
- Risk 8: An attacker hacks the airline mailing list, receives the cargo assignment, changes the data contained and sends the cargo assignment to a service provider

\[ \text{Matulevičius et al., 2016} \]
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Take Home

- Why Prioritization is needed
  Basic Trade-offs

- Cost-Value Approach
  - Sorting Requirements by cost/value
  - Estimating Relative Costs/Values using AHP
Lecture Goals

• Define the goals of requirements management
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Exercise
AIS – Airline Information System

→ Invoicing
Rinv01. AIS should create an invoice for a booking.
Rinv02. AIS should send a created invoice to the customer
Rinv03. Customer should pay the invoice using AIS
Rinv04. AIS should close a paid invoice

→ Boarding
Rboa1. AIS should create a boarding pass
Rboa2. AIS should register a boarded customer

→ Booking
Rboo1. AIS should allow the customer to book an available flight
Rboo2. Customer should query the airline company for available flights
Rboo3. Customer should choose the number of seats on the available flights
Rboo4. AIS should book an airline flight based on the booking info

Exercise
Requirements Prioritisation

→ Perform requirements prioritisation
  - Use the AHP method
  - Prioritise requirements according to
    - Value
    - Cost
  - Show prioritisation results in a plot