Why Prioritize Requirements?

• Planning software development
  – Scenario: not enough time, budget or resources to implement all requirements listed in an SRS.
  – Requirements in an SRS will be implemented, but the implementation may happen in stages (releases).
  • All requirements are mandatory, but some are essential/critical while others are not.
• 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

Basics of Prioritization

• 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
  • Should definitely be excluded
  • Leaving a pool of “nice-to-haves”, which we must select from.

Prioritization Approaches

• Priority classification
  – Assign each requirement to a priority classification category
  – Example categories: high, medium, low
• Cost-Value Approach
  – Prioritize requirements using ROI (aim for high value, low cost)
• Others approaches
  – Quality Function Deployment (QFD)
  – Total Quality Management (TQM)
  – WIN-WIN

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:

  ![Cost-Value Trade-Off Diagram]

  [KR97]
Approaches to relative comparisons

- **Basic sort** - for every pair of requirements (i,j), ask if i>j?
  - E.g. bubblesort - start in random order, and swap each pair if out of order
  - Requires n*(n-1)/2 comparisons

- **Construct a Binary Sort Tree**
  - Requires O(n log n) comparisons

- **Construct a Minimal Spanning Tree**
  - for each pair (Ri, Ri+1) get the distance between them
  - Requires n-1 comparisons

Prioritization Challenges

- **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 stakeholders

Cost Value Approach:
Analytic Hierarchy Process (AHP)

1. **Determine relative value of requirements.**
   - Stakeholders perform a pair-wise comparison of values.

2. **Determine relative cost of requirements.**
   - Software engineers perform a pair-wise comparison of costs.

3. **Prepare a ROI graph.**
   - Plot the cost (x-axis) and value (y-axis).
   - Use the diagram to determine priority (SE and stakeholders).

AHP: 1. Relative value

- 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.

AHP: 1. Relative value [2]

- **Estimate the Eigenvalues:**
  - **Step 1:** Normalize the columns:
    - Calculate the sum of each column
    - Divide each element in the matrix by the sum of it’s column

<table>
<thead>
<tr>
<th></th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>1</td>
<td>1/3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>R2</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>R3</td>
<td>1/2</td>
<td>1/5</td>
<td>1</td>
<td>1/3</td>
</tr>
<tr>
<td>R4</td>
<td>1/4</td>
<td>1/3</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

- **Step 2:**
  - Calculate the sum of each row
  - Divide each row sum by the number of rows

<table>
<thead>
<tr>
<th></th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>0.21</td>
<td>0.18</td>
<td>0.18</td>
<td>0.48</td>
</tr>
<tr>
<td>R2</td>
<td>0.63</td>
<td>0.54</td>
<td>0.45</td>
<td>0.36</td>
</tr>
<tr>
<td>R3</td>
<td>0.11</td>
<td>0.11</td>
<td>0.09</td>
<td>0.04</td>
</tr>
<tr>
<td>R4</td>
<td>0.05</td>
<td>0.18</td>
<td>0.27</td>
<td>0.12</td>
</tr>
</tbody>
</table>

AHP: 1. Relative value [3]

- **Estimate the Eigenvalues:**
  - **Step 2:**
    - Calculate the sum of each row
    - Divide each row sum by the number of rows

<table>
<thead>
<tr>
<th></th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
</tr>
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<tbody>
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<td>0.04</td>
</tr>
<tr>
<td>R4</td>
<td>0.05</td>
<td>0.18</td>
<td>0.27</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Sum rows and divide by num rows

<table>
<thead>
<tr>
<th>sum</th>
<th>sum/4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.05</td>
<td>0.26</td>
</tr>
<tr>
<td>1.98</td>
<td>0.50</td>
</tr>
<tr>
<td>0.34</td>
<td>0.09</td>
</tr>
<tr>
<td>0.62</td>
<td>0.16</td>
</tr>
</tbody>
</table>
**AHP: 1. Relative value [4]**

Result of AHP
- the estimated percentage of total value of the project

\[
\begin{array}{cccc}
R1 & R2 & R3 & R4 \\
1/3 & 1 & 5 & 3 \\
1/2 & 1/5 & 1 & 1/3 \\
1/4 & 1/3 & 3 & 1 \\
\end{array}
\]

\[
\begin{array}{cccc}
R1 & R2 & R3 & R4 \\
0.21 & 0.18 & 0.18 & 0.48 \\
0.63 & 0.54 & 0.45 & 0.36 \\
0.11 & 0.11 & 0.09 & 0.04 \\
0.05 & 0.18 & 0.27 & 0.12 \\
\end{array}
\]

- Req1 - 26% of the value
- Req2 - 50% of the value
- Req3 - 9% of the value
- Req4 - 16% of the value

**AHP: 2. Relative cost**

- Follow the same process to determine relative cost as for relative value:
  - Create an \( n \times n \) matrix (for \( n \) requirements)
    - For element \((x,y)\) in the matrix enter:
      - 1 - if \( x \) and \( y \) are of equal cost
      - 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, 2-6.8 if compromise needed
  - ...and for \((y,x)\) enter the reciprocal.
  - Estimate the eigenvalues:
    - E.g. “averaging over normalized columns”
    - Divide each element in the matrix by the sum of its column
    - Divide each row sum by the number of rows
  - Result: the estimated percentage of total cost of the project

**AHP: 3. Plot ROI graph**

- ROI Graph:

**Other selection criteria**

Other ways to group requirements:

**Case Study**

- 10 stakeholders
- 17 feature groups
- Each stakeholder prioritized the feature groups
- Ranked the priorities
- Studied how the different stakeholders voted and the resulting priority ranking

Source: Adapted from Park et al., 1999

[KR97]

[PHN00]
Visualizing “Value by stakeholder”

- Graph showing correlation between stakeholder's priorities and the group's priorities
- Can also be thought of as “influence of each stakeholder on the group”

Weighting Stakeholders

- To prioritize requirements accurately, may need to value stakeholders’ differently
  - E.g. to reflect credibility?
  - E.g. to reflect size of constituency represented?
- Weighting Stakeholders Priorities
  - Assign a weight to each stakeholder.
    - The sum of the weights is equal to 1.
    - \[ p_i = \sum_{k=1}^{m} w_k \times p_{ik} \]
      - \( p_i \) is the priority of requirement \( i \)
      - \( w_k \) is the weight of stakeholder \( k \)
      - \( p_{ik} \) is the priority of stakeholder \( k \) on requirement \( i \)
      - \( m \) is the number of stakeholders

Conflict Resolution - basics

- Defining Conflict
  - In RE, focus typically is on logical inconsistency:
    - E.g. conflict is a divergence between goals - there is a feasible boundary condition that makes the goals inconsistent [van Lamsweerde et al. 1998]
  - Note:
    - conflict may occur between individuals, groups, organizations, or different roles played by one person
- Resolution Method:
  - Three broad types of resolution method can be distinguished:
    - Co-operative (or collaborative) methods, which include negotiation and education;
    - Competitive methods, which include combat, coercion and competition;
    - Third Party methods, which include arbitration and appeals to authority.

Basic approaches to conflict resolution

- Negotiation
  - A collaborative exploration:
    - participants attempt to find a settlement that satisfies all parties as much as possible.
  - Also known as:
    - Integrative behaviour
    - Constructive negotiation
  - Distinct from:
    - Distributive/competitive negotiation
- Competition
  - Is maximizing your own gain:
    - no regard for the degree of satisfaction of other parties.
    - But not necessarily hostile
  - Extreme form:
    - When all gains by one party are at the expense of others
- Third Party Resolution
  - Participants appeal to outside source
    - The rule-book, a figure of authority, or the toss of a coin.
    - Can occur with the breakdown of either negotiation or competition as resolution methods.
  - Types of third party resolution
    - Judicial: cases presented by each participant are taken into account
    - Extra-judicial: a decision is determined by factors other than the cases presented (e.g. relative status of participants)
    - Arbitrary: e.g. toss of a coin
References
