Quality Management of Software and Systems: Quality Function Deployment (QFD)
Contents

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• Fundamental idea of QFD
• Procedure concerning the application of QFD
• Involved persons and goals concerning QFD
• Analysis of customer requirements
• The House of Quality
• Development-accompanying QFD
• Case study measuring/measurement tool
Motivation

• Ensure
  • That the customer requirements enter the development process as clearly identified requirements
  • That they are consequently realized there up to implementation details
  • That quantifiable, checkable target values are defined for developing on the basis of customer requirements
  • That is possible to trace back every decision to a corresponding customer requirement

• Traditional approach
  • As few faults/errors/defects as possible
  • On schedule
  • High test costs
  • The product will be less bad
Motivation

• Approach QFD
  • Preventive-oriented quality management
  • Serving the purpose
  • Fulfillment of customer expectations
Motivation
Problems with the Product Development

- Resources are scarce in principle
- Customer requirements enter the development process without a controlled orientation of the development potentials
- In the development phases capacities are used in positions which cannot clearly (or often only intuitively) be assigned to a requirement on the part of the customer
Fundamental Idea of QFD

- Systematic application of the resources in those positions which ensure the fulfillment of the most important customer requirements.

```
+   +   +   +
+   +   +   +
+   +   +   +
```

```
+   +   +   +
+   +   +   +
+   +   +   +
```

- most important customer requirements
- "best efforts"
- mean software
- excellent software
Procedure concerning the Application of the QFD

- Identification of customer requirements
- Weighting of customer requirements
- Weighted customer requirements passed on to the phases of the software development process where they are handled and realized
Involved Persons and Goals concerning QFD

• Team consisting of the members of the individual development phases (e.g. marketing, development, quality assurance)
• Persons who can provide important information about the development of a product in the current phase
• Support of the coordination of all units involved in the development process
• Goals
  • Working out of objectives for the development and quality assurance based on the customer requirements
  • Tracing of the realization of customer requirements through all development phases up to implementation details
  • Avoidance of too complex software resp. not user-oriented software
  • Early identification of risks which are otherwise often detected during or after the implementation phase
  • Reduction of development time
Analysis of Customer Requirements

1. House of Quality
2. Indirect Customer Interview
3. Direct Customer Interview
4. Accompanying Information
5. Customer Voice Table
6. Affinity Diagram
7. Customer Context Table
8. Relation Diagram
9. Hierarchy Diagram

Customer Segments
- Customer requirements
- Technical characteristics

Customer characteristics
Analysis of Customer Requirements

• Steps
  • Segmentation of customer groups on the basis of different characteristics (1)
  • Determination of target groups based on this segmentation
  • Determination of customer requirements by
    • Indirect interview in the environment of future clients (2)
    • Direct interview with future users or with the aid of customer observations, e.g. concerning the handling of a prototype (3)
    • Information concerning products already in use (e.g. laud, problems, questions) (4)

• Problems of the direct interview
  • The requirements given by the customer are often about design concepts or solutions
  • Customers intensely think – particularly in software development – in solutions
  • Possibly manipulation of the software engineer so that not the most cost- or time-effective solution for the customer is developed

• Consequence: ask the customer for the reasons behind his requirements
Analysis of Customer Requirements

• Recording of customer requirements
  • Customer Voice Table (5)
  • Writing down of customer requirements thematically structured, e.g. according to
    • Problems
    • Requirements
    • Technical realization possibilities
    • Charging of time and costs
  • Completion of the gained information
  • Examination of their validity

• Affinity Diagram (6)
  • Cluster the customer requirements
    • Ignore connection to possible realization possibilities
    • Identify backgrounds for requirements (e.g. should be self-explanatory: possible cause: easy to handle or easy learnable)
  • Identify generic terms for requirements
  • Subsume similar requirements
Analysis of Customer Requirements

• Customer Context Table (7)
  • Statements about the customer environment
    • Who?
    • When?
    • Where?
    • Why?
    • What?
    • How?

• Relation Diagram (8)
  • Listing of contents of the Customer Context Table in consideration of their dependences

• Hierarchy Diagram (9)
  • Contents of the Relation Diagram and the Affinity Diagram structured according to thematic levels
Customer Segments/Customer Requirements Matrix

- Evaluates the customer requirements according to their importance for the individual customer segments
- Generates customer requirements evaluated according to their priority as input for the House of Quality
The House of Quality

- Listing of customer requirements
- Correlation of technical characteristics
- Comparison with the competition
- Weighting of customer requirements
- Comparison with competitors with respect to technical characteristics
- Definition of target values required to fulfill technical characteristics
- Evaluation of technical characteristics
- Listing of technical characteristics

Steps:
1. What
2. Relationship
3. How much
4. How
5. Comparison with the competition
6. Correlation of technical characteristics
7. Definition of target values required to fulfill technical characteristics
8. Evaluation of technical characteristics
9. Comparison with competitors with respect to technical characteristics
The House of Quality

• **Goal**
  - Realization of the customer requirements in physical characteristics in consideration of important factors for the development process

• **Steps**
  - List customer requirements (1)
  - Weight customer requirements in pair wise comparison (2)
  - Make comparisons with competitors to determine objectives for a positioning in the market (3)
  - Deternminate the technical characteristics for the realization of the customer requirements (4)
  - Target values of these technical characteristics (5) and provide the guideline values for the fulfillment of the technical characteristics
  - Determine to what extent technical characteristics influence each other and if these dependences are positive or negative (6)
The House of Quality

• The relation/connection/correlation matrix (7)
  • Gives information about which customer requirements are realized by which technical characteristics
  • Already here it can be tested/check if a customer requirement has been forgotten (row did not get a symbol), or
  • if a technical characteristic exists which has no relation to customer requirements (column is empty)
• Product of the weighting of a customer requirement and the factor of the relation gives the local priority of a technical characteristic
• The sum of these priorities gives the evaluation of the technical characteristics (8). Characteristics get a high evaluation if they relate to highly important or to many requirements
• The current plan is compared to similar solutions provided by competitors (9)
Development-Accompanying QFD

Phase 0
- Customer Segment
  - Customer requirements

Phase 1
- Technical Characteristics
  - Customer requirements

Phase 2
- Technical Characteristics
  - Entities/Processes

Phase 3
- Subsystems
  - Entities/Processes

Phase 4
- Subsystems
  - Detailed Processes

Phase 5
- Modules
  - Detailed Processes

Analysis

Design

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Case Study Measurement Tool

- A product to be redeveloped should be analyzed with the aid of QFD. This product is a tool for the determination of software measurements.
- The target groups (customer segments) to be taken into account during the analysis are: software developers, staff members in the quality assurance department and the software manager.
• Consider customer segments vs. customer characteristics (1)

<table>
<thead>
<tr>
<th></th>
<th>Developer</th>
<th>QA</th>
<th>Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>knowledge concerning measuring</td>
<td>0</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>trained with regard to tool use</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>typ. problem evaluation</td>
<td>local</td>
<td>local to global</td>
<td>global</td>
</tr>
<tr>
<td>expected acceptance</td>
<td>0</td>
<td>+</td>
<td>0</td>
</tr>
</tbody>
</table>

• For the description of dependences different value scales are used. Here the following scale is assumed
  • unimportant = 0, minor important = 1, mean = 3, strong = 5, very strong = 7, extremely strong = 9
Consider customer segments with regard to criteria important for the company

- For this purpose, at first the priorities of the corresponding criteria have to be compared with each other

<table>
<thead>
<tr>
<th></th>
<th>saleable number</th>
<th>buying decision ability</th>
<th>multiplier effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>saleable number</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>buying decision ability</td>
<td>0,2</td>
<td>1</td>
<td>0,33</td>
</tr>
<tr>
<td>multiplier effect</td>
<td>0,33</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>$\sum 1,53$</td>
<td>$\sum 9$</td>
<td>$\sum 4,33$</td>
</tr>
</tbody>
</table>

Saleable number is a more important criterion in measures (=3) than the multiplier effect.
Normalization (column sum must be 1):

<table>
<thead>
<tr>
<th></th>
<th>saleable number</th>
<th>buying decision ability</th>
<th>multiplier effect</th>
<th>( \sum ) 1,9</th>
<th>0,63</th>
</tr>
</thead>
<tbody>
<tr>
<td>saleable number</td>
<td>0,65</td>
<td>0,56</td>
<td>0,69</td>
<td>0,69 = 3/4,33</td>
<td>0,63</td>
</tr>
<tr>
<td>buying decision ability</td>
<td>0,13</td>
<td>0,11</td>
<td>0,08</td>
<td>( \sum ) 0,32</td>
<td>0,11</td>
</tr>
<tr>
<td>multiplier effect</td>
<td>0,22</td>
<td>0,33</td>
<td>0,23</td>
<td>( \sum ) 0,78</td>
<td>0,26</td>
</tr>
<tr>
<td>( \sum ) 1</td>
<td>( \sum ) 1</td>
<td>( \sum ) 1</td>
<td>( \sum ) 3</td>
<td>( \sum ) 1</td>
<td></td>
</tr>
</tbody>
</table>
• Transfer of criteria priorities

<table>
<thead>
<tr>
<th></th>
<th>developer</th>
<th>QA</th>
<th>manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>saleable number</td>
<td>sale: 10000</td>
<td>sale: 500</td>
<td>sale: 500</td>
</tr>
<tr>
<td>prio: 63 %</td>
<td>local: 0,91</td>
<td>local: 0,045</td>
<td>local: 0,045</td>
</tr>
<tr>
<td></td>
<td>global: 57,3 %</td>
<td>global: 2,8 %</td>
<td>global: 2,8 %</td>
</tr>
<tr>
<td>buying decision ability</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>prio: 11 %</td>
<td>local: 0,11</td>
<td>local: 0,33</td>
<td>local: 0,56</td>
</tr>
<tr>
<td></td>
<td>global: 1,2 %</td>
<td>global: 3,6 %</td>
<td>global: 6,2 %</td>
</tr>
<tr>
<td>multiplier effect</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>prio: 26 %</td>
<td>local: 0,11</td>
<td>local: 0,33</td>
<td>local: 0,56</td>
</tr>
<tr>
<td></td>
<td>global: 2,9 %</td>
<td>global: 8,6 %</td>
<td>global: 14,6 %</td>
</tr>
<tr>
<td>segment priority</td>
<td>Σ 61,4 %</td>
<td>Σ 15 %</td>
<td>Σ 23,6 %</td>
</tr>
</tbody>
</table>
### Customer Voice Table (5)

<table>
<thead>
<tr>
<th>Customer requirement</th>
<th>Technical restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>determine McCabe</td>
<td>occupy max. 100 kByte memory</td>
</tr>
<tr>
<td>limit value specification</td>
<td></td>
</tr>
<tr>
<td>determine Halstead</td>
<td></td>
</tr>
<tr>
<td>variable user interface</td>
<td></td>
</tr>
<tr>
<td>statistical functions</td>
<td></td>
</tr>
<tr>
<td>graphical editing</td>
<td></td>
</tr>
</tbody>
</table>
Case Study Measuring/Measurement Tool

• Affinity Diagram for the Customer Voice Table (6)
### Customer Context Table (7)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>is</td>
<td>manager</td>
<td>working time</td>
<td>office</td>
<td>progress and quality control</td>
<td>system up to 100 modules</td>
</tr>
<tr>
<td>is not</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>event.</td>
<td></td>
<td>evenings</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>is</td>
<td>developer</td>
<td>working time</td>
<td>office</td>
<td>check target values</td>
<td>individual modules</td>
</tr>
<tr>
<td>is not</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>event.</td>
<td></td>
<td>evenings, weekend</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Case Study Measuring/Measurement Tool

- Hierarchy Diagram (9): additional requirements due to the Customer Context Table
  - PC- and workstation-version
  - at least 100 modules must be analyzable
  - Batch operation and interactive

Measuring Tool

- measurements
- var. user interface
- conf. eval.
- technical restrictions

McCabe, Halstead, limit values, interactive, Batch, statistic, graphic, max. 100 KB, min. 100 mod., workstation, PC
### Case Study Measuring/Measurement Tool

#### Customer Segments/Customer Requirements Matrix

<table>
<thead>
<tr>
<th></th>
<th>developer, 61,4 %</th>
<th>QA, 15 %</th>
<th>manager, 23,6 %</th>
<th>total weight of the requirem.</th>
</tr>
</thead>
<tbody>
<tr>
<td>limit values</td>
<td>1/2 %</td>
<td>5/1,5 %</td>
<td>7/3 %</td>
<td>∑ 6,5 %</td>
</tr>
<tr>
<td>McCabe</td>
<td>5/9,9 %</td>
<td>5/1,5 %</td>
<td>5/2,2 %</td>
<td>∑ 13,6 %</td>
</tr>
<tr>
<td>Halstead</td>
<td>3/5,9 %</td>
<td>3/0,9 %</td>
<td>3/1,3 %</td>
<td>∑ 8,1 %</td>
</tr>
<tr>
<td>Batch op.</td>
<td>1/2 %</td>
<td>7/2,1 %</td>
<td>7/3 %</td>
<td>∑ 7,1 %</td>
</tr>
<tr>
<td>interactive op.</td>
<td>7/13,9 %</td>
<td>7/2,1 %</td>
<td>1/0,4 %</td>
<td>∑ 16,4 %</td>
</tr>
<tr>
<td>statistic</td>
<td>1/2 %</td>
<td>3/0,9 %</td>
<td>5/2,2 %</td>
<td>∑ 5,1 %</td>
</tr>
<tr>
<td>graphic</td>
<td>1/2 %</td>
<td>3/0,9 %</td>
<td>7/3 %</td>
<td>∑ 5,9 %</td>
</tr>
<tr>
<td>min. 100 Mod.</td>
<td>0/0 %</td>
<td>3/0,9 %</td>
<td>5/2,2 %</td>
<td>∑ 3,1 %</td>
</tr>
<tr>
<td>max. 100 kB</td>
<td>3/5,9 %</td>
<td>3/0,9 %</td>
<td>5/2,2 %</td>
<td>∑ 9 %</td>
</tr>
<tr>
<td>workstation</td>
<td>9/17,8 %</td>
<td>5/1,5 %</td>
<td>0/0 %</td>
<td>∑ 19,3 %</td>
</tr>
<tr>
<td>PC</td>
<td>0/0 %</td>
<td>5/1,5 %</td>
<td>9/3,9 %</td>
<td>∑ 5,4 %</td>
</tr>
<tr>
<td><strong>∑ 31/61,4 %</strong></td>
<td><strong>∑ 49/15 %</strong></td>
<td><strong>∑ 54/23,6 %</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Distribute segment priority to requirements with respect to their weights

61,4% * 3

31
• Weighting of customer requirements concerning competition factors:
• Weights
  1 = bad resp. nonexistent, 2 = weak, 3 = mean, 4 = good, 5 = very good
• Sales argument
  1,0 = no argument; 1,2 = weak sa, 1,5 = strong sa
## The House of Quality

<table>
<thead>
<tr>
<th>Requirement</th>
<th>weight.</th>
<th>now</th>
<th>Comp. A</th>
<th>Comp. B</th>
<th>Plan</th>
<th>Improve.</th>
<th>sa</th>
<th>Total</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit values</td>
<td>6,5 %</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>1,2</td>
<td>31,2</td>
<td>5,5 %</td>
</tr>
<tr>
<td>McCabe</td>
<td>13,6 %</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>1,2</td>
<td>81,6</td>
<td>14,5 %</td>
</tr>
<tr>
<td>Halstead</td>
<td>8,1 %</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>1,5</td>
<td>48,6</td>
<td>8,6 %</td>
</tr>
<tr>
<td>Batch op.</td>
<td>7,1 %</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>1,5</td>
<td>42,6</td>
<td>7,6 %</td>
</tr>
<tr>
<td>Interactive op.</td>
<td>16,4 %</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>1,2</td>
<td>78,7</td>
<td>14 %</td>
</tr>
<tr>
<td>Statistic</td>
<td>5,1 %</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1,2</td>
<td>18,4</td>
<td>3,3 %</td>
</tr>
<tr>
<td>Graphic</td>
<td>5,9 %</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>1,5</td>
<td>35,4</td>
<td>6,3 %</td>
</tr>
<tr>
<td>Min. 100 Mod.</td>
<td>3,1 %</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>1,2</td>
<td>24,5</td>
<td>4,3 %</td>
</tr>
<tr>
<td>Max. 100 kB</td>
<td>9 %</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1,2</td>
<td>32,4</td>
<td>3,6 %</td>
</tr>
<tr>
<td>Workstation</td>
<td>19,3 %</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1,5</td>
<td>144,8</td>
<td>25,7 %</td>
</tr>
<tr>
<td>PC</td>
<td>5,4 %</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>1,2</td>
<td>25,9</td>
<td>4,6 %</td>
</tr>
</tbody>
</table>

\[ iprvt. = \frac{\text{plan}}{\text{now}} \quad ; \quad \text{total} = \text{requir.} - \text{weight.} \times iprvt. \times sa \]

\[ \sum 100 \% \]
### Case Study Measuring/Measurement Tool: Customer Requirements/Technical Requirements Matrix

<table>
<thead>
<tr>
<th></th>
<th>priority</th>
<th>command language</th>
<th>window system</th>
<th>compiler-compiler</th>
<th>data compression</th>
<th>graphic library</th>
<th>statistic library</th>
<th>scanner a. parser</th>
</tr>
</thead>
<tbody>
<tr>
<td>limit values</td>
<td>5,5 %</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>McCabe</td>
<td>14,5 %</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Halstead</td>
<td>8,6 %</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Batch op.</td>
<td>7,6 %</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>interactive op.</td>
<td>14 %</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>statistic</td>
<td>3,3 %</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>graphic</td>
<td>6,3 %</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>min. 100 mod.</td>
<td>4,3 %</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>max. 100 kB</td>
<td>3,6 %</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>9</td>
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<td>workstation</td>
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<tr>
<td>PC</td>
<td>4,6 %</td>
<td>3</td>
<td>5</td>
<td>7</td>
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<td>5</td>
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<tr>
<td>∑ 100 %</td>
<td>197,2</td>
<td>220,2</td>
<td>233,7</td>
<td>120,4</td>
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<td>56,7</td>
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<td>16,7 %</td>
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<td>11,8 %</td>
<td>4,8 %</td>
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