Visualizing the Impact of Non-Functional Requirements on Variants – A Case Study

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The importance:

Many developers must address NFRs.

e.g. Teamcenter software non-functional requirements are represented as Items and are the criteria for setting views of the Product Structure (performance view and the security view).

The problem:

Current visualization techniques lack convenience and do not provide sufficient clarity about impact of non-functional requirements on variants.
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The problem:
The NFRs are dispatched everywhere in the figure.

Minimal effort
Matching effort
Collection effort

Good quality schedule
Minimal conflicts
Good participation

Collect timetables
By Person
By System
Collect from Agents
Collect from Users

Choose schedule
Schedule meeting
Manually
Automatically
Send Request
Receive Response

Minimal Disturbances
Accurate Constraints

VP1
VP2
VP3
Who is the visualization for?

Every stakeholders that has to deal with non-functional requirements and their impact on variants:

- From the vendor side: technical sales support, benchmarker, developers, prototypers, project leaders, implementators etc.
- From the customer side: managers, project leaders, users, etc.
What is the visualization for?

The visualization should support the work of stakeholders in each business and product lifecycle management steps when one has to deal with non-functional requirements and their impact on variants:

- Benchmark (incl. Prototype)
- Process Accessment
- Specification
- Implementation
- Testing and Validation
- Change Management Process

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We propose a visualization that expects to help to see at first glance:

- the Non-Functional Requirements (NFRs)
- the Functional Requirements
- the Impact of NFRs on variants
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Functional Requirements

Non-Functional Requirements

Variants Panel

Impact of NFRs on Variants Panel

Quality Requirements Panel

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Map model [Rolland 2000, Rolland et al. 2007]
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Functional Requirements

Variants Panel

Variants are based on map model.

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Why variant representation based on MAP model?

The visualization supports all variant types: optional variants, alternatives, mandatory, iterative.

<table>
<thead>
<tr>
<th>MAP graphical representation of a section</th>
<th>Atomic Variant</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{ij}$</td>
<td>$V_i$</td>
</tr>
<tr>
<td>$G_i$</td>
<td></td>
</tr>
<tr>
<td>$a$</td>
<td></td>
</tr>
<tr>
<td>$l$</td>
<td></td>
</tr>
<tr>
<td>$G_j$</td>
<td></td>
</tr>
<tr>
<td>$b$</td>
<td></td>
</tr>
</tbody>
</table>
Visualizing the Impact of Non-Functional Requirements on Variants – A Case Study

<table>
<thead>
<tr>
<th>Map sections linked by a bundle relationship</th>
<th>Simple Variant with Alternate Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Diagram of bundle relationship" /></td>
<td><img src="image2" alt="Diagram of alternate choice" /></td>
</tr>
<tr>
<td>Map sections linked by a multi-thread relationship</td>
<td>Simple Variant with Multiple Choice</td>
</tr>
<tr>
<td><img src="image3" alt="Diagram of multi-thread relationship" /></td>
<td><img src="image4" alt="Diagram of multiple choice" /></td>
</tr>
</tbody>
</table>
### Visualizing the Impact of Non-Functional Requirements on Variants – A Case Study

**Map sections linked by a path relationship**

<table>
<thead>
<tr>
<th>$G_1$</th>
<th>$G_2$</th>
<th>$G_3$</th>
<th>$G_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\exists_i$</td>
<td>$\exists_j$</td>
<td>$\exists_k$</td>
<td>$\exists_l$</td>
</tr>
</tbody>
</table>

**Path Composite Variant**

![Path Composite Variant Diagram]

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Map sections linked by a multi-path relationship

Multi-Path Composite Variant

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NFR Visualization
Using the representation of [Chung et al., 1996]

Decomposition of NFR goal Performance/Time into one or two sub-goals

Non-Functional Requirements

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Quality Requirements Panel

Non-Functional Requirements

Performance/Time
[FLMdataReporting]

Time
[ProduceReportStatement]
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Impact of NFRs on Variants Panel

Correlation links, adopted from [Chung et al., 2000]

<table>
<thead>
<tr>
<th>BREAK</th>
<th>HURT</th>
<th>UNKNOWN</th>
<th>HELP</th>
<th>MAKE</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>-</td>
<td>?</td>
<td>+</td>
<td>++</td>
</tr>
</tbody>
</table>

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Impact of NFRs on Variants Panel

Layer 1: Impact of NFRs on atomic variants

Layer 2: Impact of NFRs on simple and composite variants

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• NFRs Impact on atomic variants

Variant \( V_i \)

\(<\text{NFR Impact value on atomic variant}>\)

Time

[ProduceReportStatement]

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### Visualizing the Impact of Non-Functional Requirements on Variants – A Case Study

<table>
<thead>
<tr>
<th>Map rel.</th>
<th>Representation of the corresponding variant</th>
<th>Visualization of NFR Impact on variant</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td><img src="image" alt="Atomic Variants Vi, Vj, ..." /></td>
<td><img src="image" alt="NFR impact on Atomic Variants Vi, Vj, ..." /></td>
</tr>
</tbody>
</table>

None
## Multi-Thread relationship

**Simple Variant with Alternate Choice VSa**

- $V_i$
- $V_j$
- ...

**QoS(VSa)**

- NFR impact on Simple Variant with Alternate Choice VSa

**NFR impact of each atomic variant $V_i, V_j, ...$ of the Simple Variant with Alternate Choice VSa**

**NFR [NFR goal]**

## Bundle relationship

**Simple Variant with Multiple Choice VSm**

- $V_i$
- $V_j$
- ...

**QoS(VSm)**

- NFR impact on Simple Variant with Multiple Choice

**NFR impact of each atomic variant $V_i, V_j, ...$ of the Simple Variant with Multiple Choice VSm**

**NFR [NFR goal]**

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### Visualizing the Impact of Non-Functional Requirements on Variants – A Case Study

<table>
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<th>Map relationship</th>
<th>Representation of the corresponding variant</th>
<th>Visualization of NFR Impact on variant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path relationship</td>
<td><img src="image" alt="Diagram of Path Composite Variant CVp" /></td>
<td><img src="image" alt="Diagram of NFR impact on variant" /></td>
</tr>
</tbody>
</table>

**Path relationship**
- Sub path 1
- Sub path 2
- Sub path n

**Visualization of NFR Impact on variant**
- NFR impact of sub path 1 variant Vi
- NFR impact of sub path 2 variant (here the simple variant with alternate choice) QoS(V2)
- NFR impact of sub path n variant (here the variant Vn) QoS(Vn)

**Map relationship**
- Path Composite Variant CVp

**Diagram**

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### Map relationship

<table>
<thead>
<tr>
<th>Multi-path relationship</th>
<th>Representation of the corresponding variant</th>
<th>Visualization of NFR Impact on variant</th>
</tr>
</thead>
</table>

**Multi-path relationship**

**Representation of the corresponding variant**

**Visualization of NFR Impact on variant**
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Summary Graphical Representation on NFR Impact on Simple & Composite Variants
## NFR’s testing and ISO compliance

### Example

<table>
<thead>
<tr>
<th>No</th>
<th>NFR</th>
<th>Test Scenario</th>
<th>Example</th>
<th>ISO Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Suitability</td>
<td>Execution of instructions and function blocks, transfer of data, time response.</td>
<td>Transfer of bytes per second</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The capability of the test object to provide an appropriate set of functions for specified tasks and user objects.
Scalability of the representation:

The scalability is enabled by

• 1) the decomposition method of the map for the functional requirements and
• 2) the typology of NFR according to the Chung NFR types or ISO9126.

As requirements become more complex, one can keep the representation uncluttered by showing a map of the highest level. The user may view details by traversing the hierarchy of maps.

Also, rather than viewing a total representation, the user can view NFRs according to their NFR types. For example, one could view first the NFR decomposed goals of performance and then the NFR decomposed goals of user-friendliness or security.
The case study

The visualization has been used in practice for validating the work. This study addressed software for reporting Product Lifecycle Management (http://www.siemens.com/plm).
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Map of data reporting tool for Product Lifecycle Management

Functional Requirements

Where used information
Where referenced information
BOM information
Workflow information
Master information
etc.

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### Evaluation

**All variability representation types**

<table>
<thead>
<tr>
<th>Type of expressed variability</th>
<th>Variant type according our approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative bundles</td>
<td>Simple Variant with multiple choice Multi-path Composite Variant</td>
</tr>
<tr>
<td>Alternatives</td>
<td>Simple Variant with Alternate Choice</td>
</tr>
<tr>
<td>Options</td>
<td>Optional Variant like Simple Variant with multiple Choice or Path Composite Variant or Multi-path Composite Variant or atomic Variant which belongs to a Path Composite Variant</td>
</tr>
<tr>
<td>Optional Alternatives</td>
<td>Optional Variant like Simple Variant with Alternate Choice belonging to a Path Composite Variant</td>
</tr>
</tbody>
</table>

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**Visualizing the Impact of Non-Functional Requirements on Variants – A Case Study**

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Visualizing the Impact of Non-Functional Requirements on Variants – A Case Study

Evaluation
- Dependencies
- NFRs representation
- Clarity
The results

This visualization approach clarifies use of variant combinations based on non-functional requirements. One can navigate through the variants and get information about the quality attributes according to the approach.

Applying our approach, we obtained preliminary design views for the reporting tool that were implemented in the resulting reporting system. Leaders who participated in this case study responded positively.
Thanks for your attention!

Questions?