A Quality Based Approach for the Analysis and Design of Information Systems

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1. Introduction to Research Topic

Information Systems (IS) require high cost for their maintenance activities. The relative cost for maintaining software and managing its evolution represents more than 90% of the total project cost [1]. The underlying assumption for this PhD work is that the earlier we can measure the quality of future software, the more we can improve it by being able to correct errors at the specifications level and the less will be the cost of these corrections. We propose to measure software quality using conceptual representations of the information system for both static and dynamic aspects.

2. Significant Problems in the Field and their Current Solutions

Conceptual Models (CM) are the abstraction of the universe of discourse under consideration [2]. They are designed as part of the analysis phase and serve as a communicating mediator between the users and the development team. Generally the following three objectives are associated with the CMs: Meet the users' requirements, provide a formal representation of the observed reality, and be a basis for the implementation and evolution of the future information system. Although a CM may be consistent with the universe of discourse but it might not necessarily be correct [2]. This suggests that there is a strong urge for a quality oriented approach that can help in ensuring the consistency and correctness of the CMs. Studies show that defect detection in the early stages of the application development can be 33 times more cost effective than testing done at the end of development [3]. It is shown that the improvements in the quality of the CMs lead towards the improvements in the overall quality of the delivered systems [4].

Unlike the software engineering discipline where there is a proliferation of the methods and metrics for evaluating the quality of the software product, there is

significantly little literature devoted towards the quality of the CMs [2]. Despite the growing interest in the discipline of quality of conceptual models, as of today there doesn't exist any known standards such as the ones existing for software engineering. Moreover, there are no generally accepted guidelines for evaluating the quality of the CMs and little agreement exists among the experts as to what makes a "good" CM [4].

In [4], the author shows that the researchers have not converged towards one quality framework and that the practitioners are not actively involved in evaluating the quality of the CMs.

Furthermore there does not exist any framework, other than that of Lindland et al. [6] that has both a theoretical basis and an empirical validation [7]. Similarly most of the existing frameworks provide ways for quality evaluation but only a handful of them provide suggestions for defect correction.

3. Proposed Approach and its Expected Contributions

Our propositions rely on [4] and thus we considered synthesizing (existing concepts proposed by researchers) and adding the new concepts to formulate a comprehensive quality approach for conceptual modeling.

This approach is dedicated to the evaluation and improvement of CMs quality. The main contributions include:

- The identification of a set of quality attributes relevant to both researchers and practitioners (see Section 3.1).
- The definition of "quality pattern" concept similar to design pattern. Sixteen quality patterns, based on validated quality attributes, are already identified (see Section 3.2).
- The development of a software utility implementing the proposed approach.
- A validation process implying both researchers and practitioners.

3.1. Initial Survey to validate quality attributes

Our approach relies on practitioners' viewpoint for validation. We first identified an initial set of quality attributes resulting from a literature review. A web-based survey was then formulated for validation. The purpose of this survey was twofold:

i. To serve as a validation exercise and collect the feedback from professionals including practitioners over the efficacy of the selected quality attributes.
ii. To study the general practices and views of the professionals over the quality of CMs.

Survey comprises of 42 questions. Respondents were asked to mark each of our quality attributes on four categories (Please see Table-1). In total 179 professionals (including IS managers, IS developers, researchers etc.) were contacted to complete the survey. However, 57 professionals completed the survey that resulted in the response rate of 31.8%. Table-1 summarizes the responses. Due to space constraints, we are listing the survey results of only some of the quality attributes.

Table 1. Respondents' feedback over the selected quality attributes.

Dimension	Quality Attributes	NOT Related to Quality	Related to Quality	Not answered	I am not sure
Readability	Clarity	22.2	75.9	0	1.9
	Documentation Degree	0	88.9	0	11.1
Functionality	Completeness	7.4	75.9	3.7	13
	Relevancy	3.7	83.3	3.7	9.3
	Reliability	11.1	79.6	3.7	5.6
	Practicability	9.3	77.8	3.7	9.3
Conformance	Syntactic Correctness	13	74.1	3.7	9.3
	Semantic Correctness	1.9	81.5	3.7	13
Complexity	Simplicity	11.1	75.9	3.7	9.3
	Structural complexity	11.1	75.9	1.9	11.1
Maintainability	Modifiability	11.1	70.4	1.9	16.7
	Understandability	7.4	87	3.7	1.9
	Extendibility	3.7	83.3	3.7	9.3

3.2. Quality pattern and quality oriented development process

Our proposed approach capitalizes some practices in the domain of quality evaluation and improvement. These practices are identified from a thorough literature review.

3.2.1. The quality pattern meta-model

Our quality meta-model follows a Goal Question Metric (GQM) [8] approach. It is based on the notion of quality patterns and manages the model quality with respect to user's needs. The meta-model in Figure-1 is generic and simple. A "quality goal" expresses a need to improve the quality of a CM. A quality goal could be related to several quality attributes.

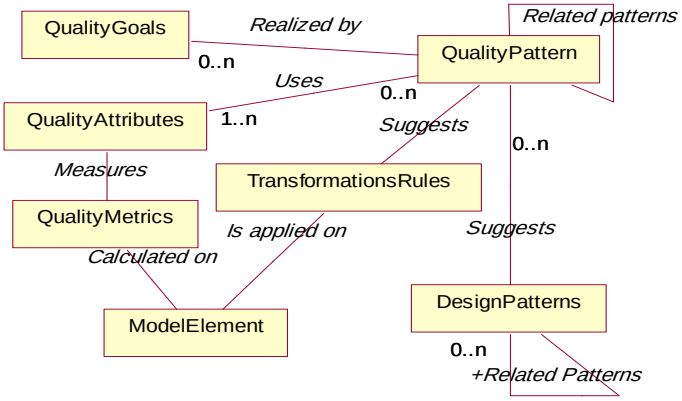

Fig. 1. Proposed Meta-Model

For example, the quality goal “make my CM more extendible” is related to “modularity” and “complexity” quality attributes. Quality attributes are contained in quality patterns that guide their measurement and improvement. Quality attribute are quantifiable through quality metrics. Based on the results of the quality metrics, corresponding predefined transformations and/or appropriate design patterns are proposed for improvement. The strength of our model lies in the relationship between the quality patterns and design patterns.

3.2.2. An instantiation of the quality pattern meta-model

Currently we have identified sixteen quality patterns based on the above mentioned meta-model. Each of the quality patterns respects the following outline that has become fairly standard within the software community to structure patterns.

Name: a significant name summarizing the pattern objective. **Context**: characterization of the situation in which the pattern applies. **Problem**: description of the problem to solve or the challenge to be addressed. **Solution**: the recommendation to solve the problem. **Keywords**: a list of keywords related to the pattern content **Related patterns**: patterns that are closely related to the one described.

Table-2 sketches an example of a quality pattern dedicated to the evaluation and improvement of the simplicity of a conceptual model.

Table 2. Quality Pattern for Model Simplicity.

Pattern Name	**Model Simplicity**
Context	There is a need to maintain model simplicity
Problem	Complex models are difficult to understand, implement and maintain. The complexity could be difficult to manage as it could be related to several sources (domain, structure, modeling notation etc.).
Solution	Design patterns: High cohesion, indirection and polymorphism GRASP patterns. Transformation rules: divide a model, merge classes/entities, use factorization mechanism etc.
Keywords	Complexity, Simplicity, Structural Complexity, Size
Related patterns	Model Modifiability; Model Reusability

3.2.3. Quality-Pattern driven evaluation process

Our proposed quality aware methodology aims at helping the achievement of a quality goal formulated by an IS designer. The process starts with the formulation of a quality goal (by the IS designer). The approach helps in the achievement of this goal by identifying and proposing a set of applicable quality patterns. The interpretation of a quality patterns proposes either a set of transformation rules or a set of suitable

design patterns leading to the improvement of the CM according to the formulated quality goal.

3.3. An Automated Environment to Implement the Proposed Approach

We propose to design and develop a prototype implementing the proposed approach. This implementation has two core objectives. It will first help in demonstrating the feasibility of the approach. The second objective is related to the validation of the approach as we plan to make the prototype available to students, researchers, and practitioners to collect their feedbacks.

3.4. Validation of the Proposed Approach

The proposed approach will be validated on the basis of the feedback received from different populations (researchers, professionals, students etc.) who have either used the proposed utility for evaluating and improving the quality of their models or have either been interviewed or surveyed over the efficacy of the proposed quality concepts.

We propose the following research methods for validation. However, other suitable methodologies can also be used or employed for validation.

- Quantitative Methods; such as surveys that are used to gather data from different IS stake holders. For example, we used an online survey to gather data from different IS stake holders over the selected quality attributes.
- Qualitative Methods such as ethnography, action research, use case study etc.

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