Quantitative Metrics for Requirements Quality a posteriori

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***Abstract*—The question of ”how to measure the quality of requirements?” remains problematic due to its subjectivity.**

In this paper we present various quantitative metrics for assessing the quality of requirements assuming a relation between requirements quality and maturity of requirements, i.e., number of changes to be done in requirements document. We consider the number of corrections done in a requirements document within the requirements engineering (RE) and implementation stages; as well as their influence on the time for development process.

Importantly, the proposed metrics appropriate for assessing the quality of requirements only after project completion. Therefore, this method is a good tool for empirical studies, even though not usable to assess the attributes.

I. Introduction

A. Problem

Measuring the quality of requirements remains problematic [1] due to its subjectivity. There are only few quantitative metrics to measure the quality of requirements. All of them are looking at intrinsic characteristic of requirements, e.g., lack of syntactic defects or conformity to qualitative attributes. Such approach makes them dependable on the requirements' statement and, therefore, decreases an accuracy of the measurement. In other words, the clear baseline for the comparison of results from several separate projects is vague. Assessment of same quality characteristics within different project don't assume equality in outcoming criteria.

B. Contribution

We present various quantitative metrics for assessing the quality of requirements assuming a relation between the requirements quality and corrections of the requirements done within RE and system implementation work flow. Comparing with existing approaches, discussed in section II, our method considers the quality of requirements with respect to the process, measuring the number of changes and time-consumption during RE and implementation phases. We consider the changes in requirements document done within requirements engineering and implementation stages [2], and their influence on the time for development process. The suggested metrics take into account a maturity of the requirements and reflects its leverage on the product, resulting in a number from 0 (bad) - 1 (good) for a quality assessment. A developed system, which has passed an acceptance test by a customer, is considered as a baseline for the resulting product. Importantly, the proposed metrics are usable to assess the quality of requirements only after project completion.

The presented approach can be considered for empirical studies; and is in plan to employ in our study for doctoral thesis regarding requirements categorization approach. The requirements quality with appliance of the requirements categorization approach will be measured by the proposed metrics; afterwards, the results will be compared with an outcome of the project without the requirements categorization approach.

II. Related Work

A. What does “quality” mean?

Despite multiple publications about requirements quality and its assessment, the term “quality” is still subjective [3], [4]. Industry standards [5] specify characteristics and criteria, which presumed effective for improving requirements quality, e.g, completeness, unambiguity and others. Additionally, the research community provided several types of quality definition and methods for its assessment. For example, Lamsweerde provides a defect-based checklist to inspect requirements for possible flaws and errors in [6]; Pohl proposes a framework defining dimensions of quality: the specification dimension, the representation dimension, the agreement dimension [7]. This approach purports an uncertain assessment due to impreciseness of the considered attributes, such as requirements adequacy or pertinence. Instead of such level of granularity for requirements consideration, our method take into account a requirements artifact (RA) in general.

Another approach implies syntactic check of the requirements text for improving its comprehension, correctness, ambiguity and other akin characteristics e.g. [8], [9]. All these metrics apply intrinsic inspection of requirements and assess qualitatively the requirements' statement. Oppositely to them, our metrics provide a quantitative analyze of a whole document with the requirements.

In comparison with described above methods, activity-based quality models shift their approach from inherent properties to the context of process, and propose a meta quality model [10], [11]. Furthermore, the ”quality question” also turns to a consideration of how the requirements quality impacts project success and the relation between them in scientific community [12], [13], so as among practitioners [14]. In contrast to this approach, our metrics grant a relative simplicity level and provide a precision with cardinal number in assessment.

Chain of studies about relation between quality and project outcomes, [15], [13], [16] triggers our research to the proposed metrics. Scientific papers investigating maturity of requirements [17], [2] and their complexity [18] give a base for idea of transforming a relation between requirements quality and number of changes in requirements document into quantitative measurement.

The presented in this paper metrics consider generally requirements artifact for its maturity and a process of adjusting the requirements at RE and implementation phases, in a quantitative way, a posteriori.

III. Metrics

In these metrics we consider a maturity of requirements as a characteristic of the quality. Every RE artifact (a document with requirements) has its index of maturity. The range of this index varies from 0 to 1: 0 means "bad" and 1 indicates "good" quality. The requirements quality presents by a maturity index: coefficient inferred from a number of RE process iterations (a certain amount of changes applied to requirements' document). *The more mature requirements are: the less changes (RE iterations) RE artifact requires in sum; the shorter time for development process is needed;* ***thus, the better quality of such requirements; the higher index of the requirements maturity*** *(Equation 1):*

$$\textit{maturity index} = \frac{1}{\mu(R_j)} \tag{1}$$

,where $\mu(R_j)$ is a calculated number of the iterations for a considered RE artifact (R_j); j is an initial iteration for calculation.

The input for the first iteration of RE process is a "raw" requirements. During the RE phase, the requirements become elaborated (changed with respect to a project's demands); the result of this process is a corrected RE artifact, that is an input to the next stage (SE). Therefore, we consider the initial RE artifact as a document with a single iteration and *maturity index* = 1.

Figure 1 provides a graphical explanation of the metrics. The work flow is divided into RE and SE processes' iterations along the time line: $t_1, t_2, ..., t_i$ - present the time spent for requirements elaboration during RE phases (RE iteration); $t'_1, t'_2, ..., t'_i$ - present the time spent for development process based on the provided requirements (SE iteration). Output of every RE iteration is a RE artifact (depicted as $R_1, R_2, ..., R_i$ on the); and every SE phase results into a SE artifact, e.g.software architecture (shown as SW), till the end SE phase, which leads to the release of a product and finishing a project.

Consequently, to calculate the *maturity index* of the requirements, the following metrics should be determined:

$$\mu_1(R_j) = i - j \tag{2}$$

,a number of iterations for the requirements R_j;

$$\mu_2(R_j) = t_i - t_j \tag{3}$$

,amount of time (in hours) between initial and the last phases of RE process applying the requirements R_j;

$$\mu_3(R_j) = \sum_j t_{j+1} - t_j{'} \tag{4}$$

,total amount of time required for SE process;

IV. Conclusion

Tatiana ►Pros:◄

- The proposed metrics provide a uniformity in measurements of requirements quality;
- baseline for all assessment;
- Simplicity;
- can be used in empirical measurements.

Tatiana ►Cons:◄

- Firstly, the problem of this approach is: it doesn't take into account the quality of project and its correlation with the requirements quality.
- Secondly, the approach is theoretic (academic) and has not yet been applied on practice.

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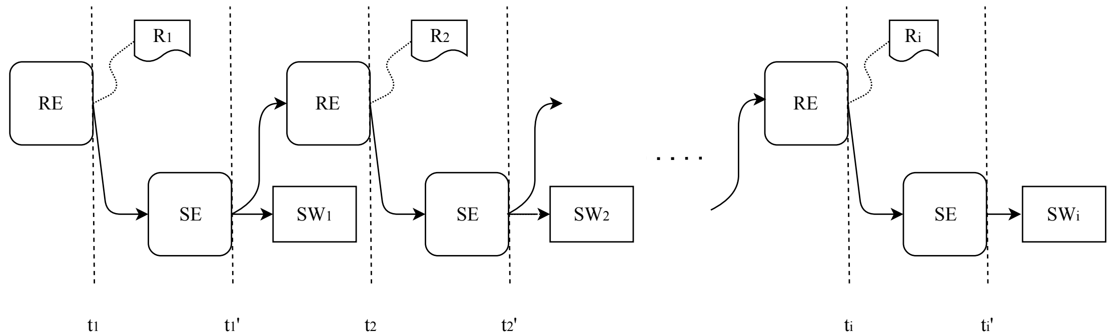

Fig. 1. Work flow of the

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