A Meta-Requirement Approach to Validate User Requirement Specification: Threshold Definition

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2023 IEEE 8th International Conference On Software Engineering and Computer Systems (ICSECS) | 979-8-3503-1093-1/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICSECS58457.2023.10256371

***Abstract*— The software requirement specification document is critical for ensuring that software development projects are completed on time, within budget, and meet the needs of all stakeholders. User requirement completeness refers to the extent to which user requirements accurately and fully capture the needs and expectations of stakeholders for a given system or application. The completeness of user requirements is critical for the successful design and implementation of information systems, as incomplete requirements can lead to a range of issues, including system failure, delays, and cost overruns. The author has developed a meta-requirement validation approach to validate the completeness of a set of requirements. Based on a numerical reading, the user of the approach will be able to determine the completeness of the requirement. This publication's main objective is to identify the threshold value through a method of literature search. The identified threshold value will be used to determine the minimum reading for the result to be deemed complete. The result of a 70% value has been identified to be suitable for the use of the validation approach.**

Keywords—Requirements Engineering; Design Science Research; Information Systems; Information System Design Theory; Meta-requirement

I. INTRODUCTION

Design science research (DSR) is a field that focuses on developing and evaluating innovative artefacts or designs to solve complex problems in various domains such as information systems, engineering, and healthcare. DSR is an iterative process that involves creating, testing, and refining the artefact until it meets the desired performance requirements and adds value to the relevant stakeholders. DSR aims to contribute to the advancement of knowledge by providing practical solutions to real-world problems.

Part of this area of knowledge is being known as information system design theory (ISDT). The field of ISDT is a theory that provides a framework for designing and developing effective Information Systems (IS) [1]. It derived from the area of knowledge of Design Science Research (DSR). It is a key concept in DSR, whereby it is a problem-solving paradigm that aims to create innovative solutions to complex problems through design, implementation, and evaluation [2]. ISDT focuses on the design of IS artefacts, such as databases, software systems, and user interfaces, by providing a set of guidelines and principles that can be used to ensure their effectiveness in addressing specific business needs. According to Hevner et al. (2010), ISDT is a critical component of DSR, as it provides a theoretical foundation for the creation of practical and useful IS artefacts.

From there, the author has proposed the knowledge of the stated field in the field of Software Engineering. The solution will work in the context of project management, where its main aim is to assist in the validation of requirements completeness with the assistance of Meta-requirement. Meta-requirements are high-level requirements that define the properties or characteristics of the requirements themselves, rather than the product or system being developed. These requirements are critical for ensuring the quality and effectiveness of the software development process.

Ultimately, the solution will produce a numerical reading that reads the successful traceability between the meta-requirement and requirements. This reading will define the completeness status of the set of requirements. The next course of action is to define the suitable threshold value that must be achieved to differentiate the result of the executed trace. In this section, the research will discuss the threshold value that has been agreed upon for measuring the completeness of requirements. The threshold value will be presented as a percentage of pattern similarity or adherence when comparing the User Requirements (UR) mapping to the defined Meta-Requirements (MR).

The objective of the publication is to

1. Execute a literature review
2. Analyse
3. Defining the threshold value.

This paper will be structured in the following: introductory, literature review, methodology, result, and conclusions.

II. RELATED LITERATURE

A. Design Science Research and Information System Design Theory

Design Science Research (DSR) is a problem-solving approach that involves the creation of innovative solutions through a process of design, implementation, and evaluation. Information System Design Theory (ISDT) is a theory that

provides a framework for designing effective Information Systems (IS) by providing a set of guidelines and principles that can be used to ensure their effectiveness in addressing specific business needs. Together, DSR and ISDT can provide a comprehensive approach to designing and developing high-quality IS solutions that meet the needs of users and organizations.

According to [3], DSR and ISDT are complementary approaches that can be used to create effective IS solutions. DSR provides a systematic and rigorous approach to problem-solving, while ISDT provides a theoretical foundation for the design of IS artefacts. By combining these approaches, researchers can create IS solutions that are both theoretically sound and practically useful. The authors note that ISDT can also be used as a tool for evaluating the effectiveness of DSR solutions, providing a way to ensure that they meet the requirements of the business.

In summary, the combination of DSR and ISDT provides a powerful approach to designing effective IS solutions. DSR provides a structured approach to problem-solving, while ISDT provides a theoretical foundation for the design of IS artefacts. Together, these approaches can be used to create high-quality solutions that meet the needs of users and organizations.

The development of the validation approach was based on the application of two major fields of knowledge; ISDT and RE. The generation of the most important artefact, MR, is under the knowledge area of ISDT. This represents the outcome of the research's first objective. This high-level abstract artefact serves as the main guidance in the validation of the STATE OF COMPLETENESS. Meta-requirement will then be utilized through the mapping of User Requirement, under the knowledge area of RE. This is the basis to determine the STATE of the project URS. The mapping will then be done through a manual process, which is guided by the defined set of rules to identify the correct mapping of the set of UR to the set of MR.

B. Meta-requirement Validation Approach

The development of the validation approach was based on the application of two major fields of knowledge; ISDT and RE. The generation of the most important artefact, MR, is under the knowledge area of ISDT. This represents the outcome of the research's first objective. This high-level abstract artefact serves as the main guidance in the validation of the STATE OF COMPLETENESS. Meta-requirement will then be utilized through the mapping of User Requirement, under the knowledge area of RE. This is the basis to determine the STATE of the project URS. The mapping will then be done through a manual process, which is guided by the defined set of rules to identify the correct mapping of the set of UR to the set of MR.

III. METHODOLOGY

The research methodology incorporates certain elements of the processes outlined in references [4]–[6]. To address the research question at hand, the study relies on conducting a literature review encompassing publications from academic journals, conference proceedings, and books. Additionally, relevant information from websites and press articles is taken into consideration. The chosen topic is regarded as a well-established and mature area of interest, and sources from reputable publishers, such as SCOPUS-indexed and ISI journals, are selected for the collection of information.

A preliminary exploration was conducted by searching Google Scholar using a combination of terms such as Systematic Literature Review (SLR), Systematic Mapping Study (SMS), Software Development (SD), Software Engineering (SE), Requirement Engineering (RE), Problems, Opportunities, Challenges, Project Management, Tender, Failures, and Gaps. This is being done with consideration of no specific publication dates as they were deemed irrelevant to the literature review task. Each publication identified was thoroughly examined and synthesized to address three main aspects: (1) Factors contributing to both success and failure in software development projects, (2) Proposed methods or tools for eliminating or mitigating failures, and (3) The most crucial artefacts in Requirements Engineering (RE).

After a quick analysis that was done based on the collected studies, the publications that were chosen were deemed relevant and their ability to provide valuable insights that were in line with the research interest. The literature review was then evaluated with consideration of complying with the research objective and synthesizing the findings from these selected studies to extract pertinent information and address the predefined research questions.

A. Threat to validity

Despite the potential for an exhaustive literature search and comprehensive analysis of results by extensively searching every available source worldwide, researchers still face certain limitations. This section addresses the threats to validity. Fully abstracting pure requirements engineering challenges before project execution is not entirely feasible due to the strong association between the actual term that is being utilized and Computer Science, particularly Software Engineering. The presented findings could be aligned completely with the research questions but are included in the study based on their relevance or it could also be otherwise. This aspect will be further explored in section 5.

Additionally, the human factor poses a threat to the validity of this research. No automated tools were employed, and all the information compiled for this study was gathered through the efforts of human researchers. Despite striving to create a comprehensive compilation of all existing meta-requirement creation methods worldwide, this research is subject to the constraints and limitations inherent to human researchers themselves.

IV. RESULT

This value will determine whether the existing URs conform to the defined MR in terms of completeness, represented by the proposed unit of measurement called STATE. STATE is used to compare the percentage of mapped URs to the MR graph pattern and to conduct a similarity pattern analysis to determine if it achieves a 70% similarity threshold.

TABLE I List of Relevant DSR Threshold Value Literature

Author(s) /Year	Method of Experimentation	Threshold Metric	Defined Threshold/Improvement Reading
[7]	Investment-adjusted cost-sensitive learning vs Threshold moving vs Synthetic minority oversampling vs Instance weighting vs MetaCost	Effectiveness Robustness	40.44% lower than that of IW (best case) and 42.04% lower than that of THR (worst case) The best case is an 8% improvement, worse case is a 35% improvement
[8]	Interviews and evaluations of a functioning	Practical viability	A threshold of value of 0.7 Cronbach's coefficient alphas was used.
[9]	Field study Survey Six-point Likert scales	Team performance(TP) Perceived useful(PU) Perceived enjoyment(PE) Ease of use(EU)	TP Mean, std dev: 4.86, 0.69 PU Mean, std dev: 4.71, 1.38 PE Mean, std dev: 4.43, 1.13 EU Mean, std dev: 4.14, 1.21
[10]	Comparing initial project vs implemented method project in terms of Unit price (€/FP) and Speed of delivery (FP/month)	Unit price (€/FP) Speed of delivery (FP/month)	Unit price (€/FP) shows an 'average of 50% improvement'. Speed of delivery (FP/month) shows an 'average of 50% improvement'.
[11]	Focus group interview sessions within the organization	Feasibility	A threshold value of at least 80% was defined based on the cases for each process
[12]	Training and 7 points Likert scale	Interest and enjoyment Intrinsic motivation Perceived competence Pressure and effort	0.80 0.83 0.86 0.93 A defined threshold value of 0.70
[13]	Survey	Perceived ease of use Perceived usefulness Behavioral intention	Minimum 1.75 and 2.06 which represent a range of agree to highly agree was shown
[14]	Actual operating cash flow vs predictive model	Benchmark's threshold	Thresholds of -40% to 40% in comparison to actual cash flow
[15]	Online survey and interviews	Reliability	The threshold of 0.6 Cronbach's Alpha was defined
[16]	Formative - GUI mockup evaluation by user Summative - interview 7 students	Accuracy of the forecast model	Accuracy of between 75% and 80% during the formative assessment
[17]	6-point scale	Reliability	Reading of 0.926 and 0.946 during different iterations. Defined 0.7 Cronbach's alpha as a threshold
[18]	Questionnaire	Addressability, Reputation, and Commitment	0.763, 0.786, and 0.548 A defined threshold value of 0.70
[19]	Interview Machine learning (Random forest and COSINE SIM) Field test	Relevancy Feasibility Usefulness	Achieved 75% in meeting decision-makers' minimum requirements
[20]	Naive Bayes classifier Logistic regression	Prediction quality measuring accuracy and the F-measure for individual models	A threshold of 0.5 was defined
[21]	Focus group discussions	Accuracy, relevance and usability	No threshold was defined.

[22]	Survey Interviews	Trust factor	The threshold was defined at 3.5 in the form of median
[23]	Focus group Interview Focus group Survey	Utility Usability Design principle Acceptance	The threshold value of 0.7 was defined
[24]	Questionnaire 5-point Likert scale	Usability Efficacy Reliability	0.6833, 0.6383 0.6686 Threshold refers to Nunnally 70%
[25]	Bayesian Belief Network predictive model	Strength of the relationships between variables	(Significance threshold=0.85) based on model averaging
[26]	Fuzzy theory traceability and vector model	Completeness Correctness Consistency	The value of α=0.40 was defined as a threshold value that is appropriate for the researcher.

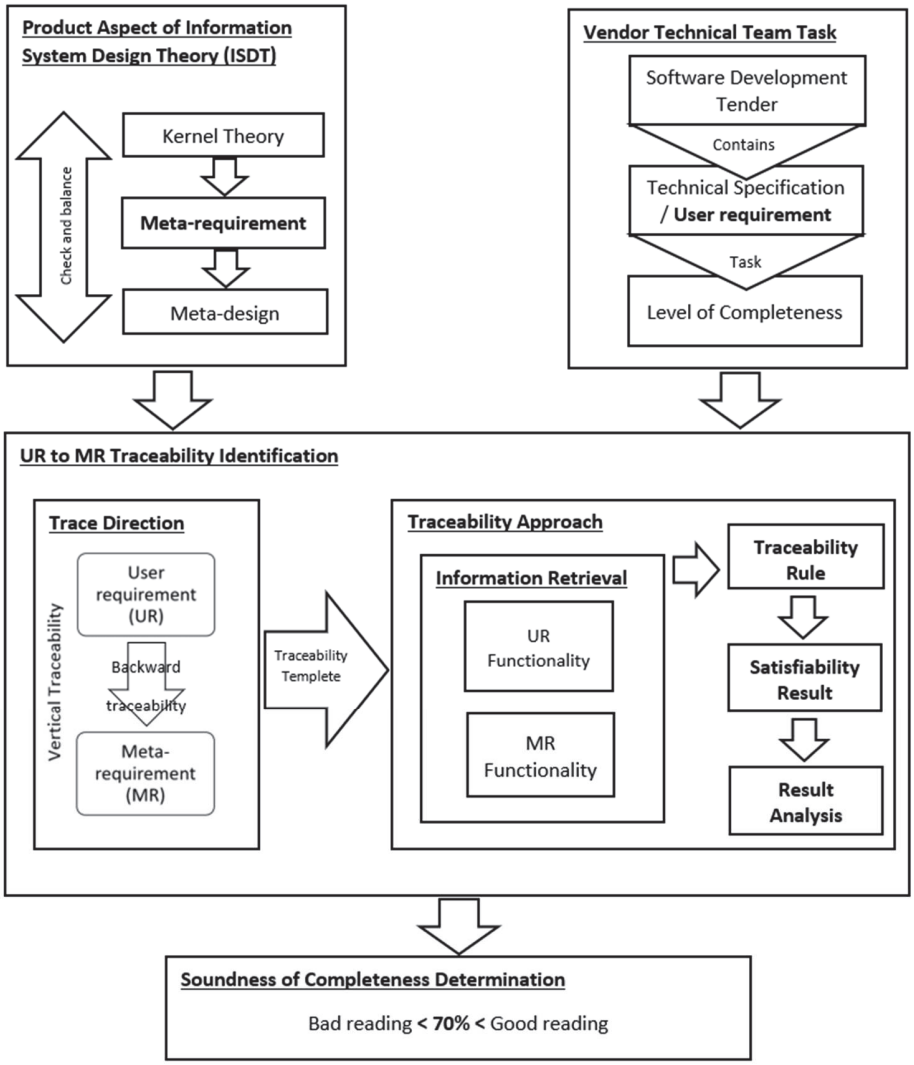

Fig. 1 A Meta-requirement Validation Approach

The use of questionnaires and surveys in the evaluation of DSR is subjected to measurement metrics such as reliability, ease of use, accuracy, etc. are accompanied by some sort of scaling method in determining the outcome of the quantitative evaluation. The most common is the Likert scale [27], [28]. Likert Scale is a type of psychometric response scale that is usually included in the questionnaire-based evaluation, in which responders specify their feedback in the form of a level of agreement with the statement. Depending on the evaluation setup, the Likert scale could range from five to seven points. Researchers will then refer to [29] as their main source of the threshold value, whereby in the experimentation that involves survey and questionnaire where Cronbach's Alpha is being set at an average of 0.7 by most of the highlighted research.

There were also experimentations involving organizational business data to evaluate forecasting or predictive model [7], [14], [16], [20], [25]. This involves researcher executing their developed prediction model and benchmarking the outcome of the model with real-world data. The range of thresholds that were identified by this type of research is within the range of a minimum of 40% [14], and a maximum of 97% [20]. This is subjected to the different models and evaluation metrics that are being implemented by the researcher.

In conclusion, the value of the threshold that will be applied to this research will be 70% of the overall mapping of UR to MR. This is based on the average reading of the threshold that was pre-defined by selected previous researchers (refer to Table 1) or the result of each measurement of their research and should be sufficient to be defined as the official threshold value of the project UR STATE. The findings in this chapter will be utilized further in the development of the Meta-requirement Based Validation Model (refer to Figure 1) by providing a threshold value that will use in the "Soundness of Completeness Definition" component.

V. CONCLUSION

With current research progress in the area of interest, there seems to be slow progression in initiating relationship meta-requirements and user requirement. The effort of establishing a comprehensive knowledge in defining the relationship between the two artefacts, within the context of UML and meta-requirement in the Software Engineering domain maybe a significant concern that will require serious attention from various parties such as body of knowledge of both SE and ISDT.

Our future endeavors will concentrate on developing an algorithm aimed at establishing the connection in term of associated relationship between both artefact and utilizing it as per suggested (refer to Figure 1). The approach will be able to be utilize in the attention of analyzing pre-project user requirement completeness within the ISDT and SE environment while considering all relevant artefacts.

ACKNOWLEDGMENT

This work was supported in part by Grant RDU220348

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