Questions Related to Uncertainty of Requirements Prioritization

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Abstract— Requirements prioritization activity of a software intensive system is significant in finding the priorities of requirements for implementation, thereby ensuring that the product developed meets the needs and expectations of the stakeholders. It is a challenge for software organizations because it demands a significant amount of decision making, which plays an important role in delivering high quality software to the customers. Decision makers who judge the priorities of requirements are human beings and human judgments may not be absolutely sure. The difficulties are aggravated with varying, incomplete, uncertain, undifferentiated and evolving requirements. Hence, techniques that aid in determining priorities of requirements must give space to the inclusion of uncertainty as a central aspect. The objective of this paper is to present a brief overview of requirements prioritization activity and some related questions to be expounded that interested researchers can dig into. The questions focus on proper acknowledgment of uncertainty during prioritization.

Index Terms—requirements prioritization uncertainty;human judgment;aggregation algorithm

I. INTRODUCTION

All requirements are not equally important. For example, the need for a university website system to provide examination results is likely far more important than setting the university song as a ring tone. Sommerville, 1997 defines Requirements Prioritization (RP) as the activity during which the most important requirements are discovered [2]. RP helps the requirements management team to identify the most important requirements and plan releases with the right functionality so that the needs of customers and users are satisfied [3]. This serves as a major step towards the delivery of a successful project or product. RP further helps to focus the best efforts of developers on the features that matter most for the customer satisfaction, thereby ensuring quality [4].

Large scale software systems may have hundreds and even thousands of requirements. Roger S Pressman, 2001 pointed out those priorities must be assigned to the several requirements cropped up during elicitation since tight deadlines may preclude the implementation of every software requirement [5]. Through RP, it is possible to utilize limited resources efficiently by focusing on the requirements that are most critical to the success of the project. Further, proper prioritization and implementation of requirements are important for overall survivability and economic growth of the company. In the words of Patrik Berander and Anneliese Andrews, 2007 the significance of RP is stated as below [6]:

The correct requirements and planning suitable releases with the right functionality is a major step towards the success of a project or product.

If the wrong requirements are implemented and users resist using the product, it does not matter how solid the product is or how thoroughly it has been tested. Hence, it can be concluded that a list of prioritized requirements obtained using RP is the key input that drives all the subsequent activities of software development and is of paramount importance, irrespective of the type, complexity and size of the project. Section 2 gives a brief note on various reasons for the existence of uncertainty during RP. Section 3 presents the claims and arguments made by several researchers, which act as the motivating factors behind the questions presented in this paper. Section 4 is the description of the questions to be expounded that provide a roadmap to evolve the requirements prioritization activity with a new outlook. Section 5 presents the conclusion.

II. UNCERTAINTIES OF REQUIREMENTS' PRIORITIES

F David Garlan, 2010 argues the necessity of embracing uncertainty in all areas of software engineering [7] as a first-class concern and RP is not an exception. Requirements are descriptions of the future system's functions, features, properties or expected behaviour. Assessments about the priorities of the requirements will be carried out by stakeholders whose judgment is all about their perception of the system, which cannot be precise always. Ambiguity masked in the forms of uncertainty, incompleteness, ignorance and vagueness do exist. Assessors have to cope up with different conceptualizations of uncertainty. Ambiguity during RP may arise for several reasons: specification of requirements using natural language, availability of partial knowledge about the future application and inability of assessors to provide precise judgments. [8, 9, 10].

Hence, it is understood that if uncertainty is ignored, success of the product may be affected [11]. Ambiguity brought on by lack of knowledge has to be modelled in some form during RP, which is of minimal use otherwise

III. CALL FOR ACKNOWLEDGMENT OF UNCERTAINTY

The dire need for the acknowledgment of uncertainty in RP, complemented by the observations made by several researchers is mentioned below.

- Grant Ruhe, 2000 said estimating is about predicting in the face of uncertainty and incomplete knowledge. Precise answers exhibit the high probability of being incorrect.

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The major contribution factor to the well reported high percentage of failed software projects is the built in human trait to prefer precision over accuracy [12].

- Moisiads, 2002 introduced an RP tool to capture stakeholders' opinions using graphical fuzzy rating scale. The argument is that people tend towards ranges that are flexible to express uncertainty rather than single points [13].
- Paolo Avesani et al, 2004 presented the limitations of recent approaches to RP as their inability to address uncertainty and incompleteness. Rating scales used for requirements evaluation based on discrete categories is another limitation [14].
- Ruhe et al, 2005 mentioned the current challenges of RP as incompleteness and uncertainty of information, conflicting, not enough stakeholder involvement, geographically distributed stakeholders, resource bottlenecks etc. Ruhe's essay on estimation perspectives recorded software schedule and cost estimation models as producing optimistic, most likely and pessimistic estimation ranges rather than point estimates because upfront estimates could not be precise always [15].
- Ruhe et al, 2005 portrayed RP activity both as an art and a science. As art, it depends on human intuition. As science, it depends on computational algorithms to produce best solutions. A release planning framework for RP which combines the human experience and knowledge with the strength of computational algorithm is launched. Ruhe concluded that hybrid approaches that integrate in this manner have proven most promising [16].
- Rudolf Vetschera, 2006 characterized software development projects as decision problems under risk. His work recommended to evaluate the decision alternatives that occur in the software process in terms of likelihood [17].
- B Regnell et al, 2007 argued that human judgment is imprecise by nature irrespective of absolute or relative judgment in view of the fact that some requirements can be estimated precisely, some others with reasonable precision and some others cannot be estimated at all [18].
- Jane Cleland- Huang, 2008 opined that decision support mechanism for RP has to be more sophisticated in order to accommodate the partially ignorant or fully ignorant information provided by stakeholders [19].
- Hermann A Daneva, 2008 put forth the idea of comparing two RP techniques empirically, one which uses approximation and one without. The intention is to find whether people like approximations or the opposite [20].
- Andrea Herrmann Barbara Paech, 2008 put forth the reasons for significant variation in the prioritization results of the experiment conducted by them. The causes were attributed to difference in experiences, uncertainty of the estimations, difficulty in foreseeing the priorities, missing information leading to differing assumptions, missing experience, misunderstandings concerning the method and missing knowledge about market and reality [21].
- Annabella Loconsole et al, 2011 introduced a novel distributed and automated RP technique and the paper concluded with one of the future challenges as acknowledgment of uncertainty during RP [22].

Hence, as stated above many RP techniques and related concepts in the literature address the compelling need for acknowledging ambiguity, uncertainty, incompleteness and imprecision of the priorities of requirements, but few of them provide a workable solution. Hence, a fundamental paradigm shift in the area of requirements prioritization is insisted. The shift is from behaving as if uncertainty does not exist to accepting uncertainty as a central fact.

IV. QUESTIONS TO BE ANSWERED

This section presents the two questions to be expounded and a note on further work highlighting the need for incorporating uncertainty during RP.

A. Question 1

"How can uncertainty be acknowledged properly during prioritization of requirements?"

A Requirements prioritization technique (RPT) helps to establish priorities for requirements and hence facilitates to select the right set of requirements for product delivery. It is desirable and possible to have all the requirements implemented, if projects have unlimited resources. RPTs are out of context in such a scenario. But in practice, projects generally face constraints on resources such as schedule, budget, manpower and technological requirements. Gilb and Maier, 2005 defined priority as "priority is relative right of a requirement to the utilization of limited or scarce resources" [23]. Hence, it is not possible to have all the requirements requested. In such a case, RPTs pave the way for the better utilization of limited resources through the clear division of requirements to be delivered immediately and the remaining ones that can be postponed for later increments. Therefore, by attending to high priority requirements first rather than low priority ones, project cost and duration can be saved and most importantly the customers are made satisfied.

Current RPTs in the literature operate with the aim of carrying out prioritization activity, while insisting on the precise assessments of priorities of requirements. Several RPTs were introduced in the literature and several experiments [4,24,25,26,27] evaluating these RPTs were being conducted to explore possibilities under various environments. Every RPT requires the assessment of requirements' priorities using one of the measurement scales: nominal, ordinal, interval and ratio. A study of RPTs mentioned in the literature and the corresponding assessment scale employed is discussed by the authors [1]. It is clear that the literature has in its store many RPTs based on nominal, ordinal and ratio scales but no comprehensive technique exists for prioritization using interval scale [28]. With the interval scale it is possible to evaluate each requirement's importance with a range of values rather than precise values as in nominal, ordinal and ratio cases.

Weber, 1987 pointed out that the interval scale could accommodate incomplete and uncertain information [29]. Importance of a requirement is relative worth, utility or value considerations of assessors. It lies in the eyes of the beholder and is usually difficult to assess with precise values [30]. Uncertain nature of human judgment tends to be conveniently expressed using intervals rather than precise values. With this drive, intervals of categories like low to medium, medium to high etc. can be used to evaluate requirements' importance's. Probabilities can also be used to express uncertainty and intervals are necessary to describe degrees of belief [31]. Hence, the RPT can also consider assessment of priorities with probability values across the assessment scales. On the contrary, Karlsson, 2006 mentioned that interval scale does not have any clear application in requirements management [32].

B. Question 2

Question 1 focuses on proper accommodation of uncertainty during RP. It is not the end of the world. The assessments thus made incorporating uncertainty have to be processed to generate final priorities. Hence, question 2 takes the following form.

"How individual assessments collected from multiple decision makers can be aggregated to generate collective reliable priorities?"

It is quiet easy task to determine the priorities of requirements if a single stakeholder provides precise priorities over a set of requirements along the dimension of a single attribute. However, it is more challenging to aggregate the imprecise judgments of diverse group of stakeholders over a set of requirements characterized by multiple attributes.

To answer this, various aggregation mechanisms in the literature have to be studied in the light of several constraints they impose. Some of the aggregation algorithms are: Weighted Sum Model (WSM), Weighted Product Model (WPM), Analytic Hierarchy Process (AHP) and Multiplicative AHP [33], Multiple Attribute Utility Theory [34], Dempster Shafer Theory of evidence for attribute aggregation [35], Evidential Reasoning (ER) and Interval Evidential Reasoning (IER) [36].

The algorithms have to be studied in terms of input requirements, processing complexity and the richness of outputs they produce. The algorithm adopted should work to generate optimal solution satisfying the conflicting preferences of all stakeholders. How changes in the priorities of requirements are effected when requirements are added or deleted also has to be explored. The algorithm has to be investigated for its capability of handling both complete and/or incomplete assessments in a consistent manner so that even an inexperienced assessor can produce realistic scores. Sensitivity analysis has to be done by assigning different weights to decision makers and study the results to resolve disagreement among them.

V. CONCLUSION

Uncertainty is becoming increasingly important in today's world and software is not an exception. RP is presented as a decision making problem with a central focus on due acknowledgment of uncertainty present during assessment of requirements' priorities. The intention is to create a wide scope of further research that interested readers can dig into. The two questions presented demand considerable attention and further effort.

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