A Systematic Approach for Identifying Requirement Change Management Challenges: Preliminary Results

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ABSTRACT

Requirement Change is one of the most challenging tasks in software development lifecycle, particularly in the complex context of Global Software Development (GSD). During the last decade, many studies are carried out to address these problems, however, careful examination of these works suggests that there’s a potential research gap. This paper has performed a Systematic Literature Review (SLR) to identify the most significant/commonly studied challenges of requirement change management process and furthermore this process under GSD context. We identified ten challenges such as impact analysis, cost estimation, artifacts documents management, requirement traceability, requirements dependency, conflicts with existing requirements, time estimation, change prioritization, user involvement, and system destabilizing. Furthermore, three challenges such as communication and coordination, knowledge sharing, management, and Change Control Board (CCB) management are identified for globally distributed projects. We also mapped these identified challenges to Requirement Change Management Process (RCMP) outcomes proposed in our previous study. We believe that mapping between RCM challenges and RCMP outcomes will enhance the practical significance of this study results. Considering the systematic literature review results, we suggest that there is a need to develop a framework for requirement change management for quality software systems development.

CCS CONCEPTS

Software Engineering, Software Requirements Management

KEYWORDS

Requirement change management, Requirements evolution, Global software development, Systematic literature review

1 INTRODUCTION

Requirements Engineering (RE) is one of the critical phase of Software Development Life Cycle (SDLC), and a study in the UK reported that 40% of the total software development process problems are related to RE process [1]. Furthermore, requirement change is the only fact that is perpetual throughout a project lifecycle and sometimes about 50% of the system requirements modified before they are put into service [2]. An improvised, vague and poorly executed requirement change management process can result in many problems related to cost and time, and even jeopardize the project success [3-5]. The study conducted by Standish (2017) revealed that requirement change increases the project cost by three times and project time by two times [6].

A number of factors have driven these changes, such as evolving customer needs or business goals, organizational policies, working or system operating environment, and government regulations. Similarly, having various ways to express the requirements by different stakeholders also results in ambiguity and inconsistency in requirements, and causes requirement change [7]. Furthermore, because of various benefits such as low cost, access to skillful teams, and access to market, many companies has adopted GSD paradigm [8]. However, the presence of cultural, temporal, and geographical differences in GSD complicates this process even further [9-11]. Additionally, requirements change also negatively impacts work distribution in GSD projects [12].

In spite of the importance of an effective RCM process in software quality and success, little research has been carried out to identify and analyze the key RCM challenges, and even ISO/IEC standards don’t have RCM as a formal process.

In order to develop an RCM framework and eventually to design quality software systems, we carried out a systematic and methodological approach (SLR) to identify the most important/commonly studied challenges that influence the RCM process. In addition to core RCM process challenges, we identify some other challenges that affect the RCM in globally distributed projects. In previous study, we proposed a novel RCMP, which fills
the research gap identified in ISO/IEC standards [13], and to achieve practical significance of identified challenges, we developed a mapping of identified challenges to RCMP outcome. We believe that our SLR on key RCM challenges or risks lays a critical foundation to develop an RCMP framework and a mapping of RCM challenges to RCMP outcome helps to make effective use of SLR results.

The rest of this paper is organized as follows. A literature review of existing research is presented in section 2. Section 3 introduces the research methodology of the current research. Initial results are presented in section 4. Lastly, conclusion and future work are discussed in section 5.

2 BACKGROUND

Software development is a dynamic process, and requirement change or evolution is inevitable and driven by a number of factors like change in market trends, business goals and customer needs [14]. Accordingly, effective requirement change management model or framework is required to develop quality software systems. Furthermore, in the context of GSD, the presence of diverse sets of stakeholders, temporal, and geographical differences make the RCM process more difficult for globally distributed projects [15, 16].

In the past, many empirical studies have been carried out to explore different aspects of RCM process. Accordingly, Jayatilleke and Lie [17] investigated the existing research/literature on causes of change, processes, and techniques designed to manage requirement change problems. Formal and semi-formal processes of RCM have been critically evaluated. They used the same approach as we performed, however, this study focuses on only generic concepts related to RCM process such as cause of change etc. and somehow missed the potential challenges that lie in RCM process. In another study, Ali and Li [18] implemented a three-stage requirement change management model for globally distributed projects. Their results showed the practical significance of proposed approach and addresses some of the important aspects of RCM problems. However, their approach is inadequate in two perspectives: First, they missed the communication mechanism across different GSD sites with the consideration of different project management approaches in GSD paradigm. Second, they missed the constitution and execution of CCB.

Furthermore, Khan, A. et al. [19, 20], used empirical technique such as SLR, questionnaire to investigate the communications risks of RCM process in GSD projects. They concluded that, due to geographical, socio-cultural, and temporal differences, communication and coordination is crucial in RCM process of globally distributed projects. These two studies investigated communication risks affecting RCM process in globally distributed projects which is one of the challenges that influence RCM in GSD paradigm, however these empirical studies missed many other important aspects of GSD paradigm such as knowledge management and sharing, and CCB management.

To the best of our knowledge, little research has been undertaken to explore the challenges associated with RCM process. Only one study [21] carried out, and they identified some challenges related to RCM process, including reusability, change activity management, software artifacts management, and change automation. However, they used ordinary literature review technique which is not as systematic as SLR and missed some relevant papers.

In Summary, no systematic empirical study such as SLR has been undertaken to identify the RCM process challenges. Secondly, the temporal, cultural and geographical differences in GSD paradigm instigate many challenges in RCM process. Accordingly, there is a need to investigate the challenges that affect the RCM process of globally distributed projects. We believe that our SLR results about RCM process challenges for globally distributed projects would fill the identified research gaps and at the same time would help to develop a framework to handle requirement change problems.

3 RESEARCH METHODOLOGY

Systematic Literature Review (SLR) is an approach to identify, access, and elucidate the existing research relevant to a specific research areas, or phenomenon of interest [22]. An SLR provides an opportunity to achieve a deeper insight into a relevant area. An SLR is a defined and methodical way of identifying, assessing, and analyzing published primary studies, which are usually not fully addressed in ordinary literature reviews approaches. An SLR also allows researchers to identify potential research gaps in published research for future research activities. The major steps of the SLR process followed in this study are:

- Construct and execute search strategy for relevant studies.
- Perform a study selection process.
- Apply quality assessment criteria.
- Extract data and analyze the extracted data.

Research question formulation is the first step of an SLR process. In this paper, we formulated the following two research questions:

RQ1: What are the challenges of an RCM process?

RQ2: What are the challenges of an RCM process in global software development?

In the second phase, we formulated the search strategy according to our defined research questions. In the third phase, studies relevant to the phenomena of interest were selected based on a defined selection process. And then on selected primary studies quality assessment were performed. In the last, the data was extracted from selected primary studies for further analysis. The SLR was undertaken by three researchers, i.e. one student and two academic staff members.

3.1 Search Strategy
This subsection presents the search strategy to execute an SLR process. To design the search strategy, we perform the following steps:

- Extract search terms from defined research questions.
- Identify synonyms or search term for main search keywords.
- Design search string using AND and OR boolean operators.

In this study, the following keywords were identified as major search terms.

RQ1: Challenges, Requirement Change Management

RQ2: Challenges, Requirement Change Management, Global Software Development

By performing cross-validation in well reputed academic repositories, we identified the following main search terms or synonyms for each search keyword.

**Challenges:** “Challenges” OR “problems” OR “difficulties” OR “complications” OR “obstacles” OR “barriers” OR “hurdles” OR “risks”

**Requirement Change Management:** “Requirement change” OR “Requirement Volatility” OR “Requirement Creep” OR “Requirement Change management” OR “Requirement change difficulties” OR “Requirement change analysis” OR “Requirement change identification/type” OR “requirement change models/processes”

**Global Software Development:** “Global software development” OR “global project management” OR “GSD” OR “Global Software Development” OR “Offshore software development” OR “distributed software development” OR “offshore outsourcing” OR “Global Software Engineering” OR “Distributed Software Engineering” OR “GSE”

After defining the synonyms or search term for each search keyword, we have defined the following search strings (only RQ1 presented as sample).

(“Challenges” OR “problems” OR “difficulties” OR “complications” OR “obstacles” OR “barriers” OR “hurdles” OR “risks”) AND

(“Requirement change” OR “Requirement Volatility” OR “Requirement Creep” OR “Requirement Change management” OR “Requirement change difficulties” OR “Requirement change analysis” OR “Requirement change identification/type” OR “requirement change models/processes”)

Some relevant publications used to validate the search terms and search string. The following academic research repositories were used for this study.

- IEEE Access. (http://ieeexplorer.ieee.org)
- Science Direct. (http://www.sciencedirect.com/)
- Springer Link. (http://link.springer.com/)
- ACM Digital Library. (http://dl.acm.org)
- Google Scholar. (http://scholar.google.com/)

Because these research sources differ in their search mechanisms, we customized the search strings accordingly.

In the next phase, primary studies selection process was performed. The student performed the primary studies selection process and the academic staff members cross verified the selection process. In the first iteration, studies were selected based on the paper title and abstract. In the second iteration, the selected studies were shortlisted by reading the complete papers. Additionally, general criteria for inclusion and exclusion of studies will be applied. The broad search was conducted in May and June 2018 and the studies published or available online till 30, June 2018 are included in data extraction process.

The following inclusion criteria were used in the selection process:

- Studies focused on answering our research questions.

Furthermore, the following exclusion criteria were used:

- Papers written in non-English language.
- Technical reports, and white papers.

In the next phase, each paper was assessed based on the quality criteria shown in Table 1. There are two possible answers Yes=1 and No=0 for each quality assessment question. The minimum quality score of 3 (75%) was used to select primary studies. Finally, 43 studies were selected based on the inclusion and quality assessment criteria.

<table>
<thead>
<tr>
<th>Quality Criteria</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are the research goals clearly stated in the paper?</td>
<td>Yes =1&lt;br&gt;No =0</td>
</tr>
<tr>
<td>Is the proposed technique clearly described and justified?</td>
<td>Yes =1&lt;br&gt;No =0</td>
</tr>
<tr>
<td>Was the research empirically validated?</td>
<td>Yes =1&lt;br&gt;No =0</td>
</tr>
<tr>
<td>Does this study discuss the RCM challenges for general RCM process or GSD projects?</td>
<td>Yes =1&lt;br&gt;No =0</td>
</tr>
</tbody>
</table>

**4 INITIAL RESULTS AND DISCUSSION**

This section introduces the preliminary findings of an SLR and mapping between RCM challenges and RCMP outcomes. The total number of results obtained by executing the search strings are shown in Table 2. Appendix A lists the complete list of studies selected by SLR.
Next, we will discuss RCM challenges frequency and theirs mapping RCMP outcomes. Below is the list of outcomes of the RCMP proposed in [13].

1. Items to be changed are identified and recorded.
2. Change impacts are analyzed.
3. The cost and schedule of changing items are estimated.
4. Changes to the items under requirement change are approved.
5. Changes to the items under requirement change are implemented.
6. Changes to the items under requirement change are verified and validated.
7. Changed items deliverables are updated and communicated to concerned parties

<table>
<thead>
<tr>
<th>Resource</th>
<th>Total Results</th>
<th>Initial Selection</th>
<th>Final Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE Xplore</td>
<td>60</td>
<td>29</td>
<td>16</td>
</tr>
<tr>
<td>ACM</td>
<td>15</td>
<td>10</td>
<td>03</td>
</tr>
<tr>
<td>Science Direct</td>
<td>41</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>Springer</td>
<td>68</td>
<td>34</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>184</td>
<td>89</td>
<td>43</td>
</tr>
</tbody>
</table>

The SLR has identified 43 papers. Among them 32 are deal with general RCM challenges and 11 of them with RCM under GSD context.

A coding scheme based on grounded theory was used to review the literature and conceptualize the underpinning RCM challenges. We have identified, labelled and grouped the related challenges to general categories and calculated the frequency. Furthermore, similar or related challenges were semantically compared and grouped under relevant categories. Our study discovered ten challenges of general RCM process, which are listed in Table 3 with frequencies (appears in how many papers) and their mapping with RCMP outcomes.

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Frequency (total=32)</th>
<th>%</th>
<th>RCMP outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact Analysis</td>
<td>21</td>
<td>67</td>
<td>2</td>
</tr>
<tr>
<td>Cost Estimation</td>
<td>8</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>Artifacts Documents Management</td>
<td>8</td>
<td>25</td>
<td>1, 4, 7</td>
</tr>
<tr>
<td>Requirement Traceability</td>
<td>7</td>
<td>22</td>
<td>1, 7</td>
</tr>
<tr>
<td>Requirements Dependency</td>
<td>5</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>Change Conflicts with Existing</td>
<td>4</td>
<td>12</td>
<td>4, 6</td>
</tr>
<tr>
<td>Time Estimation</td>
<td>4</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

From the above table, we can see that impact analysis is the most highly cited challenge (67%) and it is mapped to outcome 2 of RCMP outcomes. In RCM process, inclusion/exclusion or modification of requirements requires careful analysis of new system state, consistency with existing business goals and impact on other operational constraints [4, 7].

Cost and time estimation are one of the critical aspects of project management cited by (25%) and (12%) of the primary studies respectively. It is obvious these two challenges are mapped to outcome 3. Artifacts documents management is another key challenge of RCM process studied and cited by (25%) of existing research. The management of SDLC phases product such as requirement document, design document, source code, and testing document is crucial, especially if change occurs in the last phases of SDLC such as during testing. In connection with RCMP outcomes, it can be mapped to outcome 1, 4, and 7, because these three also deal with documents management. Similarly, Requirements traceability is cited by (22%) of primary studies and can be mapped to outcome 1 and 7 of RCMP outcomes.

The other key challenge of RCM process is requirement dependency (16%), which impacts RCM in the early phase and can be mapped to outcome 1. Similarly, requested change conflict with existing requirements is cited in 12% of primary studies, impacts RCM process during approval and implementation, and accordingly can be mapped to outcome 4 and 6. Additionally, change prioritization and user involvement are less frequently studied and can be mapped to outcome 4, 5, 1 and 3, 7 respectively.

Finally, system destabilizing is another challenge, but it seems difficult to find suitable mapping with RCMP outcomes. This is an open question that needs further assessment of both literature and RCMP.

Apart from general RCM process, we have identified three key challenges that are specific to the RCM of globally distributed projects, as shown in Table 4.

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Frequency (total=11)</th>
<th>%</th>
<th>RCMP outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication &amp; Coordination</td>
<td>10</td>
<td>91</td>
<td>1, 3, 7</td>
</tr>
<tr>
<td>Knowledge Management &amp; Sharing</td>
<td>8</td>
<td>73</td>
<td>1, 4, 7</td>
</tr>
<tr>
<td>Change Control Board (CCB) Management</td>
<td>2</td>
<td>18</td>
<td>4</td>
</tr>
</tbody>
</table>

In GSD paradigm, the teams are distributed across different geographical development sites, and the presence of temporal and
cultural differences often cause many difficulties. Communication & coordination are the key challenges that impacts RCM and this point is confirmed in this research (91%), and mapped to outcome 1, 3, and 7, because these outcomes requires communication with the end user. The next key challenge is knowledge management and sharing cited in 73% of primary studies. It is mapped to RCMP outcome 1, 4, and 7 similar to artifacts documents management. Finally, CCB management deals with change approval cited in 18% of primary studies and is mapped to outcome 4. Considering the above discussion, some mappings are obvious, and some mappings are arguable and could be adjusted in the future.

There are some limitations of this study. The main limitation of this study is incompleteness. Our findings depend on the set of keywords and search engines, which might not cover all relevant studies. In order to limit the risk of incompleteness in keywords lists, we used a set of well-known RCM papers to build the search terms. We also used four different electronics databases to reduce inherent limitations of existing search engines. Also, the search engine may miss some most recent publications. However, we believe that our preliminary results cover most relevant published works.

5 CONCLUSION AND FUTURE WORK

Requirement change management is an important aspect of the requirement engineering phase and plays a crucial role towards project success. Changed customer needs, market trends, and organizational or business needs are the main reasons of RCM. In the presence of temporal and geographical differences, this process becomes even more difficult. The requirement evolution could overshadow the benefits gained through the presences of globally distributed teams.

As a first step to address these issues, we identified a list of RCM challenges through SLR. The most cited RCM challenges are impact analysis, time and cost estimation, artifacts documents management, requirements traceability, requirements dependency, and requested change conflicts with existing requirements. In addition to these challenges for the general RCM process, three challenges are identified that influence the RCM process in globally distributed projects. Finally, we map these identified challenges with the RCMP outcomes proposed in our previous study. We believe that, mapping of SLR results with RCMP outcomes helps industry professional to make effective use of SLR results.

In the future, we plan to conduct an empirical study with the industry professionals to validate our SLR results. We also aim to improve the mapping of RCM challenges with RCMP outcomes.

REFERENCES


APPENDIX A: List of Studies Selected in SLR


