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Requirement Change Management Techniques in Software Systems

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***Abstract*— During software development requirement gathering is an important phase. Requirements are the basis of software development. The success or failure of any software depends upon level of understanding developed in requirements. During software development requirements keeps on changing due to different reasons. Hence requirements are such a critical phase that leads to the total project failure. So, to understand the impacts and to identify the conflicts with existing requirements, it is important to manage and analyze the requirements well. Requirement change management is the interest of this paper. Different requirement change management techniques has been discussed in this paper and analyzed them well and finally conclude the results accordingly.**

***Keywords* – Requirement Change Management, Methodology, Change Management Process, Software System**

I. INTRODUCTION

At the start of project development, requirements are not frozen or concrete. Sometimes the change is inevitable due to change in customer requirements or the environment in which the system has to operate. Hence, developing requirements is a part of software process and it includes requirements changes. During software development, the requirements are changing all the time and with the progress of the system, requirements become more and more complicated. It is proved by the previous researches that correcting a requirement error later in SDLC costs much more than their correction at requirement development stage. Various research works shows that the main cause of project failure is that the requirements changes are not managed. Hence requirements are such a critical phase that leads to the total project failure. So, to understand the impacts and to identify the conflicts with existing requirements, managing requirements is essential. Specially for complex systems, along with the well-organized requirement engineering process, there should be effective requirement change management as well.

In this paper, we have discussed different requirement change management techniques such as, multilevel ontology framework, configuration management process, waterfall methodology, knowledge management system, light weight agile approach etc. any many others and their analysis in detail. There are different frameworks and techniques to manage requirement changes, hence reducing the risk of software failure due to requirement level problems. In the section I of this paper, an introduction is given about our paper.

In section II, existing work on managing requirements changes is discussed. Different techniques for requirement change management are given interest in this section. In section III, a detailed analysis is done for various requirement change manage techniques and a table is also given to show it. In the last section of this paper, a conclusion is drawn from the whole discussion.

II. LITERATURE REVIEW

In Software development change occurrence of any process production couldn't be tolerate able and it will be highly resistive as confusion is being created by this between developers. Similarly, customer's confidence is also broken by this change as a result production will become non-reliable. There could be different reasons for such situation of changes such as application deployment on platforms that are multiple variant or for the simultaneously testing distinct support tools or may be over workload of developers at the same time. In a highly organized manner these modifications are needed to be changed by developers. The objectives are fulfilled by Software Configuration Management SCM to avoid a situation in which changes occurs. [1]

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Presently, Global Software Development GSD Paradigm is adopting by Software firms increasingly this is due to low cost's quality software production. Challenges CHs which are related to project administration is done by this study. RCM activities are negatively impacted by these challenges in GSD firms. The findings revealed by a research work shows that 3 out of 10 CHs are critical. This kind of study is helpful for RCM practitioners in GSD or for GSD Firm success. [2]

Majority of firms has considered GSD to develop low cost quality product in less time. However, GSD Firms faces many challenges which are related to requirement change management. In 2019, research is done for the development of software RCM and implementation of Maturity Model SRCMIMM . GSD Firms can be assisted by this SRCMIMM for the modification and improvement of activities. [3]

Changes Requirements must be undertaken by the Software development process and as a result cost, time and quality of final product is affected by these requirement changes. When Software development is global, the change problem is unavoidable. So in global GSD environments, there must be proper improvements of the quality of Requirement change Management. In 2019, a study worked on the hypothesis that misunderstandings and miscommunications problems leads to requirement change request which can be corrected by using the multilevel ontology framework that will greatly support RCM in GSD environment. By using a questionnaire and a case study, this framework was appraised successfully. [4]

Critical phase of SDLC is Requirement Engineering. Many Challenges are being posed by the evaluation of Business and technology which becomes the reasons of changes in requirements. In the development process software changes are inevitable and could became source of project risk. RCM problems are not fully addressed by the Configuration Management process which had been developed earlier. As a result RCM Process is proposed in another research work for addressing this kind of issues. Deficiencies of existing requirement change process are significantly addressed by this proposed system. [5]

A significant role is played by the Engineering change management in leveraging design efficiency, shorten the time span of system development and reducing the waste of resources. A direct or indirect module partitioning approach is undertaken by most existing studies in which various components based on expert/user domain knowledge are clustered i.e. subjective and time consuming. To fill the gap, novel approach is proposed by another research study by the help of which engineering change management is supported in the smart PSS context. [6]

The impact of change requests on the developed software development project's outcomes due to requirement defects are compared by this research by using waterfall methodology. On the basis of injected defects in software during their development and in term of total expended effort ,outcomes are measured while different ways are examined by the prior literature to minimize defects in requirements so as to minimize change requests to occur in requirements. Due to change requests, new requirements and defects are increased. So for the improvement of software project outcomes, there must be proper efforts that can reduced the change requests is necessary. [7]

At the start of project development, requirements are not frozen or concrete. Sometimes the change is inevitable due to change in customer requirements or the environment in which the system has to operate. Hence, developing requirements is a part of software process and it includes requirements changes. It is proved by the previous researches that correcting a requirement error later in SDLC costs much more than their correction at requirement development stage. In a research article in 2017, researchers presented a method of requirement change analysis. This is a three step process, first in change analysis using functions, second is the identification of change difficulty and third is the identification of dependencies using a matrix. To illustrate its usefulness, in a university, this method is applied to a course management system. [8]

Various research works shows that the main cause of project failure is that the requirements changes are not managed. Hence requirements are such a critical phase that leads to the total project failure. Different research articles addresses requirements change in different ways. In a paper written in 2017 , a systematic review

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method is used to discuss four requirements-related views which include the causes of requirements changes, requirement change management processes, change management techniques used and organizational decisions regarding requirement changes. This paper discussed the strengths and weaknesses of already existing techniques used for managing requirement changes. [9]

In the software development life cycle, the requirements are changing all the time and with the progress of the system, requirements become more and more complicated. Specially for complex systems, along with the well-organized requirement engineering process, there should be effective requirement change management as well. Software systems are described with the help of diagrams and various views by OOSE using UML. Therefore effective requirements change management is required by software development using UML. In 2016, a requirement change management model is proposed in a research article. This model is for Object-oriented methodology with UML. A case study is used in this paper and its business models are taken as user requirements and are used for the demonstration of proposed model. The performance of the proposed system is also evaluated. [10]

Requirements changes cannot be avoided in software development. Although the requirements change management is important, requirements change knowledge management (RCKM) is also concerned by other research studies as well. On the basis of the design of a knowledge management system to manage change and the analysis of change cause, knowledge transfer and sharing of RCKM is explored. In 2019, Yuqing Yan and Zhenhua Zhang presented a research work in which they discussed the previous researches in different aspects. The results are also analyzed after that. This paper discusses the methods of knowledge transfer and sharing on the basis of change cause analysis; data flowchart design, and RCKM functional modules. Further study is suggested in the conclusion. [11]

Nowadays, global software development is growing at a great pace. Due to demand of rich communications, both the requirements engineering and the requirements change management are very challenging activities. In global software development, addressing cultural and geographical differences is necessary. The importance of project management in RE and RCM processes is investigated by a research work of Muhammad Shafiq in 2018. Project management frameworks are proposed for RE and RCM. To validate the frameworks, a survey and expert interviews are conducted. For the analysis of collected data, statistical tools are applied. The significant impacts of both frameworks are shown by the results in GSD environment. [12]

Presently, agile development methodology is becoming very popular. Efforts have been to put on agile RE techniques to traditional development and vice versa. But, the difficulty in maintaining the fundamental nature of agile is the biggest problem. In 2018, for an agile requirement management approach, researchers define six criteria and a light weight agile approach is presented through which, while combining the RE techniques, agile characteristics can be maintained. An industrial case study is also discussed. [13]

In 2016, Naveed Ali and Richard Lai presented a method to manage requirements changes for global software development in their research. This is a three phase method, first is to consider the changes required between various GSD sites, second is to perform a change analysis according to the development work and last phase includes making final changes in the GSD sites. We applied our method to an online shopping system case study for validation of our system, here a group of students played the role of stakeholders. It is inferred from the results that to facilitate the stakeholders for managing requirements changes for GSD, this method is better than others. [14]

III. ANALYSIS

A lot of different approaches for requirement change management are discussed. Different latest research works are considered in this paper. The analysis of the techniques discussed in different research works is represented in the form of table given below.

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No.	Author	Techniques Proposed	Case Study	Attributes	Methodology
1	Hussain Saleem, 2019	Requirement change management model	Software Configuration Management SCM	Reliability	Step 1: Check reasons for change Step 2: Avoid change situations
2	M. A. Akbar, 2018	Requirement change analysis	Global Software Development GSD Paradigm	Efficiency, Reliability	Step 1: Change analysis Step 2: Change Identification Step 3: Handle challenges
3	M. A. Akbar, 2019	Requirement change framework	Development of software RCM and implementation of Maturity Model SRCMIMM	Security, Safety	Step 1: Develop Change Step 2: Change Implementation maturity model SRCMIMM
4	A. A. Alsanad, 2019	multilevel ontology framework	By using a questionnaire and a case study	Understandability	SWOT analysis of RCM techniques
5	S. Answer, 2018	Configuration Management process	Unspecified	Security, Safety, Reliability, Risk management	change analysis
6	Pai Zheng, 2019	novel approach	Unspecified	Maintainability	Existing change analysis
7	K. Chari, 2017	waterfall methodology	Unspecified	Maintainability, Reliability	Step 1: Compare defects Step 2: Inject defects Step3: Analyze

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8	S. Jayatilleke, 2017	Requirement change analysis	Course Management System	Understandability, Efficiency, Reliability	Step 1: Change analysis Step 2: Change Identification Step 3: Identification of dependencies
9	S. Jayatilleke, 2017	Systematic review method	Unspecified	Manageability analysis	SWOT analysis of RCM techniques
10	J. Tomyim, 2016	Requirement change management model	Mission Hospital Phuket	Performance, Effectiveness	OOSE with UML techniques
11	Y. Yan, 2019	Knowledge management system (Knowledge transfer and sharing methods)	Unspecified	Security, Safety, Reliability, Efficiency	Design of KMS, factors affecting knowledge transfer and methods used to implement knowledge transfer
12	M. Shafiq, 2018	Requirements change management framework	Unspecified	Maintainability, Reliability	Survey and expert interviews are used for evauation
13	W. Shim, 2018	Light weight agile approach	Industrial case study	Effectiveness, Efficiency	Six criteria
14	N. Ali, 2016	Framework for requirements changes for GSD	Online Shopping System case study	Security, Safety, Reliability, Risk management	Step 1: Consider required GSD changes Step 2: Perform change analysis Step 3: Implement the changes in GSD sites

In the research paper by Hussain Saleem 2019, a method of analyzing requirement change is discussed. This is two-step process, first is finding the reasons behind the change and second is to avoid the situation in which that change occurs. Software Configuration management is used in his work to validate the results.

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His proposed method is reliable. In 2019, research is done for the development of software RCM and implementation of Maturity Model SRCMIMM. GSD Firms can be assisted by this SRCMIMM for the modification and improvement of activities. It is secure and safe.

In 2019, a study worked on the hypothesis that misunderstandings and miscommunications problems lead to requirement change request which can be corrected by using the multilevel ontology framework that will greatly support RCM in GSD environment. By using a questionnaire and a case study, this framework was appraised successfully. His proposed method is reliable and understandable. RCM Process is proposed in another research work for addressing the risk of changes. Deficiencies of existing requirement change process are significantly addressed by this proposed system. This technique is secure, reliable and risk management can be done by it.

Novel approach is proposed by another research study by the help of which engineering change management is supported in the smart PSS context. In this research, changes are examined by the existing system and then these changes will be handled. On the basis of injected defects in software during the development and in term of total expended effort, outcomes are measured by K Chari in 2017 while different ways are examined by the prior literature to minimize defects in requirements so as to minimize change requests to occur in requirements. This is three-step process, first is to compare defects that causes change , second is inject defects that can cause change and the third is to analyze the results of those defects.

In the research paper by S. Jayatilleke, in 2017, a method of analyzing requirement change is discussed. This is a three step process, first in change analysis using functions, second is the identification of change difficulty and third is the identification of dependencies using a matrix. Course management system case study is used in his work to validate the results. His proposed method is efficient and reliable. SWOT analysis of requirement engineering techniques is done by S. Jayatilleke using systematic review method. Manageability analysis is done in his work. Another requirement change management model proposed by J. Tomyim, is very effective and its performance efficiency is validated by applying this model on to a case study “Mission Hospital Phuket”.

Discussion of previous researches is done in another research work. Knowledge transfer and sharing models proposed in this work are safe, secure, efficient and reliable. M. Shafiq presented requirements change management framework, whose validation is done by expert interviews and surveys. His proposed framework is reliable and maintainable. W. Shim, in 2018 presented light weight agile approach and six criteria is defined to manage agile requirements. Due to this criteria, agile characteristics can be maintained while managing requirements. This technique is applied to an industrial case study, the results shows the efficiency and effectiveness of this approach.

A framework for requirement changes for global software development, proposed by N. Ali, in 2016, is a three phase method, first is to consider the changes required between various GSD sites, second is to perform a change analysis according to the development work and last phase includes making final changes in the GSD sites. Online shopping system case study is used to analyze security, safety, reliability and risk management in this technique. It is inferred from the results that to facilitate the stakeholders for managing requirements changes for GSD, this method is better than the existing ones.

IV. CONCLUSION

Requirement changes are difficult to manage as it is the very critical phase of SDLC and is the basis of total success or failure of the software. The main purpose of all the techniques and approaches discuss in this paper is to reduce the risk of software failure due to requirement level errors. One of the best ways to reduce risk is to understand the requirements at the requirement phase rather than much later in the software development process. Also the skilled and qualified engineers are vital to the success of any software development. Tools to handle requirement changes are also available.

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