

Recent trends of Risk Management in Software Development: An Analysis

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ABSTRACT

One of the essential objectives of any software industry is to develop customer satisfied software. Due to the intangible nature of software, occurrence of risk has become one of the key concerns of the industry. As such, it is important to ensure software development process to have effective risk management strategies. As risk occurrence is inevitable, risk mitigation strategies have come a long way since past two decades. This paper therefore put forth an analysis of various trends in risk management that exist across software industries. An empirical investigation carried across software industries is further presented which throws light on the scope for effective risk management research to further progress.

Keywords: Software Engineering, Risk Management, Risk mitigation methodologies, Software Quality

I. INTRODUCTION

Software has proven to be a panacea to several application domains since six decades. However, due to the inherent nature of software being flexible and intangible, it is always prone to risk occurrences. Risk is deemed to be a consequence of inadequate information. Hence, risk management is considered to be one of the vital activities of software management. Therefore, last two decades has witnessed evolution of several new approaches, methodologies and techniques to help mitigate the risk. This study therefore comprises of information related to history of risk management, analysis of different research works related to risk management and further to classify risks in concurrence to types of projects, as an effort to study risk management.

It is after the World War II that risk management gained its significance in software development process. Due to the impact of globalization, software industry started to grow into a multi-billion dollar industry and application of software found its way in every part of science and technology, from entertainment to defense. As software industry evolved and expanded, it was necessary to study and avoid risks because of the huge investment involved in it. Different strategies were designed to avoid as well handling risk. Consequently, risk management turned out to be a science which now has a long history of several decades.

Further, exponential growth of internet influenced risk management to a great extent. New and efficient strategies had to be designed for a totally different platform. Strange risks, which were

never considered before, started affecting the projects. Other non-standard practices such as outsourcing, networking and resource sharing became tougher challenges for risk management. To manage and handle such situations effective strategies were developed alongside. Mathematical modeling, graphical representations, feedback systems, surveys and statistical analysis in risk management gained its popularity for their efficiency.

As such, risk management has become one of the most important concerns of effective project management. Risk mitigation strategies thus followed during risk management process are not taken from a standard research and applied in the project however they are studied, analyzed and carefully tailored to suit the requirements. Furthermore, in case of large software projects, new strategies are developed for the project if none of the existing strategies can fulfill the requirements.

II. RESEARCH IN SOFTWARE RISK MANAGEMENT

Literature survey enables one to get deeper understanding of the research topic surveyed and referred. Such knowledge facilitates one to comprehend the importance of the area of their research. A sample list of journal articles and research papers is studied and analyzed as shown in Table 1.

The graphical representation of the number of papers which were published in the last six years is shown in Fig.1 Increase in the number of papers based on risk management methodologies proves an increasing demand for advanced risk mitigation strategies. Data for risk analysis is available from several past and on-going projects which indicate the need for mitigation strategies to solve newer problems faced in those projects.

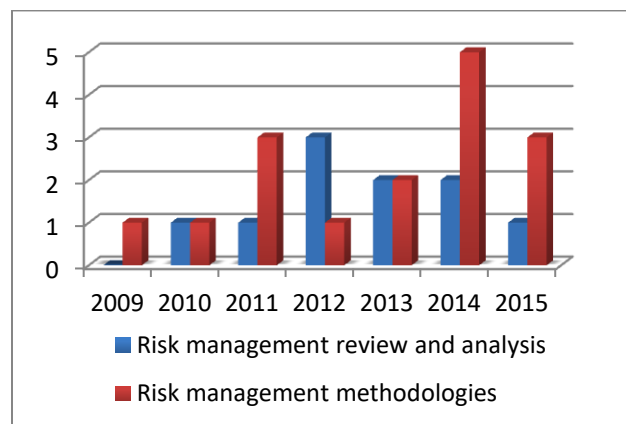


Fig.1 Classification of review papers based on the content

III. REVIEW OF RISK ANALYSIS AND METHODOLOGIES

A detailed and comprehensive analysis is carried out upon several software projects to understand risk management in software development by various research fraternities. Their

works can be further classified into two categories namely work related to risk associated concerns and risk management methodologies adopted in various organizations. This section put forth sampled articles which are reviewed and their relevance to the topic is presented.

REVIEW

- Risk assessment was dependent on the human judgment for a long time until the formal and mathematical models evolved. This eliminated the ambiguity and the uncertainty caused by the human error in assessing the situation. Objective indicators, the metrics collected from project baseline, can help assess the situation in a more reliable and accurate way. Quality indicators such as requirement complexity, requirement volatility and organizational efficiency are used to transform the risk analysis from state of guessing to an accurate calculation. [30]
- Risk management, generally, has a long history of several decades. Risk management has evolved from a metric used to prevent monetary losses in financial and insurance organizations, to a life-saver for all the type of organizations, it was a great journey. Analysis of the evolution of risk management therefore gives great hold on the current research on risk management. [3]
- Risk, in software projects, is uncertain. Therefore, it is important to identify the probability of risk. Newer methods and techniques, like stepwise regression analysis, are developed to estimate and calculate the probability of risk and to increase the project success rates. [25]
- Identifying risk factors and prioritizing them before working on mitigation is one smart way to deal with risk. There are several factors, from human error, unrealistic schedule to inadequate quality and overestimation of IT capabilities. Most of the risk mitigation methodologies work based on these factors. [6]
- Identification of a list of risk factors is necessary for effective mitigation strategy. Top ten lists of risks are thus identified. There is a slight variation in this list depending on the authority that developed it; however most of the fundamental risk factors remain same. They range from project complexity, unrealistic schedule to lack of skills and poor planning. [10]
- It is worth to recall that software is essential in every domain, from entertainment to medical devices. In cases where the usage is crucial, it is important to consider usability testing as one of the contributing factors to risk management. A proper investigation and analysis will not only improve the quality, but also reduce the damages caused. [13]
- Risk management has evolved alongside software development. In fact, the growing complexity in the software development forced the risk management to create new methodologies to maintain high success rates. A bivalent analysis which uses both the existing literature and a questionnaire is developed and tested. This gives a cumulative analysis of the current state of risk management in software development. [20]
- Research carried in risk management area since twenty years has thrown new insights whenever new changes were introduced in enterprises. It was found that risk management is no longer an engineer-led culture but it depends on various factors such as market trends, financial risk and business risk. The changes in the policies and rules will result in changes to the risk management strategies. [27]

- Medical devices need best quality software and any software failure leads to catastrophic situations. Risk management is not just required in software development, but also in usability of medical devices. The empirical case study method conducted an experiment, observing how the activities were performed with focus on first few stages of risk management such as risk identification, analysis and planning. The results show that there are risks, not only in the system context but also in the usage scenarios. [26]

The articles [30], [3], [25], [6], [10], [13], [20], [27], and [26] explained in brief gives better understanding on various approaches to Risk Management. Such published research documents provide a better understanding of Risk and infers the following points.

- Risk management has evolved from simple guessing and precautionary measures to efficient mathematical modeling.
- Several methods which include identifying the indicators, investigating the Risk factors and analyzing Risk is the holistic approach found in the literature.

IV METHODOLOGIES FOLLOWED FOR RISK MANAGEMENT

- Risk assessment is vital irrespective of the software size namely small, medium and large software projects upon which risk may influence quality to a major extent. There are several research surveys conducted using various methods to assess the variation of risk with respect to size of the project. However, methods introduced due to the technological advancement are applicable to any sized software project making risk assessment one of the important activities of any software project. [2]
- Risk is still overlooked by some organizations because of its complex nature, despite its importance. One important factor influencing this practice is the nature of risk, subjective and abstract. However, point of caution to recall is that risk mitigation does not get immediate and measurable results, unlike in financial market. To model and analyze risk, certain indicators such as metrics which measures the changes are defined and used.[3]
- As software evolved to much popular web and distributed platform, developers encountered new risks that were not known before. This opened up a new window for development of stronger risk assessment and mitigation methods. Software was considered to be generic throughout the world until web platform witnessed the diverse nature based on cultural differences and geographical locations. These factors were included in the latest methodologies, which overcame the weaknesses to make risk management stronger.[6]
- It is important to assess and mitigate risk; however it is more important to identify the risk before it hampers the success of an enterprise. With the help of data model of the risk factors, it is easier to design risk mitigation strategies and security to the software projects. [7]
- Risk assessment methodologies are modernized in the recent times with introduction of systematic review of assessment and review models. The latest methods of risk management comprises of Software Risk Assessment and Estimation Mode (SRAEM) and Software Risk Assessment and Evaluation Process (SRAEP) which uses model based approach to mention a few.[8]

- Software development has reached far from being a project in an office to offshore-outsourced projects. This development has created strange risks alongside its journey. Risks involved in outsourced projects are complicated and the standard mitigation methodologies are not strong enough to handle them. [11]
- Risk management has evolved enough to control the risks to great extent and is still not possible to avoid the risks completely. A framework of risk management, which includes five phases such as risk identification, analysis, treatment, controlling and documentation, can improve the probability of project success rate. This framework is based on historical data and questionnaires [12].
- A clear and well-structured Decision Making (DM) methodology is one of the most important factors of risk management. Since Decision Making is critical, a systematic method called Systematic Literature Review (SLR) is used to avoid any complications that may arise in a complex and large software project [15].
- Conventional approach has deficiencies such as static analysis and disorganized application of methodologies. A new framework, DMAIC (Define, Measure, Analyze, Improve, Control) is thus applied to enhance quality as quality is a prerequisite for any software development. This methodology is extensively tested on various types of projects and appreciable results are proven [16].
- In most of the software projects, risks are dynamic and this compels the management model to be dynamic as well. Most of the current models do not consider the dynamic nature, which increases the failure rate. Continuous feedback, monitoring the changes in the risk factors to change the mitigation strategies accordingly, is required in the recent times. Such strategy is developed and tested for a period of six months in a large software project and found to reduce unforeseen risks, reduce complications and increase the project success rate.[17]
- However, software development is prone to risk throughout the period of project execution. Software errors are one major contributor to risk. Hence, software defects needs to be predicted at the earliest. Classifiers which can identify error prone software modules offer solution to this problem. A set of such classifiers is designed and in use which includes support vector machines, C4.5 algorithm and K-nearest-neighbor algorithm and so on [18].
- Further, there is a relationship between risk factors and the corresponding risk management technique(s). In the new proposed model, fuzzy multiple regression techniques, it was found that the project managers use most of the risk management techniques. The mining technique which uses fuzzy multiple regression analysis, was found effective in improving the probability of success rate of software projects. [19]
- Risk management methodologies are generic in nature while most of the time, a specific strategy will have to be designed for a project. Risk management in Software Product Line (SPL) points that the steps for managing risk are not clearly described in most of the projects. Research carried with SPL through several industrial cases and experiments provide results to give more importance to risk mitigation strategies.[23]
- Further, offshore outsource software development has gained popularity because of the cost savings. There are new challenges such as lack of communication among geographically distant and culturally different users, involved in this process. Cultural and geographical differences hinder communication which can cause great damage to the

project. Goal-driven Software Development Risk Management modeling (GSRM) assesses risk, manages risk, and provides facility to identify and manage risk in early stages. [24]

- Risk modeling and evaluation is important in risk management. A stepwise regression technique uses risk management controls to the risk factors. It was experimented on a group of software project managers and was found that the top ten risk factors were mitigated using control factors. [25]
- Modeling of risk management is important when the project is complex. This is more important in web application development. Since, web applications involve interaction with wide variety of customers and a simple error therefore can prove to be expensive, a strategically developed model of risk management can help reduce the errors and increase the probability of project success. [27]
- Some of the challenges encountered in the development of Risk management are software security, cultural and geographical boundaries, Risk assessment, classification and evaluation. These challenges were tried and addressed using techniques like DMAIC [16], C4.5 algorithms [18], GSRM Fuzzy regression [24].

The algorithms and methodologies listed above not only help understand risk better but also take the research on risk management to the next level.

Subsequent subsections of this article explain the objective, types of risks, and conclusion based on the Risk Mitigation literature.

V RESEARCH OBJECTIVE

Risk management has become one of the vital activities since the development of complex software. As software became an inseparable part of technology in every industry, quality and reliability index has reached new heights. Risk management is therefore acting as a backbone for the success of software industry to keep up the standards in the industrial market.

A comprehensive study and analysis of risk management in software development along with different risk mitigation methodologies therefore is deemed to be one of the objectives of this research. The above made study on progress of research in risk management areas motivated this investigation to focus on risk management study and analysis, which will be based on the reliable data collected from several service-based CMMI level 5 companies. Therefore, real time data from several such companies are investigated to get awareness on the actual implementation of risk management methodologies. This investigation enabled to analyze risk occurring phase-wise during software development process and thereby to formulate suitable mitigation methodologies. Table 2 lists most common risks corresponding to different phases in software development.

VI CASE STUDY: INSPECTION OF RISK MANAGEMENT STRATEGIES FROM VISUALIZATION OF HISTORICAL DATA

In this research, in order to study and analyze different risk management methodologies, projects related data is collected from sample industries. Study of these data unfolds interesting aspects of risk management including classification of projects, risks, and risk parameters.

Classification of different types of projects, types of risks and methodologies helps to distinctively analyze all the aspects of risk. Table 2, thus, indicate that projects are classified

based on the several constraints which includes duration, cost, team size, industry, technology used. Software projects are further classified into three categories namely small, medium and large based on cost, time and team size.

However, risk occurrence is inevitable in all the types of projects. It is also found that the risk mitigation methodologies are not generic to all the software projects. Several assumptions are made while designing a methodology. On the other hand, several adjustments have to be made by the project manager to use a particular methodology. Sometimes, a combination of two or more techniques is considered depending on the complexity of the project. Therefore, this investigation further progressed to analyze existing effectiveness of risk management strategies from the collected sampled data.

Study by analyzing various risk related methodologies adopted in the sampled industries on the sampled projects provides a better understanding of depth of effectiveness of risk management in software development. Accordingly, risk management depends on various parameters related to the project viz., type of the project, technology used, schedule, objectives of the project, team, management, resources availability, cultural differences, geographical differences, customers, web platform, outsourced project work, security and so on.

Risk management is individual to the project, though there are methodologies which describe the risk mitigation strategies and additionally there is no way to ensure that the strategies can mitigate risk completely. Elimination of risk is impossible; however, handling and avoiding it is the primary motive.

The methodologies and the analyses are evaluated with reference to their strength to mitigate risk in various types of projects. Modeling of risk mitigation strategies has gained popularity in the recent times and is proven that the solution will result in measurable results, unlike the conventional strategies dealing with vague results.

Further, it may be once again recalled that risk management has evolved along with the evolution of software industry which has now become an inseparable part of project management. Complexity in the software projects has forced the risk mitigation strategies to grow stronger. Investment in risk management is not considered expensive because of its contribution towards the projects' success.

Mathematical modeling and strategies in risk management are analyzed and experimented in software projects belonging to various industries such as finance, medical devices, defense, entertainment, web platform, ecommerce etc., Extensive research in this direction is required to apply and analyze a methodology to one project.

The method followed in this research can be narrowed down to few points of concern namely

- Classification of projects
- Classification of risks
- Stages of software development
- Mapping the risk mitigation strategies.

Risks can occur at any time during the execution of the project. The occurrence of risk at different stages of the project will lead to different consequences based on the intensity of the risk. Analysis of risk through previous literature survey has proven that risk can occur at any stage in the project cycle. The parameters that are primarily affected by risk in the project are cost, time, people and process. Based on the impact of risk on these parameters, it can be classified into

- Communication Risk
- Quality Risk

- Technological Risk
- System Configuration Risk
- Estimation Risk

Different phases of software development project, and the associated risks are shown in Table 3. Each type of risk is known to affect one or more parameters, with one common parameter – cost, it affects all the types of risks. Table 4 lists the same.

Therefore, risk management is inevitable to all types of software projects. The sub-type of risk (Communication Risk, Quality Risk, etc.) involved in different types of projects varies. However, the parameters Cost, Time, People and Process are considered to map the risks.

After classification of projects and risks, listing the parameters is the next step. However, to understand and analyze the overall process of risk management, extensive research, surveys and study on effect of different methodologies is carried out. The research aimed at mapping all these factors together. Three cases have been considered for each type of project which covers most of the risk situations. The parameters affected for each type of risk involved and the risk mitigation strategy is listed in Table 5. Table 5 not only helps to analyze the risks and risk parameters, it also assists in choosing and implementing the right risk mitigation strategy for various types of projects.

VII DISCUSSION

Since risk analysis is inherently complex, it is necessary to analyze different risk mitigation strategies and techniques by classifying the parameters, methodologies, techniques and strategies. This is not the only classification available, however this provides simple and clear understanding of the concepts. Several real time projects' data were collected and analyzed to get this classification of risks and projects. Graphical visualization of this data to obtain statistical evidence of methods used in Risk Management, and Risk impact analysis and are few of the methodologies used in risk mitigation.

The classification and methodology described in this article is generic to most of the case studies considered though there are always variations to the standards such as ISO 31000 2009 in every project. Therefore, several adjustments are made before implementing a strategy or a technique to mitigate risk in a project.

VIII CONCLUSION

Risk management is an on-going process. There is no standard method which can be applied to all the projects. Every project varies from others. Project size, resources, industry, process, technology used, platform and many others, make every project unique.

Risk management needs intense research for improving the existing methodologies and designing new ones to match the requirement. Since there are huge number of projects going on in software industry, real time data is sufficient enough to conduct experiments, analyze them and design better strategies.

This research therefore focused on such empirical data and has observed that slight variations in the classification of risk parameters, and risk assessment techniques can contribute to build better techniques. This research is an attempt to study and analyze several kinds of techniques taken

across the types of software projects and to observe the variations used to mitigate unresolved issues in risk management.

References

- [1] L. Noguera, 'A Risk Assessment Model for Evolutionary Software Projects'.
- [2] A. Sharif and S. Basri, 'A Study on Risk Assessment for Small and Medium Software Development Projects', *International Journal on New Computer Architectures and Their Applications*, vol. 1, no. 2, pp. 325-335, 2011.
- [3] J. Menezes, 'Defining Indicators for Risk Assessment in Software Development Projects', *CLEI ELECTRONIC JOURNAL*, vol. 16, no. 1, p. 10, 2015.
- [4] G. Dionne, 'Risk management: History, definition and critique', 2015.
- [5] D. Verdon and G. McGraw, 'Risk analysis in software design', *IEEE Security and Privacy Magazine*, vol. 2, no. 4, pp. 79-84, 2004.
- [6] A. Keshlaf and S. Riddle, 'Web and Distributed Software Development Risks Management: WeDRisk Approach', *International Journal on Advances in Software*, vol. 3, no. 3, 4, pp. 447-460, 2010.
- [7] A. Chowdhury and S. Arefeen, 'Software Risk Management: Importance and Practices', *IJCIT*, ISSN, vol. 02, no. 01, pp. 49-54, 2015.
- [8] R. Higuera and Y. Haimen, 'Software Risk Management', Pennsylvania, 1996.
- [9] 'Systematic Review of Software Risk Assessment and Estimation Models', *International Journal of Engineering and Advanced Technology*, vol. 1, no. 4, pp. 298-305, 2012.
- [10] T. Arnuphaptrairong, 'Top Ten Lists of Software Project Risks : Evidence from the Literature Survey', *Proceedings of the International MultiConference of Engineers and Computer Scientists*, vol. 1, 2011.
- [11] S. Sundararajan, P. Vijayaraghavan and M. Bhasi, 'Case study on risk management practice in large offshore-outsourced Agile software projects', *IET Software*, vol. 8, no. 6, pp. 245-257, 2014.
- [12] 'An enhancement of framework software risk Management methodology for successful Software development', *Journal of Theoretical and Applied Information Technology*, vol. 62, no. 2, pp. 410-423, 2014.
- [13] C. Lindholm and M. Höst, 'Introducing Usability Testing in the Risk Management Process in Software Development', *IEEE*, vol. 5, no. 13, pp. 5-11, 2013.
- [14] A. Poth and A. Sunyaev, 'Effective Quality Management: Value- and Risk-Based Software Quality Management', *IEEE Softw.*, vol. 31, no. 6, pp. 79-85, 2014.
- [15] N. CHE PA and B. ANTHONY JNR, 'A review on decision making of risk mitigation For software management', *Journal of Theoretical and Applied Information Technology*, vol. 76, no. 3, pp. 333-341, 2015.
- [16] V. Bubevski, 'A novel approach to software quality risk management', *Software Testing, Verification and Reliability*, vol. 24, no. 2, pp. 124-154, 2013.

- [17] A. Khatavakhotan and S. Ow, 'Development of a software risk management model using unique features Of a proposed audit component', *Malaysian Journal of Computer Science*, vol. 28, no. 2, pp. 110-131, 2015.
- [18] Y. PENG, G. KOU, G. WANG, H. WANG and F. KO, 'EMPIRICAL EVALUATION OF CLASSIFIERS FOR SOFTWARE RISK MANAGEMENT', *Int. J. Info. Tech. Dec. Mak.*, vol. 08, no. 04, pp. 749-767, 2009.
- [19] A. Elzamly and B. Hussin, 'Managing Software Project Risks (Analysis Phase) with Proposed Fuzzy Regression Analysis Modelling Techniques with Fuzzy Concepts', *Journal of Computing and Information Technology*, vol. 22, no. 2, p. 131, 2014.
- [20] O. IAMANDI, S. POPESCU, M. DRAGOMIR and C. MORARIU, 'A Critical Analysis of Project Management Models and its Potential Risks in Software Development', *QUAL ITY access to success*, vol. 16, no. 149, pp. 55-61, 2015.
- [21] S. Scott and N. Perry, 'The enactment of risk categories: The role of information systems in organizing and re-organizing risk management practices in the energy industry', *Information Systems Frontiers*, vol. 14, no. 2, pp. 125-141, 2009.
- [22] D. Mankad, 'Risks Management in Software Engineering', *International Journal of Advanced Computer Research*, vol. 2, no. 4, pp. 290-293, 2012.
- [23] L. Lobato, T. Bittar, p. Neto, I. Machado, E. De almeida and S. Meira, 'Risk management in software product line Engineering: a Mapping Study', *Int. J. Soft. Eng. Knowl.Eng.*, vol. 23, no. 04, pp. 523-558, 2013.
- [24] S. Islam and S. Houmb, 'Towards a Framework for Offshore Outsource Software Development Risk Management Model', *JSW*, vol. 6, no. 1, 2011.
- [25] A. Elzamly and B. Hussin, 'Modelling and Evaluating Software Project Risks with Quantitative Analysis Techniques in Planning Software Development', *Journal of Computing and Information Technology*, vol. 23, no. 2, p. 123, 2015.
- [26] C. Lindholm, J. Notander and M. Höst, 'A case study on software risk analysis and planning in medical device development', *Software Qual J*, vol. 22, no. 3, pp. 469-497, 2013.
- [27] J. ALJABRI, 'Impact of software risk management on Analysis modeling in life cycle of web Application development', *Journal of Theoretical and Applied Information Technology*, vol. 70, no. 2, pp. 273-280, 2014.
- [28] H. Hoodat and H. Rashidi, 'Classification and Analysis of Risks in Software Engineering', *International Journal of Computer, Electrical, Automation, Control and Information Engineering*, vol. 3, no. 8, pp. 2044-2050, 2009.
- [29] T. Krishna, S. Sreekanth, K. Perumal and R. Kumar Reddy, 'Explore 10 Different Types of Software Development Process Models', *International Journal of Computer Science and Information Technologies*, vol. 3, no. 4, pp. 4580-4584, 2012.
- [30] L. Nogueira, 'A Risk Assessment Model for Evolutionary Software Projects1', *U. S. Army Research Office - under contract*.



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