FRAMEWORK DEVELOPMENT FOR REQUIREMENT PRIORITIZATION

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FRAMEWORKDEVELOPEMENT FOR REQUIREMENT PRIORITIZATION

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DECLARATION

I declare that this thesis entitled "*Framework Development for Requirement Prioritization*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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This thesis work is dedicated to my parents and my teachers throughout my education career who motivated me to work hard and my wife Natasha who have not only loved me unconditionally but motivated me to work hard for the things that I aspire to achieve.

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ABSTRACT

Requirements engineering is a crucial phase of software engineering, and requirements prioritization is an essential stage of requirements engineering. Requirements prioritization goals at eliciting which requirements of software need to be covered in a particular release. The key point is which requirement will be selected in the next iteration and which one will be delayed to other iterations for minimizing risk during development and meeting stakeholders' needs. There are many existing methods for requirement prioritization, but most of these methods do not cover continuous growth and change of requirements. Therefore, there is a need of a framework which can help to prioritize the requirements efficiently.

A systematic literature review has been performed to identify the different aspects from the existing literature. Available methods for requirement prioritization are also studied in order to find the limitations. To complete this study, the partially mixed research method has been used. The partially mixed research method contains the mixture of qualitative and quantitative methods. After identification of aspects from the systematic literature review, a survey has been performed to gain the market knowledge of the requirement prioritization process. In order to add more clarity to the results of survey, a focus group discussion has been conducted and triangulation process has been applied to find and validate the final results, using these aspects a framework has been designed to improve the requirements prioritization process.

The designed framework takes raw or non-prioritized requirements as input and a list of most important aspects that has been identified in this study, then each requirement is mapped with each aspect using scale o to 3. 0 for no relation, 1 for weak relation, 2 for moderate relation, and 3 for strong relation, this provides an importance score and each requirement is then prioritized based on obtained importance score, which is presented by the framework as output.

Keywords: requirement prioritization, requirement engineering, requirement validation

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LIST OF ABBREVIATIONS

RE	-	Requirements Engineering
RP	-	Requirement Prioritization
SDLC	-	Software Development Lifecycle
SLR	-	Systematic Literature Review

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Software's are outcome of the development activity hands on the requirements in order to implement requirement we usually have, limited budget and limited time which in return develops the need of prioritizing the stakeholder's requirement. At some stage of development process, it is vital to take decision on which requirements are to be executed first. Requirement prioritization plays an important role in the development process; therefore, it is an important process to make a project successful. To decide which requirements should be implemented first requirement are prioritized [1]. It deals with the importance and need of urgency of different requirements to achieve the completion of project and satisfaction of stakeholders associated with that project by adapting limited resources of the project [2]. In the process of prioritization of requirements, it should be made sure that developers and customers are on the same page, as most of time developers don't generally know which requirements are important as business aspect and customers don't know which requirements should be implemented first for a quality product.

It is difficult to complete the project before deadline or in a limited budget because of numbers of requirements associated with each software project. The purpose of requirement prioritization is to help in making decisions on what requirements should be implemented first. A software can always be improved by adding more functionality and by implementing the different requirements. Customer satisfaction is

an important Part of the software development [3]. However, requirement prioritization is an early step of any software project therefore, customer satisfaction should not be given much importance because most of the customers are non-technical and they do not have much knowledge of the system [4].

Requirement prioritization process categorizes that which of the requirements can be ignored or delayed for the next release [5]. Data about priority of requirement is required to assist the project manager to resolve the conflict but also to ignore the minimum significant requirements, plan for version deployments, and make the essential adjustments [6]. Software requirement prioritization is a challenging process to implement. Number of companies actually do not know how to allocate and set priorities or how to connect those priorities efficiently to stakeholders. It is important to prioritize the requirements according to their importance, since there are multiple stakeholders involve in every software development project. Therefore, every stake holder has its own definition of importance of requirements.

The requirement that is most significant for the customers may not be that vital when other aspects e.g., price, cost, risks are considered. It is important for developers to develop the functionality that is anticipated by the customers, as less risky, less expensive, and so forth, for satisfaction of customer and for maximizing the profit and reputation of organization. Since every stake holder has its own definition of importance therefore requirements prioritization can be done by analyzing and considering many different aspects.

An aspect is property of requirements which can be used to prioritize the requirements in any software development project. Some of the common aspects which are considered while prioritizing are time, importance, penalty and cost [7]. When there is only one common aspect of every stakeholder it is easy to prioritize the requirements according to that single aspects, on the other hand if there are multiple aspects (which almost every project contains) involved in projects the prioritization process gets complex, and high priority requirements may get ignored or satisfaction of customer can be very expensive to obtain [8].

Therefore, it is important to consider all the aspects while prioritizing requirements. It is possible that in this process important aspects can be ignored and lead towards failure of project and fail to meet customer satisfaction. This study will examine the aspect analysis of requirements prioritization. And impact of those projects on the development of software project.

1.2 Problem Statement

Requirement Prioritization is a very important process in software development but mostly ignored by the domain of software engineering [9]. Requirement prioritizations is the process of choosing specific set of requirements to execute or implement in next release [10]. If the development team is running out of resources, it becomes necessary for the development team to prioritize the requirements. In this process requirements are given priority by taking different aspects in account. There are many methods to prioritize the requirements i.e. analytical hierarchy process, numerical assignment, cost-value approach etc. [11] which helps the stakeholders to prioritize the requirements to select the most important one. All of the methods of requirement prioritization depend on different aspects to allocate the priorities. The aspect is a property by which set of specific requirement can be assigned i.e. cost, time, value, importance [12], but all of the methods lack number of important aspects which leads to the failure or challenging nature of the projects. Number of the literature fails to identify number of the aspects which should be consider in the process of assigning the priorities to the requirements [13]. The effectively prioritization of requirements will help in successful execution of the software projects.

1.3 Research Questions

The purpose of this study is to identify the maximum number of aspects to develop fa framework in order to make the requirement prioritization process efficient.

RQ 1 What are different aspects of requirements prioritization?

RQ 2 How a framework can help in choosing an appropriate aspect for requirement prioritization?

1.4 Research Objectives

Software development is very complex process there are a lot of requirements associated with a single project. And there are limited sources like time, budget, and man power etc. to complete the project. Hence, it is very difficult to implement all those requirements with limited resources. Therefore, the need of requirement prioritization arises. Requirement prioritization is the process of assigning priorities to the set of requirements to make decision which set of requirements should be implemented first.

There are many requirement prioritization methods which help the stake holders to prioritize the requirements. Each technique prioritizes the requirement by considering some aspects i.e., cost, time, value, importance. An aspect is a property by which a requirement can be prioritize. For instance, customer wants a software in limited budget. Cost is the important aspect according to customer while prioritizing the requirements in such case requirements which will cost less will be given high priority. The objective of this research study is to identifying and analyzing the different aspects of requirements in prioritization process. And how those aspects affect the process of software development.

1.5 Research Methodology

A systematic literature review has been conducted in this study in order to identify the maximum number of aspects.in order to validate the finding of this study a survey has been conducted to validate the results of survey a focus group discussion has been conducted, then after performing the mixed method research a framework will be developed which will help in identifying the important aspects of requirements prioritization. After the development of framework, a survey will be conducted to validate the developed framework from experts.

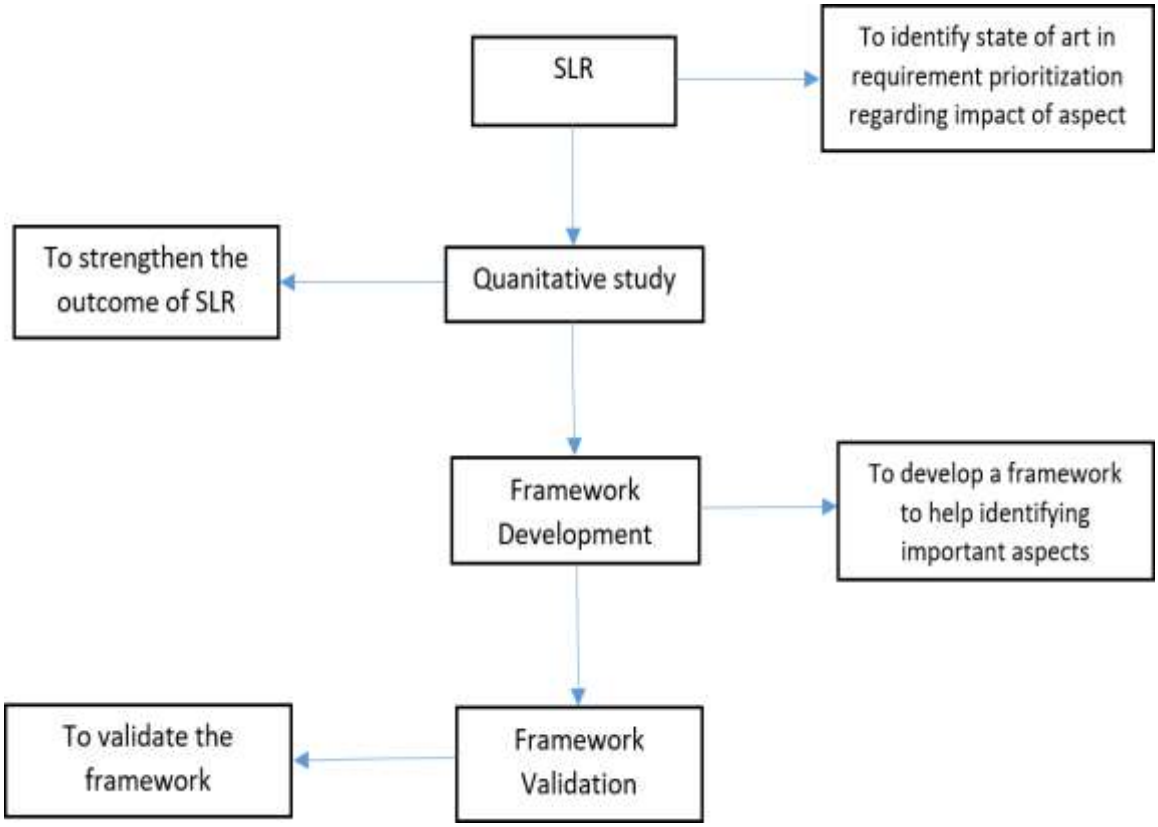

Figure 1.1: Systematic Literature Review

In software engineering field systematic literature review is much known research method. Systematic literature review is a method of evaluating and understanding all accessible research related to a particular research question or topic area Evidence Based Software Engineering is a research methodology used in the field of education, social policies and psychotherapy. For this systematic literature review, guidelines are provided by Kitchenham [29]. First, the review protocols are designed to drive systematic literature review.

The review protocol consists of seven phases of research, the first step is do develop the research questions, the second step is about developing a optimized search string which will help to get the maximum relevant study, the third step contains selection of research information, next step is about collecting of different research studies fifth step involves the including or excluding of selected papers, and the last two steps are about checking the quality of selected studies and data synthesizing.

The motivation for the research is based on the various research problems reported in the literature and associated with different approaches to prioritizing needs and features. Research questions are based on research motivations. Research questions help define research limitations while examining research published in a defined domain.

The essential for empirical study in software engineering is rising. Numerous investigators today, implement and authenticate their provided solutions by doing empirical study. Survey is one empirical method which enables researchers to collect and validate their research findings from experts. The primary purpose of the survey is to simplify the results. Once the aspects of requirement prioritization are identified, they are forwarded to experts for evaluation the first step in expert evaluation is making a selection criterion for experts. The second step is selection of experts.

Next experts are familiarized with issues and their responses collected, followed by presentation of results. The experts in our case are Software Engineers, for which we sampled students and teachers of Computer Science and related disciplines due to ease of access to them. After selection of experts, a list of identified aspect and their impact on the process is given to them for their intellectual advice regarding naming conventions, terminologies, and suggestions for any new aspects. Once the reviewed lists of aspects are finalized, the survey was conducted according to the recommendation given by Kasunic [14].

1.6 Thesis Organization

In rest of the thesis second chapter is on literature review with the relative work. In literature review requirement prioritization process is explained with their advantages then requirement prioritization methods challenges and aspects are identified and discussed at the end of literature review the related studies and sources are added with their key factors, advantages and limitation to give a more detailed review.

Third chapter presents the methodology of the thesis in which the overview of the methodology used is given and then the structure of methodology used is discussed with its advantages, population and purpose the justification and results are also

discussed in this chapter. Fourth chapter includes results and their explanation from both surveys and focused group methods. The results from both survey and focus group are explained. Fifth chapter includes analysis phase in which all the results of both survey and focus group are analyzed and compared with each other and the final result through triangulation process is generated which shows the justification and validation of final result because of reversed method and the last sixth chapter is based on discussion. The discussion chapter includes the answers to all research questions according to final results, contribution of thesis, limitation of work and the future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A detailed literature review has been performed from selected studies. To carry out this study, a systematic literature review has been performed. This chapter of the study discuss the concept of requirement prioritization, how requirement prioritization can be done, what are some available methods and methods for performing prioritization process. And what is the importance of requirement prioritization in the software development process.

Requirement prioritization is an important part of software development process because it helps the stakeholders to choose the requirements which should be available in next release [2]. It is an important process because almost every software project has limited resources in terms of time, budget, importance and deadlines.

The purpose of requirement prioritization is to maximize the customer satisfaction and to make the software successful by choosing the appropriate requirements. There are many aspects of requirement prioritization like time, cost, importance etc. the systematic literature review has been conducted in this chapter to identify the maximum aspects of requirement prioritization. This chapter of study also discuss the methods for prioritization and the limitations in existing methods.

Most of the existing methods like cost-value approach, 100$ approach targets some specific aspects to prioritize the requirements, number of aspects are being ignored in the process of requirement prioritization with these methods. This chapter identifies number of aspects which are ignored by the existing prioritization process, so that requirement prioritization can be done.

The limitations and identified aspects are used in further research to develop a framework which will help the stakeholders to prioritize the requirements efficiently, so that rate of failure of requirements can be minimized.

2.2 Systematic Literature Review

After studying the research method of systematic literature review its concluded that this method is very famous in software engineering field for domain exploration. A systematic literature review is "a means of evaluating and interpreting all available research relevant to a particular research question, topic area or phenomenon of interest" [15].

Evidence based software engineering is the practice followed by the systematic literature review. To conduct this systematic literature review, kitchenham's course of action has been followed [16]. In order to perform this systematic literature, review a review protocol has been developed.

There are seven phases in review protocol: (I) First one is research motivation and the preparation of research questions (ii) Developing search string (iii) Choosing databases (iv) collection of research articles (v) defining inclusions, exclusion criteria of study selection (v) Defining Quality Assessment Criteria and (vi) data production.

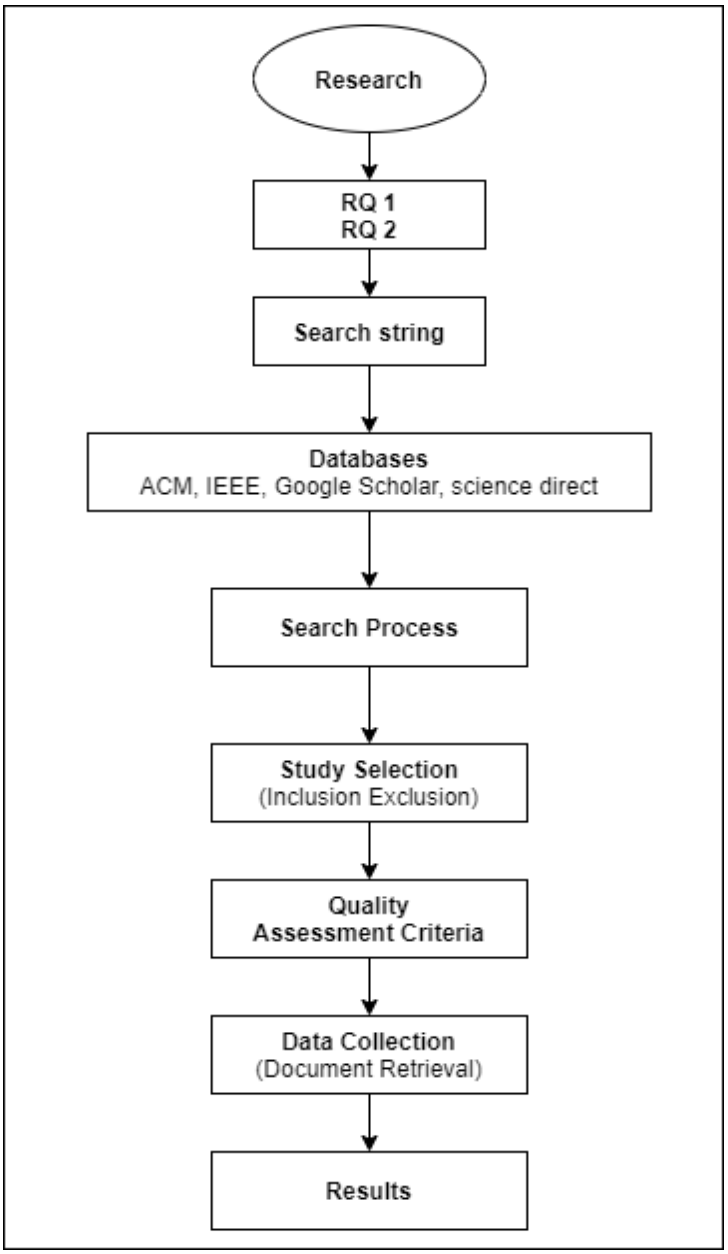

Figure 2.1: Review protocol for systematic literature review

2.2.1 Research Motivation

Most of the software fails because of different factors. Standish group has two definitions of failure of software according to their traditional definition the software is successful only if the project was completed in an estimated time, remained in estimated budget, and gained customer and user satisfaction irrespective of the original scope. According to this definition in 2011, 22% of the software projects were failed. While

in 2012, 17% of the project was failed. In 2013, 19% of the project was failed. In 2014, 17% of the projects was failed and in 2015 the percentage of failed software was 19%.

Although, according to new definition of software failure the project is successful if it is completed within time and using the estimated budget. If the software fails to meet any single requirement of successful software it will be label as challenged software and if project is not completed either in estimated time and budget it will be considered as failed project. However. According to this definition in 2011, 22% of the software projects were failed. While in 2012, 17% of the project was failed. In 2013, 19% of the project was failed. In 2014, 17% of the projects was failed and in 2015 the percentage of failed software was 19% [17].

According to Standish group report the main reason of software project failure is that the vendors are failed to deliver project within deadline or the project has crossed the limit of estimated budget. Because most of the times there are number of requirements in software requirement specification document and it is not possible to execute every single requirement within estimated resources therefore, the need of requirement prioritization arises which helps the stakeholders to select the requirements which are important.

Requirements prioritization is an important part of requirements engineering in software development process it helps the stakeholders to choose specific number of requirements from the pool of requirements [2]. It is an important process because almost every software project has limited resources in terms of time, budget, importance and deadlines. The purpose of requirement prioritization is to maximize the customer satisfaction and to make the software successful by choosing the appropriate requirements.

2.2.2 Search Process

To get the related search studies the search process is carried out very sensibly. Multiple databases are searched to collect different articles and research papers.

The information to develop a search string is based on the constructed research questions, and different domains of problem has been covered in search string. To collect the data from different selected databases a list of keywords has been selected and used. In order to identify the related studies, search string is applied in versatile manners.to construct the search string for this systematic literature review the KitchenHam's guidelines has been followed. Moreover, radical search methods are used with a mixture of Boolean operators and different search option to carry out search process stronger.

Following the keywords list which are used in this research.

i. Requirements prioritization methods
ii. Aspects of requirement prioritizations
iii. Requirement prioritization framework

2.2.3 Research Inclusion and Exclusion Criteria

The primary focus of the research is to find multiple aspects of requirement prioritization and to study the existing methods in order to propose a new framework using the different identified aspects of requirement prioritization. Selection of different research studies of research studies is established on support for empirical indication in particular area.

2.2.4 Inclusion Criteria

Following protocols have been developed for inclusion criteria of this research.

i. Studies which are written in English language
ii. Studies which focused on requirement prioritization process and methods
iii. Paper which discusses the different requirement prioritization aspects.
iv. Paper discussing the different methods of requirement prioritization
v. Paper discussing the failure of software requirement prioritization

vi. Papers with the potentials of answering one or multiple parts of the research questions

2.2.5 Exclusion Criteria

i. Studies which are written in any other language than English are excluded.
ii. Redundant papers
iii. Grey papers
iv. Those studies which do not answers the research questions of this study.

2.2.6 Quality Assessment Criteria

The quality assessment criteria depend upon diverse research questions which assess the quality of a research study. Every study is allocated some points established on the research questions [16]. Dyba have presented a method for quality assessment in checklist form [15]. The main goal of these assessment criteria is to find out the most related research studies and to think through these studies as a part of the systematic literature review.

2.2.7 Data Collection

There are number of tools present that support the data collection process. Medley tool has been used in order to collect data. The process of data collection is based on data research question, and only selected papers are considered. The first research question targets the aspect of requirement prioritization. The second research questions are based on the identified aspects of requirement prioritization so that a framework can be proposed for the process of requirement prioritization. Total 324 papers were retrieved in the first phase and by passing those papers from the inclusion and exclusion criteria 203 papers were rejected and 121papers were selected and reviewed in order to identify the different aspects of requirement prioritization.

Bibliometric Analysis

Table 2.1 Bibliometric Analysis

Sr.	Title	Key findings	Limitations	Year	Reference	Authors
1	Enhancing the Process of Requirements Prioritization in Agile Software Development - A Proposed Model	Identifies customer-oriented aspects for customer satisfaction	Fails to identify logical aspects like dependency, contradiction etc.	2017	[2]	Mohammad Alkandari Asma Al-Shammeri
2	Software requirements prioritizing	This study explains two methods of requirement prioritizing which are pair wise comparison and numerical analysis	Unable to present an alternative requirement prioritization technique to overcome limitations	2018	[4]	J. Karlsson
3	Software Requirements Prioritization: A Systematic Literature Review on Significance	new categories of the participating stakeholders this paper explains multiple aspects like size, cost of requirement prirotization	This study provides a way to do research on requirement prioritization process and the limitation of this study is that it only identifies the issue doesn't provide a valid solution			F. Hujainah, R. B. A. Bakar, M. A. Abdulgabber Zamli

Sr.	Title	Key findings	Limitations	Year	Reference	Authors
4	Software Requirements Selection Using Consistent Pairwise Comparison Matrices of AHP	This study presents a new method to priroitze the requirements based on the exsisting available techniqes	N/A	2018	[29]	Karl Eugene Wiegers
5	Software Requirements Selection Using Consistent Pairwise Comparison Matrices of analytical hierarchy process	Identifies the issues and uses of pair wise comparison technique for requirement prioritization	This technique only focuses on business aspects and fails to ensure customer satisfaction.	2011	[30]	Sadiq, M. Khan, S.Mohammad, C. W.
7	Prioritization of issues and requirements by cumulative voting: A compositional data analysis framework	Proposed a framework for prioritization of requirements by using 100$ prioritization technique	100$ technique works well when there are small number of requirements and there is a chance of biasness	2002	[8]	Lauesen, Soren
8	Prioritization of quality requirements: State of practice in eleven companies,"	Presents the result of an empirical study that examines how QR are prioritized in practice at eleven software companies.	This study lacks to provide a framework that can help to choose appropriate requirements from the SRS	2011	[30]	Svensson, Richard Berntsson Gorschek, Tony Regnell, Björn Torkar, Richard Shahrokni,

Sr.	Title	Key findings	Limitations	Year	Reference	Authors
9	Cost-value requirements prioritization in Requirements Engineering	this study proposed a new framework for requirement prioritization based on cost-value approach	fails to maintain customer satisfaction because all the aspects are business oriented	2016	[30]	Sie, Audrey Alami, Daniel
11	Requirements Prioritization Challenges in Practice	only two aspects, importance and cost as only requirement prioritization aspects	They have missed other important business and technical aspect	2018	[5]	Hujainah, Fadhl Bakar, Rohani Binti Abu Abdulgabber
12	An Appraisal of Software Requirement Prioritization methods	technical aspects i.e., scalability, complexity, ease of use and reliability	This study has missed out many other aspects of requirements prioritization	2018	[19]	Ikono, Rhoda Gambo, Ishaya Olaronke, Iroju Rhoda, Ikono Ishaya
13	Impact and challenges of requirements elicitation & prioritization in quality to agile process: Scrum as a case scenario	Literature review on the importance of requirement prioritization and use of prioritization in improving software quality	Software quality also depends on some other factors which this paper failed to discuss	2017	[36]	Mansoor Abdullateef Zamli, Kamal Z

Sr.	Title	Key findings	Limitations	Year	Reference	Authors
14	Handling stakeholder conflict by agile requirement prioritization using Apriori technique	Proposed method for prioritizing requirements.	Failed to identify number of different aspects of requirement prioritization	2017	[10]	Anand, R. Vijay Dinakaran, M.
15	Requirement Risk Prioritization Using Analytic Hierarchy Process,A Gateway to Identify Risky Requirements	Briefly identifies the analytical hierarchy process process in order to identify the different risky requirements	This study is only limited to analytical hierarchy process however limitations of this process is already explained in this thesis	2018	[43]	Chandani, Priyanka Gupta, Chetna
16	A method for analyzing stakeholders' influence on an open-source software ecosystem's requirement engineering process	Explained the process of requirement engineering in open-source project organizations	Failed to identify the maximum aspects of requirement prioritization therefore number of angles for prioritizing the requirements are missed	2006	[39]	Linåker, Johan Regnell, Björn Damian, Daniela
17	Requirements Prioritization methods Comparison	Compares multiple requirement prioritization methods	Multiple methods and their limitations are presented however there are multiple aspects for requirement prioritization that are missed in this study	2017	[3]	Amjad Hudaib, Raja Masadeh, Mais Haj Qasem

Sr.	Title	Key findings	Limitations	Year	Reference	Authors
18	Factoring Requirement Dependencies in Software Requirement Selection using Graphs and Integer Programming	A model is presented in order to identify the dependency strength in multiple requirements	Didn't apply this model in real world software projects however software projects in real world can vary from	2016	[47]	Mougouei, Davoud
19	Requirements Prioritization methods Comparison	Non-functional requirement prioritization has been studied in this study	additional methods can be added to this model after studying and reviewing their properties and decide the general factors for requirement prioritization	2018	[13]	Amjad Hudaib, Raja Masadeh,
20	Closing the Stakeholder Expectation Gap: Managing Customer Expectations Toward the Process of Developing Information Systems	Illustrated the diversity of aspects that project man? agers need to address in order to pave the way for successful projects	Identifies the aspects which can lead to the success of a project but there are also many other aspects which can affect the success of the software projects.	2016	[41]	Basten, Dirk Stavrou, Georgios Pankratz, Oleg
21	Multi-Aspects Based Requirements Prioritization Technique for Value-Based Software Developments	Identified the business aspects to propose a framework for requirement prioritization process.	The proposed framework is only based on the business aspects of requirement prioritization number of aspects are missing in this framework	2014	[55]	Sher, Falak Jawawi,Dayang N.A.Mohamad,

Sr.	Title	Key findings	Limitations	Year	Reference	Authors
22	A critical analysis of methods for requirement prioritization and open research issues	evaluated of most commonly methods used for requirement prioritization and proposed a new method for requirement prioritization	This study proposed a method for reqiorement prioritization which is based on the existing methods number of other aspects for requirement prioritization has been over looked in this study	2009	[18]	Farhan M Khan, Shahbaz a. Khan
23	Comparison of Requirement Prioritization methods to Find Best Prioritization Technique	This study conducted a brief comparison of different requirement prioritization methods	Existing methods have multiple drawbacks and this study fails to proposed a new system for requirement prioritization	2015	[11]	Ali Khan, JavedUr Rehman, Izaz Hayat Khan, Yawar Javed Khan, Iftikhar Rashid, Salman
24	Value-Oriented Requirements Prioritization in a Small Development Organization	Discuss the requirement prioritization importance and why small organizations lack requirement engineering focus	There are number of aspects which can contribute in success of projects and this study only covers a few aspects	2007	[27]	Jim Smith, Randy K. Cordes, Davis
25	The Impact of Agile Software Development Process on the Quality of Software Product	This study discusses the impact of agile development process on quality of software's	This study is lacking many other things like resources size of organization which can affect the quality of a software	2018	[5]	Jain, Parita Sharma,

2.3 Discussion

There are number of researches has been conducted which shows the importance of requirement prioritization in software projects. According to author in paper "An Evaluation of Requirement Prioritization methods with ANP" [18] software projects have number of requirements which cannot be completed within specific constraints like time, budget etc. and most of the time all the provided requirements are not important for users. Therefore, the need of requirement prioritization arises, so that requirements can be execute regarding limited time, budget and client satisfactory.

Iroju Olaronke [19] in his research also discussed the importance of requirement prioritization process. Most of the time, acquiring and completing stakeholders' essential requirements are important details for developing a good-quality software projects [20].

Because there are number of requirements presented by user in requirement gathering phase of software development, there are some requirements which are important from user perspective and user wants development team to execute that certain requirement first, but maybe those requirements could not be implemented first and therefore are not important according to developers point of view to make a software successful, this scenario can affects the development process, customer satisfaction and quality of software as well. Therefore, requirement prioritization is as essential process to ensure the quality of software.

Requirement prioritization process helps with the selecting of the most important requirements from a list of capacious requirements collected from various stakeholders.Avesani et al. [21] in his research states that requirement prioritization is the process of originating a relative order on a specified set of requirements, with the

Ultimate goal of developing a common foundation for dividing the gathered requirements into succeeding software release. Hence, the main task of requirement prioritization process according to [22] is to choose the most significant requirements from the set of available requirements as perceived by related participants.

More than 75% of major software projects deal with budget and planning for passing or total failure. Lack of project requirements is a major reason why more than half of these failures and overcrowding. Establishing software requirements is fraught with difficulties. It is important to find a way to reduce that risk, this can be an important step in reducing the risk of software development.

High risk is involved in large scale software development. In other words, more than 70% suffer over budgets and schedules. As a result of this failure billions of dollars are spent every year, so engineers and software users can gain valuable value from any intervention that can reduce their risk. More than half of these overruns and failures in software development projects can be straight attributed to complex requirements, so it is important to reduce the risk of software development. One reason why software developers struggle to gather requirements is that the task is fraught with complexity [23] .

Hence complexity of requirement is an aspect of requirement prioritization, the requirement which are less complex and well understood are ranked higher than the requirements with high complexity.

Better the validation process leads to the successful software [24]. In software industry it is an important factor to develop the high-quality projects. Number of software fails to make it to the market ever, and those which do the success is not guaranteed because every software project has number of requirements with very limited budget and other resources, therefore it is not possible for developers to complete every single requirement, this leads towards the need of software requirement prioritization process. By prioritization of requirements each requirement gets a priority according to stakeholders. By following this process quality of software projects can be improved. Therefore, this process is important to maintain the quality of the product. Requirement prioritization is not an easy task, there are number of challenges in prioritization process.

According to Tricentis in 2018 almost 1.7 trillion dollars has been lost in softwares project failures [25]. According to Chen Yusong [26] many software fails because

requirements are not clearly understand by the developers this leads to the change of requirements and it is not possible to complete all those changed requirements in given timeline. Hence, the need of a process arises to prioritize the requirements so that software project can be made successful.

There are many requirement prioritization methods i.e. Ranking, The cost-value, pair-wise comparison, analytical hierarchy process approach, numerical assignment etc. which focuses on different aspects like cost, worth, importance of requirement to assign them priority [27]. Numerical assignment requirements are classified in various groups every group is made according to customer's or developer's definition of importance and previous experience. For example, requirements can be assembled into critical priority, modest priority and non-compulsory priority. Requirements can also be classified by stake holders as most important, moderate important, less important and unimportant groups. In order to prevent stakeholders putting all the requirements in a single group the percentage of a requirements that can be placed in a single group can be restricted. Then each group of requirement can be executed according to their priority [28].

Number of the methods lack the important aspects for example, The pair-wise comparison is a requirement prioritization technique based on analytical hierarchy process, in this technique pairs of requirements are made and priorities are given to those pairs according to their importance [29]. Hence, this in this process the requirements are prioritize against the importance according to the developers the business aspects and other logical aspects like dependencies on other requirements contradiction between requirements or feasibility of requirements are ignored which can cause a serious problem in development process. In another technique of requirement prioritization numerical values are assign to each requirements this technique is known as numerical assignment technique which focuses on the importance and quality of the product this technique also lacks to ensure that the high priority requirements selected by the experts are important according to the other aspects [30]. Cost-value approach is the another technique of prioritization of requirement which focuses on the value that will be gained from implantation of a

specific requirement and the cost which will be spend in terms of human resource, finance space etc. for implementation of that requirement [31].

Hence, this technique also focuses on the importance and cost of requirement to decide the priority of requirements therefore this technique also fails to ensure the satisfaction of customer. This leads to the importance of considering maximum number of aspects and properties of requirements in the process of prioritization.

In pair wise comparison business aspects and logical aspects like dependencies between requirements, contradicting nature of requirements are ignored. While in Numerical assignment requirements in each group will then have the same priority with no unique priority assigned per requirement. Ranking works well with only single stakeholder every stakeholder has a different definition of the importance of requirement and Cost Value Approach only focuses on business aspects and fails to ensure customer satisfaction.

Laura Lehtola, Marjo Kauppinen, and Sari Kujala [32] conducted a research on requirement prioritization challenges where they have considered only two aspects, importance and cost as only requirement prioritization aspects and have missed other important business and technical aspects. In another study [33] Umang Grang has mentioned about the cost and importance of requirements according to developer and customer, however lei in his study [12] has mentioned four common aspects of requirement prioritization which are importance, penalty, cost and time. Rhoda [19] has mentioned technical aspects i.e. scalability, complexity, ease of use and reliability while this study has missed out many other aspects of requirements prioritization.

Software provider do not aim to classify the most important and least important requirements and developers do not have any efficient mean to do this which can cause problems in achieving the quality software product. The necessity of requirement prioritization is highly acknowledged in different studies. However, number of the aspects for requirements prioritization are still missing, which can give software developers and provider companies advantage to achieve the bet quality, successful software projects and could help to gain the customer satisfaction. Prioritization for

requirements can also help the developers to select the most important set of requirements for the best possible solutions [34].

According to Eloff [35] the main of cause of software failure is the end product not meeting the requirements of customer. Because in the process of requirement gathering in a large-scale software project there are number of requirements but those requirements cannot be executed or deployed before deadline. Therefore, many requirements are ignored by developers in the process of requirement prioritization. Hence, those requirements are ignored by the developers the aspect of customer satisfaction and importance of requirement according to customer is ignored which causes customer satisfaction in result software project becomes challenging or failure.

Requirement prioritization has a very vital part in software development process. It can be defined as the selection between two or more options to decide which set of requirements should be implemented first. In case the development team is running out of time and budget for a specific requirement the need of requirement prioritization arises to select the most important requirements among all.

There are limited resources associated with the software development process therefore it is important to implement the most important requirement first to increase the customer satisfaction, to maximize the profit of organization and to decrease the chances of failure. There are many methods explained in literature review like analytical hierarchy process, cost value etc.

These methods lack the important aspects of requirement prioritization. Requirement prioritization is an important process to make a software project successful. In a study of requirement prioritization [36] it is mentioned prioritizing the requirements helps to retain the quality of a software, and make a software successful. Which develops the need to analyse the number of the aspects in prioritizing the requirements.

By studying the literature reviews it is known that the number of software project contains number of requirements, and due to limited resources i.e., time, cost it is not possible to implement all of the requirements listed in software requirement

specification document. Hence, it is a difficult and complex decision-making process to choose the specific set of requirements from a list of requirements. Therefore, the need of requirement prioritization arises.

2.4 Identified Aspects of Requirement Prioritization

Identified aspects from existing literature has been listed in this section of the study, these aspects will be used to develop a framework for efficient requirements engineering process.

Table 2.2: Identified aspects in systematic literature review

Sr.	Aspects
1	Importance
2	Cost
3	Time
4	Risk
5	Stakeholder expectations
6	Complexity
7	Dependencies
8	Scalability
9	Sensitivity
10	Against errors
11	Contradiction of requirements
12	Resources
13	Value
14	Profit
15	Approach type
16	Result type
17	Size of requirements
18	Mutual understanding
19	Sophistication
20	Customer importance

Sr.	Aspects
21	Strategic planning
22	Expert opinions
23	Success rate
24	Organization satisfaction
25	Sales impact
26	Customer satisfaction
27	Management
28	Experience of development personnel
29	Quality

There could be number of requirements for a system i.e., a hotel management system is required for a hotel with multiple requirement [37] (1) the system should allow the user to save customer information, (2) system should save the rooms charges. (3) Customers will provide the rooms on the basis of room availability, (4) system should be portable (5) system should require less development cost. Requirement 1,2,3 can be classified as system oriented or functional requirement while requirement 3 is dependent on requirement 2 and also system oriented requirement, however requirement number 4,5 lies in scalability class of the system, for example if software prioritization is not done on this system and requirement number 3 is implemented before requirement number 2, the system will not performed accordingly because if the desired system is not able to save the room information, the rooms cannot be booked according to the availability therefore it shows the importance of requirement prioritization to ensure the quality customer satisfaction and to increase the success rate of the project.

Number of researches has been conducted to identify the different aspects of requirement prioritization aspects for example cost is an important aspect.

However, cost estimation in software development process is still immature therefore, descriptions of incorrect estimates is still being reflected in numerous software project failures and the software.

For the successful and completion of software projects it is necessary to estimate the product of software correctly. One of the essential conditions for the software development lifecycle constant success is the ability to efficiently control the three classical project-related parameters: cost, time, and earned value. In initial phases of the software development process, requirements prioritization essentially depend on the stated requirements and on predictions of benefit and cost of individual requirements [38]. Therefore cost is an important factor of requirement prioritization, to complete the software successfully the cost estimation needs to be highly accurate [39].

In every software project there are some important requirements for which resources can be sacrifice for customer satisfaction of the important requirements according to customer the importance for customer satisfaction can differ by orders of magnitude. Hence, some of those important requirements are critical and have a high impact on the success of software project while others might just have a little impact in the success or the failure of the software project. Important requirement from the list of requirements should be selected for the satisfaction of the customer for implementation.

However, the importance of software requirements can differ by orders of magnitude, Hence, most software providers do not have precise and effective means for selecting the important requirements among them and the goal most software providers does not contain the separation the important requirements from the less important, nor do they have precise and effective means for doing this. As a result, it can be difficult to attain the best possible software system because of the lack of customer satisfaction [4]. The necessity for prioritizing the requirements according to their perceived importance is highly important factor to complete the projects successfully [40].

While prioritizing the requirements experience of a development personnel also plays an important role in prioritization process. There is not a single common way in software companies to perform requirement prioritization. In most cases the requirements are prioritized on the basis of the experience of the development personnel. The factors one should take into account when deciding priorities are not commonly explicated. Individuals make prioritization choices typically on the foundation of their technical knowledge or feelings.

The development personnel try to make a guess which requirement are the most important ones to customers and users, how profitable requirements are to the company, and how all this bound with the policy of the company, according to their previous knowledge. Hence the experience of development personnel is important factor to complete the project on time, if development personnel do not have any experience according to the project it will lead to the software project to a challenging project.

Expectations of different stakeholders are another factor of requirement prioritization process. According to Dirk Basten the success of project needs to reflect the stakeholder's expectations [41]. Every stakeholder has his own expectations from the projects, i.e., user the customer expectations could be that with less amount of money spend on the system project should be running as expected, therefore in requirement prioritization process expectations of stakeholder plays an important role.

Strong knowledge of software risk management is an important need which may have challenging environment to control risk [42]. There are some number of risks involve in every software project, Software project risk analysis has been given serious consideration by both academics and practitioners for quite some time. In software engineering risk management is used to deal with the internal and external risks involved in any project. The basic reason for the failure of software projects is the absence of risk management process in projects [43]. Hence, risk is an important aspect of requirement prioritization process. Hence in requirement prioritization it is important to identify the risks associated with each requirement.

Software development has always been categorized by certain factors, one of the important challenges for software developers is that of forecasting the development effort of a software system on the base of developer details, size, complexity, and other measures.

However, the development of software products in a cost-effective manner is one of the most important goal for each software organisation. The main goal is precisely the accurate estimation of the amount of effort needed to realise the projects [44]. The software industry's incapability to deliver precise estimates of effort is well known.

Requirement prioritization process also depends on the effort required to complete individual requirement i.e., developer's effort to develop any requirement, designer's effort to design the module related to specific requirement.

Size of requirement is another important aspect of requirement prioritization method, requirements of a project are prioritizing according to their size, by considering different factors i.e., time plays an important role to prioritize the requirement according to the size of individual requirement.

Now-a-days software companies are more interested in developing the software for entire market instead of developing the software for a specific customer [45]. Hence while prioritization of requirement the relation between market needs and each requirement is very important. Therefore, sales impact is another aspect for requirement prioritization to boost the company's profit. Because most of the time customer wants to boost the sales of company, the requirement which have a great impact on sales are important by customer perspective hence sales impact is an important aspect which should be focus when prioritizing the requirements.

There are some technical aspects which should be focused while prioritizing the requirements for example contradicting requirements. In software development life cycle (SDLC) requirement gathering is the most important and critical phase. Wrong, incomplete and contradicting nature of requirements can lead the project to failure or it will compromise the quality of the other phases the quality of product depends on the quality of each phase of software development life cycle. Hence, the software product. Writing good software requirements specification (SRS) is an important determinant of software quality [46].

Another important technical aspect which should be considers while performing the requirement prioritization is dependency of requirements. Numerous industrial studies however, have established that requirements of software projects are complexly interdependent and these interdependencies influence the values of requirements, therefore It is very important to consider the existence and amount of dependency in requirements [47].

In addition, the strength of the interdependent relationship varies from context to actual projects. For example, needs may depend on strengths or weaknesses. It is important to consider both the presence and strength of interdependent relationships during the selection of needs. It is important to keep project costs in budget [46]. Hence, interdependence is a key element of the service delivery process.

Resource Allocation is an important task but it is often ignored. It is important to manage the allocation of resources because the success of project is depending upon the allocation of resources for each activities of software development life cycle [48]. According to Standish group, software organizations failed to bring successful projects and this has been the important point for Software Engineering researchers. One of the causes of project failure is inadequate resource allocation to software project's activities [49].

Resource used to complete each requirement are very big contributor in requirement prioritization, most requirements are prioritizing by checking the availability of the resources. Strategic planning is an important aspect of requirement prioritization. Strategic planning is significant to bring into line software provider's business goals in order to effectively complete projects on time and under defined cost.

This way operational strategic demand management will be reasonable [50]. Strategic planning in software development lifecycle is an important aspect, it support the organization and the products of organization, and therefore strategic planning plays an important role in requirement prioritization, to make an organization successful [51].

The completeness of the requirements is important. Incomplete requirements are frequent, hard to understand, and a major source of implementation errors [52]. Completeness of requirements are very important to proper understanding of requirement which leads to the successful projects. Most of the companies has a reviewer to review the completeness of requirements and rate the requirements by using a Likert scale [53].

2.5 Summary

Quality of the software depends on the specification of requirements, and requirement prioritization process, if the requirements are prioritizing properly it will increase the quality of software and will also increase the chances of success of the software. There are number of methods present in market which helps in prioritization of requirement however, each technique has its own limitations, each technique cover some aspects of requirement, there is a need of a framework or technique which will cover the most important aspects of requirement prioritization. Therefore, a systematic literature review has been performed in order to identify the number of aspects from the literature. The process of systematic literature review has been explained briefly in this chapter of thesis, and a detailed systematic literature review has been performed to identify the number of aspects from the literature. These identified aspects will be verified and filtered by the survey respondent's results and then a framework based on these filtered aspects will be proposed which will help to improve the prioritization process.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter of study provides a brief overview of research methods used in conducting the research, the mechanism to put on research methods and methods to validate the research methods. Qualitative, quantitative and mix method research has been deliberated in this chapter of the study. The chapter explain the survey and interview procedures corresponding to their application in leading this research. The methods to conduct this research have been provided in this chapter which are followed by the validation methods. The succeeding segments of the chapter explains the approaches applied in this study and their individual validation methods.

3.2 Quantitative Research

In this method collected results are examined analytically with specific designs and computational methods. Information is collected and assessed by quantitative investigate approaches such as card sorting and survey. In this study survey method is used to validate the systematic literature review findings. This technique gives arithmetical assessment of result of study by allocating questionnaires in all the sampled population.

3.3 Qualitative Research

In a standardized study descriptive data is collected to obtain reasonable data around the results. In this type of research data is collected and authenticated by other non-numerical methods including interviews, formal methodology, case studies, self-assessment or focus group methods. We use a focus group approach to collecting useful information to verify and validate data.

3.4 Mixed Method Research

When more than one method is applied to research it becomes mixed method research, to validate the finding of study. Mixed method research is used so that obtained results can be verified by the collected historical evidence and with respect to expert opinion. Furthermore, before the conduction of entire study the inconsistent results can be eliminated.

To conduct the research there are eight research designs. Eight type of mixed research methods has been explained by the le Leech, N.L. and Onwuegbuzie [54] , as shown in the Fig 3.2.

In this research the results of qualitative study are used in order to validate the results of quantitative study, therefore a qualitative study looks more weighted compared to quantitative studies. It is verified that if the results of both methods meet the same results or not? If they do, we accept it with increased confidence otherwise the outcome is either re-verified or rejected. According to the requirements of the study 'partially mixed sequential dominant design' is used to undertake this research.

3.5 Research context and justification

The main goal of this research is to identify the different aspects of requirement prioritization. By conducting systematic literature review a framework is designed to select and prioritize the aspects efficiently so that quality software can be developed and to increase the probability of success of software project. The developed framework will allow the stakeholders to select the aspects which will help in prioritizing the requirement.

This chapter describes the framework development by analyzing different aspects of requirement prioritization by performing a literature review in past conducted studies. The previous chapter of this study focused on the number of aspects that affects the process of software development on any stage, and how efficiently choosing and prioritizing the requirements can play a vital role in increasing the quality of software and can help increasing the success rate of any software project.

In this and proceeding chapters of the research the development of framework is focused, which will contribute to the process of requirement prioritization and will contribute to success of any software projects. As identified in previous chapter there are numerous numbers of aspects which effects the development process in one way or other. However, all aspects cannot be used because of dynamic nature of different software projects with respect to stakeholders, requirements and resources located for the project.

To conduct this study a survey has been conducted which helped in gathering of quantitative information for validation of developed framework and research objectives. However qualitative study has been conducted for the validation of the research questions in a detailed manner by using the interviews and focused groups tools.

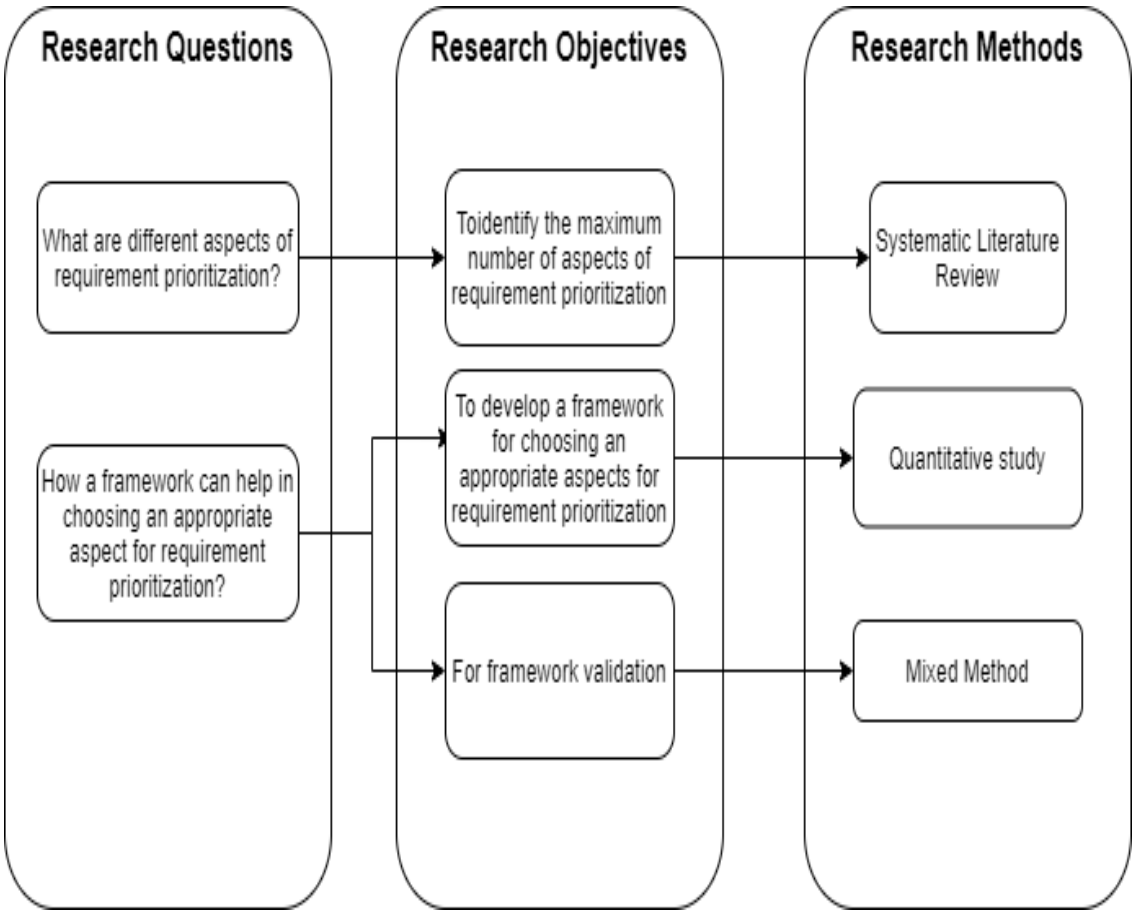

Figure 3.1 A procedural view of the methodology for this research

3.6 Methods and Respondent's Profiles

This section of the study discusses the details and different methods such as surveys and focused groups, Respondent's profiles are elaborated in this section.

3.6.1 Survey

The concept 'survey' is utilized in number of ways, but most of the time it refers to the selecting relatively large sample of people from pre-selected population (the population

of interest) followed by the group of a comparatively small quantity of data from selected population.

3.6.2 Survey Conduct

The population size in this very case can't be established with precision as the respondents are scattered and knowing the estimated population may itself require a detailed study. It is recommended that if the population size is unknown it may be ignored as increasing the population size to extensively large scale only increases the calculations. It is therefore assumed that a population size of 300 is reasonable to be considered for conducting the survey. A survey is designed to undertake the study to identify the aspects for requirement prioritization. Ten choices were given against a Likert scale ranging from (1-5). The survey is conducted using questionnaire.

3.6.3 Scale used in survey

The survey was sent 400 respondents by using number of means including paper survey, e-mails, Google talk etc. Publicly available social platforms were used for the purpose of identification of the professionals who have working, managing experience of requirement prioritization.

Table 3.1: Survey Statistics

Measure	Number
Population	*
Population accessed	400
Sample size	260

Researches which contain the questionnaires widely uses the Likert scale. The scale traditionally and observably contains five levels 1-5, where 1 (Strongly Disagree), 2 (Disagree), 3 (Neither Agree nor Disagree), 4 (Agree) and 5 (Strongly Agree), while

the seven and nine valued Likert scales have also been seen in practice although rarely. As the scale is increased with e.g., 9points it may cause misunderstanding of information for respondent and may produce wrong results while less points i.e., 3-point scale can cause insufficient information for respondents to respond for a specific answer therefore 5 scale Likert scales recommended and 5 scale Likert scale is used in this research in order to conduct the survey.

3.6.4 Respondent profile for survey

In order to get meaningful and precise responses from the respondents, the survey was sent to individuals having experience in dealing (managing, developing, managing, testing etc.) with software requirement prioritization. The survey was forwarded to research groups and software houses (programmers, team leads and project managers). As the context of this research study addresses the software requirement prioritization, it was deemed important that only the experienced professionals (having experience in software requirement engineering) respond to this survey. In order to shortlist the respondents based on their credentials a prequalification mechanism was used. Different software houses have been visited in order to identify the respondents for the conduction of survey. The identified individuals include programmers, analysts, project managers and consultants. The survey was responded by slightly over 260 respondents.

3.6.5 Focus Group

A group of experts have been selected in order to validate the findings of survey. The surroundings in which focused group process is accompanied was easy and accessible. The focus group discussion for this study contained seven experts. The purpose of focus group discussion is to validate the results that has been identified by the survey to get the answers of research questions. There are multiple research methods available alternate to focus group but focus group is very well suited to obtain the responses of new concepts and there are no limitations of discussion, hence this method is chosen to further discuss and validate the finding of research questions.

3.6.6 Participants profile in focus group

The participants of the focus group discussion were chosen among the survey respondents. Those respondents which falls under the pre-qualified section were chosen for the focus group discussion section. An online session is conducted for this activity. A meeting on zoom is scheduled and the list of questions has been emailed to the participants before the session of focus group. While performing the focus group discussion all questions are being asked by each participant and their responses have been recorded in order to get results from their responses.

Table 3.2: Interviewee's Profile (Focus Group)

Sr.	Experience	Rank	Experience(Years)	Development Experience
1	Industry	Developer	2	Yes
2	Industry	Developer	3	Yes
3	Industry	Developer	4	Yes
4	Industry	Team Lead	5	Yes
5	Industry	Developer	3	Yes
6	Industry	Project manager	3	Yes
7	Industry	Developer	4	Yes

Respondent number 1,2,3,5,7 are developer with at latest two years of experience in software industry they mentioned that they have worked on different scale of project and did the requirement prioritization based on their previous experience in multiple projects. Respondent 4 worked as a team lead and he also mentioned that he has experience of handling multiple projects and understanding the requirements of different project so that he can explain to his team. Respondent number 7 worked as a project manager for more than 4 years in software industry, he mentioned that he also has experience in requirement prioritization.

3.7 Summary

This chapter discusses the methodological ground for the research to be conducted. The basics of research and research objective is described in the beginning and a preview of the research in software engineering is presented. The research methods including survey and focus group discussion has been discussed in detail. The research design discusses the step complete methodology that has been performed to answer the research questions. First a systematic literature review has been explained in the previous chapter of this research in order to identify the different aspects from the studies, number of aspects have been identified from this method, furthermore the survey method has been discussed with the justification of using survey method, in this section each step has been discussed that has been followed to carry out the survey to verify the aspects that has been identified by the systematic literature review, in next session the selection of population and sample size has been discussed in details that how respondents are selected and how Likert scale is used to conclude the results from the survey. This chapter also briefly describes the use of focus groups, the steps that needs to be followed in focus group and the profile of participants that has been selected for the conduction of focus group.

CHAPTER 4

RESULTS

4.1 Introduction

This chapter explains the results of the survey and the outcome of the focus group that has been performed to ensure the overall survey results. This chapters contains the list of aspects that are identified from the systematic literature review in previous chapter. Those aspects which are identified by the systemic literature review and are not selected by the respondents are excluded from the study. This section of study contains the weightage values and average weightage values of the survey results for each question so that each question can be accepted or rejected. This section of study also contains the results of performed focus groups for the validation of framework.

4.2 Survey results

A survey has been conducted in a systematic way by following the design guidelines which identifies the correct results. The designed questionnaire consisted 2 parts first part was about the gap in the prioritization process and the second part was about the validation of identified aspects of requirement prioritization. The survey was designed to identify that how important is requirement prioritization for the quality of projects and how requirement prioritization can help in the success of project. And the second portion of survey was designed in order to validate the identified aspects of requirement prioritization. The target audience chosen for the survey consisted of 230 respondents, these respondents were software developers and requirement engineers.

The respondents were access in person. After collecting the results from the survey, the responses were refactored and analysis has been done using SPSS software. To

find the weightage values responses are further examined in table 4.1. Likert scale is used for analyzing the data in a systematic way. Values has been allocated to the response of the survey using Likert scale to identify the precise response of the respondents. The value allocation is done by multiplying the total value with Likert scale values. (Strongly agreed responses will be multiplied with 2, agree response value will be multiplied with 1, neutral value will multiply with 0, disagree response value will be multiplied with -2 and strongly disagree value will be multiplied with -2) and then adding these multiplied values to get a total response value of each factor.

Table 4. 1 Results of responses from survey

Sr.	Factors	Strongly Agree(2)	Agree (1)	Neutral (0)	Disagree (-1)	Strongly Disagree(-2)	Total
1	Important	274	89	0	0		361
2	Cost	282	83	0	0	0	365
3	Time	256	95	0	-1	-0	350
4	Risk	240	108	0	0	0	348
5	Sophisticated Nature	252	93	0	0	-2	343
7	Dependency	266	87	0	0	0	353
8	Scalable	146	72	0	-1	0	217
9	Sensitivity	290	77	0	0	-2	365
10	Error Free	274	83	0	-1	0	356
11	Contradicting	264	90	0	0	0	354
12	Resource Utilization	274	75	0	-83	0	266
13	Value	304	69	0	-2	0	371
14	Profit	268	84	0	-1	-4	347
15	Approach	236	106	0	0	0	342
16	Type Of Implementing	132	91	0	0	0	223
17	Size	110	65	0	-19	-48	108
18	Mutual Understanding	298	73	0	-6	0	365
19	Stakeholder Expectations	152	67	0	-82	0	137
20	Importance Of A Requirement	352	46	0	-3	0	395
21	Strategically Planning	262	94	0	-1	0	355
22	Expert Opinion	312	74	0	0	0	386
23	Success Rate	386	30	0	-1	-2	413

Sr.	Factors	Strongly Agree (2)	Agree (1)	Neutral (0)	Disagree (-1)	Strongly Disagree(-2)	Total
24	Organization Satisfaction	358	48	0	-1	-2	403
25	Sales Impact	270	91	0	-1	0	360
26	Customer Satisfaction	252	43	0	-14	-56	225
27	Management	302	78	0	0	0	380
28	Expertise Of Development Team	330	54	0	0	0	384
29	Quality Impact	324	67	0	0	0	391

5 points Likert scale has been used to give the weightages to each question, points has been assigned weights i.e., strongly agree is assigned 2 agree is assigned 2 neutral is assigned 0 disagree is assigned -1 strongly disagree -2 is assigned.

4.2.1 Average Weight from Survey

The weights of each question have been identified using Likert scale, and then average weightage value of each question has been calculated by dividing the weight by total weightage and the answers which have more than 1.0 average weightage are accepted and the questions which lies under 1.0 are rejected.

Table 4. 2 Average Weight from Survey

Sr.	Factors	Weightage Values	Average Value/230	Results
1	Importance	361	1.57	Accepted
2	Cost	365	1.59	Accepted
3	Time	350	1.52	Accepted
4	Risk	348	1.51	Accepted

Sr.	Factors	Weightage Values	Average Value/230	Results
5	Sophisticated Nature	343	1.49	Accepted
6	Complexity	349	1.52	Accepted
7	Dependency	353	1.53	Accepted
8	Scalable	217	0.94	Rejected
9	Sensitivity	365	1.59	Accepted
10	Error Free	356	1.55	Accepted
11	Contradicting Nature	354	1.54	Accepted
12	Resource Utilization	266	1.16	Accepted
13	Value	371	1.61	Accepted
14	Profit	347	1.51	Accepted
15	Approach	342	1.49	Accepted
16	Result Type	223	0.97	Rejected
17	Size	108	0.47	Rejected
18	Mutual Understanding	365	1.59	Accepted
19	Stakeholder Expectations	137	0.6	Rejected
20	Importance	395	1.72	Accepted
21	Strategically Planned	355	1.54	Accepted
22	Expert Opinion	386	1.68	Accepted
23	Success Rate	413	1.8	Accepted
24	Organization Satisfaction	403	1.75	Accepted
25	Sales Impact	360	1.57	Accepted
26	Customer Satisfaction	225	0.98	Rejected
27	Management	380	1.65	Accepted
28	Development Team Expertise	384	1.67	Accepted
29	Quality Impact Of Project	391	1.7	Accepted

4.2.2 Result explanation

The accepted and rejected factors are based on the value of Cronbach alpha, the value with low significance are rejected while on the other hand values with higher significance are accepted.

4.2.3 Cronbach Alpha

The value of Cronbach alpha is 0.74 which shows that the results are consistent it shows a close relation between sets of factors. Cronbach alpha is used to show the consistency between results and Cronbach alpha's value more than 0.70 is 'Acceptable'.

4.2.4 Low Significance Factors

According to the result of survey 5 aspects are dropped out of 29 aspects for requirement prioritization, the reason of the dropped values is that most of the participants selected neutral values instead of giving positive or negative response these don't know values caused the results to drop 5 aspects from the result.
Following are the low significance factors:

1. Do you think that while prioritization process, it should be studied that how scalable a requirement is? This factor has 0.94 weightage value which lies under the 1 that's why this aspect has been dropped out from the survey's final result. 2. How likely it is important to analyse the result type of implementing each requirement in requirement prioritization process? This factor got 0.97 weightage value which lies under the 1.0 so get dropped out of the selected result. 3. Is it important to check the "size" of each requirement while prioritization?

This factor got 0.47 weightage value which lies under the 1.0 so get dropped out of the selected result. 4. Is it important to check stakeholder expectations of requirement while prioritization?

This factor got 0.6 weightage value which lies under the 1.0 so get dropped out of the selected result. 5. Is it important to take account of customer satisfaction while prioritizing the requirements? This factor got 0.98 weightage value which lies under the 1.0 so get dropped out of the selected result.

4.2.5 High Significance Result

27 out of 29 aspects for requirement prioritization are accepted from survey, these selected aspects have high significance because most of the participants has given positive response for these aspects.

1. Is it important to check the importance of each requirement and prioritize the requirements accordingly? This factor got more than 1.0 weightage value this therefore it lies in acceptance are of the result, according to the respondents it is importance of requirement is an important aspect in requirement prioritization process.

2. Do you think “cost” is an important aspect of requirement prioritization? Most of the respondent agreed to the factor that cost is an important aspect therefore while prioritizing the requirement it is important to implement cost effective aspects in early stages of the development.

3. Do you agree that “time” to complete a requirement is an important aspect in requirement prioritization? Time is an important aspect in requirement prioritization and is accepted by the most of the respondents of the survey.

4. How likely you think that requirements should be prioritize based on the “risk” associated with each requirement? According to survey risk of each requirement

should be analysed in prioritization process of requirement. So that requirements with less risk can be executed first.

5. Is it important to check sophisticated nature of requirement while prioritization? According to the respondents is it important to prioritize the well sophisticated requirements in early stages.

6. Should "complexity" of each requirement be measured and studied while prioritizing the requirements? Respondents has agreed to that complexity of a requirement is an important aspect of requirement prioritization.

7. Do you agree that "dependency" of each requirement on other requirements should be analyzed in requirement prioritization process? According to survey result it is important to check the dependency of each requirement on other requirements.

8. Is "sensitivity" of a requirement is an important aspect in requirement prioritization? Respondents of the survey has agreed that it is important to prioritize the requirements according to the sensitive nature of each requirement.

9. Is it important to check if a requirement is error free while prioritizing the requirements? According to survey result while prioritization it is important to execute the error free requirements in early stages of development.

10. Is it important to check the contradicting nature of requirement while prioritizing? According to respondents it is important to check weather a requirement is contradicting to any other requirement while prioritization.

11. Do you think while prioritizing the requirements "resource utilization" of each requirement should be measured? Yes, most of the respondents agreed to factor that it important to check the amount of resource utilization in requirement prioritization process.

12. While prioritization of requirement it is important to check the “value” of each requirement in software project? Yes, according to survey it is important to check the value each requirement has according to different stakeholders.

13. Do you think while prioritizing the requirements the “approach” of development should be checked for each requirement? Survey result shows positive responded that the requirement should be executed based on the type of development process that requirement needs for execution. Hence checking of type of development process is an important aspect of requirement prioritization.

14. It is important to analyze that how much a requirement can add in “profit” of the organization? According to survey it is important to check how much each requirement is adding into the profit of organization before executing.

15. Is “mutual understanding” of each requirement important for requirement prioritization process? Surveys shows positive response in aspect of mutual understanding of each requirement while prioritization.

16. How likely is to check the importance of a requirement for customer? Yes, according to the result of survey it is important to prioritize the requirements according to the importance of customer.

17. Is it important to plan each requirement strategically in requirement prioritization process? Respondent of survey has agreed, therefor this aspect lies in acceptance area and it is important to prioritize the requirement and plan each requirement strategically.

18. While prioritization process how likely the expert opinion matters in a project success? According to survey results it expert opinion is an important aspect in requirement prioritization process.

19. Do you think that requirement should prioritize according to the success rate? Yes, result of survey shows that it is important to check that how much a requirement is contributing to the success of the project and prioritize those requirements accordingly.

20. Is organization satisfaction an important aspect of requirement prioritization? This shows that it is important to check the satisfactions of organization in requirement prioritize process.

21. Should we check the sales impact of implementing each requirement in prioritization process? According to this, it is important to analyses the impact of each requirement on sales and prioritize accordingly.

22. Do you think that management is an important aspect of requirement prioritization? Respondents of survey has agreed that management of a requirement is an important aspect of requirement prioritization process.

23. Is it important to consider the expertise of development team and prioritize the requirement accordingly? According to survey result it is important to check the expertise of development team and prioritize requirements accordingly.

24. Should requirements be prioritizing according to quality impact of project? Yes, according to respondents it is an important aspect in requirement prioritization process.

4.3 Focus Group Results

For evaluation and getting better results from survey, focus group method is used. Total seven respondents were selected in order to conduct the focus group studies, the selected respondents were expert in the domain of requirements engineering,

requirement prioritization specifically, these selected respondents were well educated and these respondents has well experienced in the respective field.

Every respondent in this activity has been asked research questions according to their experience. Focus group study helps to identify the ambiguities and missing aspects in the questions, in this study all the selected candidates are open to share their perspective of the given points.

A question is asked from the candidates of focus group or the respondents can discuss their ideas freely. An online meeting was scheduled on zoom application, and an invitation was sent to the relevant selected population, the selected population for this activity was expert in relevant field.

Total seven people accepted the invitation and thus the sample size for this study was seven. And all the members who accepted the invitation was added in the meeting and it took almost 2hrs to discuss all the points of discussion.

All selected members recorded their response in a comfort environment with in detail discussion and responses from all the participants are added in Table 4.4

Table 4. 3 Results from focus group data

Sr.	***Factors***	***P1***	***P2***	***P3***	***P4***	***P5***	***P6***	***P7***
1	Importance	2	1	2	1	1	2	2
2	Cost	2	1	1	2	1	2	1
3	Time	1	2	2	2	1	1	1
4	Risk	1	1	1	2	1	1	1
5	Sophisticated Nature	2	1	1	-1	2	2	2
6	Complexity	2	1	1	1	1	1	2
7	Dependency	2	-1	2	2	2	2	2
8	Scalability	1	1	1	2	1	1	1
9	Sensitivity	1	2	2	-1	1	1	1

Sr.	*Factors*	*P1*	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*
10	Error Free	-1	1	2	-1	-1	-1	1
11	Contradicting Nature	1	1	1	0	1	1	1
12	Resource Utilization	-2	2	1	1	-2	-2	-2
13	Value	1	1	1	1	1	1	1
14	Profit	1	2	2	0	1	1	-1
15	Development Approach	2	1	1	-1	2	2	2
16	Result Type	1	-1	2	2	1	1	1
17	Size	-1	1	1	1	-1	-1	-1
18	Mutual Understanding	2	-1	1	1	2	2	2
19	Stakeholder Expectation	1	2	2	1	1	1	1
20	Customer Importance	1	2	2	2	1	1	1
21	Strategically Planning	2	1	1	1	2	2	2
22	Expert Opinion	1	0	1	2	1	1	1
23	Success Rate	1	0	2	2	1	1	1
24	Organization Satisfaction	2	-1	1	1	2	2	2
25	Sales Impact	1	-1	2	1	1	1	-1
26	Customer Satisfaction	-1	-1	2	1	1	-2	1
27	Management	1	-1	2	1	1	1	1
28	Expertise Of Development Team	2	1	2	2	2	2	2
29	Quality Impact	1	1	2	1	1	1	1

4.3.1 Likert scale focus group responses

The responses are analyzed according to Likert scale to get average Weightage values. The responses from respondents are multiplied with the values of Likert scale values.

Table 4. 4 Likert Scale for focus group responses

Sr.	***Factors***	***P 1***	***P 2***	***P 3***	***P 4***	***P 5***	***P 6***	***P 7***	***Agree *2***	***Disagree *-2***	***Results***	***Avg weight***
1	Importance	2	1	2	1	1	2	2	14	0	14	2
2	Cost	2	1	1	2	1	2	1	14	0	14	2
3	Time	1	2	2	2	1	1	1	14	0	14	2
4	Risk	1	1	1	2	1	1	1	14	0	14	2
5	Sophisticated Nature	2	1	1	-1	2	2	2	12	-2	10	1.429
6	Complexity	2	1	1	1	1	1	2	14	0	14	2
7	Dependency	2	-1	2	2	2	2	2	12	-2	10	1.429
8	Scalability	1	1	1	2	1	1	1	14	0	14	2
9	Sensitivity	1	2	2	-1	1	1	1	12	-2	10	1.429
10	Error Free	-1	1	2	-1	-1	-1	1	6	-6	0	0
11	Contradicting nature	1	1	1	1	1	1	1	14	0	14	2
12	Resource utilization	-2	2	1	1	-2	-2	-2	6	8	14	2
13	Value	1	1	1	1	1	1	1	14	0	14	2
14	Profit	1	2	2	0	1	1	-1	12	-2	10	1.429
15	Approach of development	2	1	1	-1	2	2	2	12	-2	10	1.429
16	Implementation type	1	-1	2	2	1	1	1	12	-2	10	1.429
17	Size	-1	1	1	1	-1	-1	-1	6	-8	-2	-0.286
18	Mutual understanding	2	-1	1	1	2	2	2	12	-2	10	1.429
19	Stakeholder expectations	1	2	2	1	1	1	1	14	0	14	2
20	Customer importance	1	2	2	2	1	1	1	14	0	14	2
21	Strategically planning	2	1	1	1	2	2	2	14	0	14	2
22	Experts opinion	1	0	1	2	1	1	1	14	0	14	2
23	Success rate	1	0	2	2	1	1	1	14	0	14	2
24	Organization satisfaction	2	-1	1	1	2	2	2	12	-2	10	1.429

Sr.	*Factors*	*P 1*	*P 2*	*P 3*	*P 4*	*P 5*	*P 6*	*P 7*	*Agree *2*	*Disagree *-2*	*Results*	*Avg weight*
25	Sales impact?	1	-1	2	1	1	1	-1	10	-4	6	0.857
26	Customer satisfaction	-1	-1	2	1	1	-2	1	8	-6	2	0.286
27	Management	1	-1	2	1	1	1	1	12	-2	10	1.429
28	Expertise of development team	2	1	2	2	2	2	2	14	0	14	2
29	quality impact	1	1	2	1	1	1	1	14	0	14	2

Average weightage values are calculated based on the calculation done on previous table using Likert scale. The Likert scale calculation is based on the weightage values calculated in order to analyze the focus group results clearly.

4.3.2 Average Weight from Focus Group

This section of the study contains the final result of the focus group in this section average weightage value of all identified aspects are calculated. And using that weighted values the aspects are either accepted or rejected.

Table 4. 5 Average Weight from Focus Group

Sr.	*Factors*	*Avg. Weighted*	*Final Results*
1	Importance	2	Accepted
2	Cost	2	Accepted
3	Time	2	Accepted
4	Risk	2	Accepted
5	Sophisticated Nature	1.429	Accepted
6	Complexity	2	Accepted
7	Dependency	1.429	Accepted
8	Scalability	2	Accepted
9	Sensitivity	1.429	Accepted

Sr.	*Factors*	*Avg. Weighted*	*Final Results*
10	Error Free	0	Rejected
11	Contradicting nature	2	Accepted
12	Resource utilization	2	Accepted
13	Value	2	Accepted
14	Profit	1.429	Accepted
15	Development approach	1.429	Accepted
16	Implementation type	1.429	Accepted
17	Size	-0.286	Rejected
18	Understanding	1.429	Accepted
19	Stakeholder expectation	2	Accepted
20	Customer importance	2	Accepted
21	Strategically planned	2	Accepted
22	Expert opinion	2	Accepted
23	Success rate	2	Accepted
24	Organization satisfaction	1.429	Accepted
25	Sales impact	0.857	Rejected
26	Customer satisfaction	0.286	Rejected
27	Management	1.429	Accepted
28	Expertise of development team	2	Accepted
29	Quality impact	2	Accepted

4.3.3 The low significance factors according to focus group

i. Is it important to check if a requirement is error free while prioritizing the requirements?
ii. Is it important to check the "size" of each requirement while prioritization?
iii. Should we check the sales impact of implementing each requirement in prioritization process?

iv. Is it important to take account of customer satisfaction while prioritizing the requirements?

According to focus group participants it is not important to check if each requirement is error free, because this factor can be mitigated by having multiple meetings and it is very less likely that a requirement will have an error in it, therefore this aspect lies in the rejected are of the focus group result. However, according to the focus group study, size of each requirement does not affect the prioritization, and as prioritization is the early process in software development therefore the impact of each requirement on sale cannot be determined hence it lies in the rejection area of focus group result. And according to focus group participants most of the customers are non-technical and have very less knowledge of technical aspects of development therefore it is not important to check customer satisfaction of each requirements while prioritization of requirements.

In comparison of survey and focus group 2 aspects are commonly rejected these rejected aspects are

i. Is it important to check the "size" of each requirement while prioritization?
ii. Is it important to take account of customer satisfaction while prioritizing the requirements?

4.3.4 The accepted or high significance factors according to focus group

i. Is it important to check the importance of each requirement and prioritize the requirements accordingly?
ii. Do you think "cost" is an important aspect of requirement prioritization?
iii. Do you agree that "time" to complete a requirement is an important aspect in requirement prioritization?
iv. How likely you think that requirements should be prioritize based on the "risk" associated with each requirement?
v. Is it important to check sophisticated nature of requirement while prioritization?

vi. Should “complexity” of each requirement be measured and studied while prioritizing the requirements?

vii. Do you agree that “dependency” of each requirement on other requirements should be analysed in requirement prioritization process?

viii. Do you think that while prioritization process, it should be studied that how scalable a requirement is?

ix. Is “sensitivity” of a requirement being an important aspect in requirement prioritization?

x. Is it important to check the contradicting nature of requirement while prioritizing?

xi. Do you think while prioritizing the requirements “resource utilization” of each requirement should be measured?

xii. While prioritization of requirement it is important to check the “value” of each requirement in software project?

xiii. It is important to analyse that how much a requirement can add in “profit” of the organization?

xiv. Do you think while prioritizing the requirements the “approach” of development should be checked for each requirement?

xv. How likely it is important to analyse the result type of implementing each requirement in requirement prioritization process?

xvi. Is “mutual understanding” of each requirement important for requirement prioritization process?

xvii. Is it important to check the sophisticated nature of requirement in prioritization?

xviii. How likely is to check the importance of a requirement for customer?

xix. Is it important to plan each requirement strategically in requirement prioritization process?

xx. While prioritization process how likely the expert opinion matters in a project success?

xxi. Do you think that requirement should prioritize according to the success rate?

xxii. Is organization satisfaction an important aspect of requirement prioritization?

xxiii. Do you think that management is an important aspect of requirement prioritization?

xxiv. Is it important to consider the expertise of development team and prioritize the requirement accordingly?

xxv. Should requirements be prioritizing according to quality impact of project?

These aspects are most commonly accepted by survey as well. To further justify the results these results will be further analyzed in chapter

CHAPTER 5

ANALYSIS

5.1 Introduction

After analyzing both results from survey and focus group this chapter of the study will present a more justified and accurate result. The result that will be evaluated by both survey and focus group will be the final result for this study and this result will helpful in the development of framework for requirement prioritization, to prioritize the requirement efficiently.

5.2 Triangulation process

To validate the multiple methods in research triangulation method is used. A survey has been performed in order to answer the research questions and objectives identified by performing the systematic literature review. In order to appraise the results of survey a qualitative method, focus group has been performed.

Then to justify the results of both survey and focus group, The triangulation process has been performed the final result which is obtained by performing the triangulation process, will be more justifiable data. The final result shows the comparison of factors of both studies. This is the last step to obtain the final results for this research which will help to support the research questions.

There are many existing methods for requirement prioritization, however most of these methods are intended to resolve a particular issue. While in real world while prioritizing the requirements, there is no method to solve all the issues and conflicts which are presented before at once and there is no integration between the existing prioritization methods. Therefore, there is a need to present a framework that will resolve the maximum number of issues and conflicts.

Table 5.1 Final Results

Sr.	Questions	Survey	Focus Group	Validated Values	Final Results
1	Importance	1.57	2	2	Accepted
2	Cost	1.59	2	2	Accepted
3	Time	1.52	2	2	Accepted
4	Risk	1.51	2	2	Accepted
5	Sophisticated nature	1.49	1.429	1.49	Accepted
6	Complexity	1.52	2	2	Accepted
7	Dependency	1.53	1.429	153	Accepted
8	Scalability	0.94	2	2	Accepted
9	Sensitivity	1.59	1.429	1.59	Accepted
10	Error free	1.55	0	1.55	Accepted
11	Contradicting nature	1.54	2	2	Accepted
12	Resource utilization	1.16	2	2	Accepted
13	Value	1.61	2	2	Accepted
14	Profit	1.51	1.429	1.51	Accepted
15	Development approach	1.49	1.429	1.49	Accepted
16	Result type	0.97	1.429	1.42	Accepted
17	Size	0.47	-0.286	0.47	Rejected
18	Mutual understanding	1.59	1.429	1.59	Accepted
19	Stakeholder expectation	0.6	2	2	Accepted
20	Customer importance	1.72	2	2	Accepted
21	Strategically planning	1.54	2	2	Accepted
22	Expert opinion	1.68	2	2	Accepted

Sr.	Questions	Survey	Focus Group	Validated Values	Final Results
23	Success rate	1.8	2	2	Accepted
24	Organization satisfaction	1.75	1.429	1.75	Accepted
25	Sales Impact	1.57	0.857	1.57	Accepted
26	Customer satisfaction	0.98	0.286	0.98	Rejected
27	Management	1.65	1.429	1.65	Accepted
28	Development expertise	1.67	2	2	Accepted
29	Quality impact	1.7	2	2	Accepted

Final more justified and validated result from triangulation process shows that most of the factors are accepted and two factors are rejected. These two factors are:

5.2.1 Low significance factors in final results

F1: Is it important to check the "size" of each requirement while prioritization?

F2: Is it important to take account of customer satisfaction while prioritizing the requirements?

According to final results size of requirement has no big effect or requirement prioritization process, and this aspect cis therefore rejected and also the customers are mostly non-technical person therefore the customer most of the time don't know what really should be implemented first therefore customer satisfaction should not be consider in requirement prioritization process.

5.2.2 High significance factors in final results

i. Is it important to check the importance of each requirement and prioritize the requirements accordingly?

ii. Do you think "cost" is an important aspect of requirement prioritization?

iii. Do you agree that “time” to complete a requirement is an important aspect in requirement prioritization?

iv. How likely you think that requirements should be prioritize based on the “risk” associated with each requirement?

v. Is it important to check sophisticated nature of requirement while prioritization?

vi. Should “complexity” of each requirement be measured and studied while prioritizing the requirements?

vii. Do you agree that “dependency” of each requirement on other requirements should be analyzed in requirement prioritization process?

viii. Do you think that while prioritization process, it should be studied that how scalable a requirement is?

ix. Is “sensitivity” of a requirement being an important aspect in requirement prioritization?

x. Is it important to check if a requirement is error free while prioritizing the requirements?

xi. Is it important to check the contradicting nature of requirement while prioritizing?

xii. Do you think while prioritizing the requirements “resource utilization” of each requirement should be measured?

xiii. While prioritization of requirement it is important to check the “value” of each requirement in software project?

xiv. It is important to analyze that how much a requirement can add in “profit” of the organization?

xv. Do you think while prioritizing the requirements the “approach” of development should be checked for each requirement?

xvi. How likely it is important to analyze the result type of implementing each requirement in requirement prioritization process?

xvii. Is “mutual understanding” of each requirement important for requirement prioritization process?

xviii. Is it important to check the sophisticated nature of requirement in prioritization?

xix. How likely is to check the importance of a requirement for customer?

xx. Is it important to plan each requirement strategically in requirement prioritization process?

xxi. While prioritization process how likely the expert opinion matters in a project success?

xxii. Do you think that requirement should prioritize according to the success rate?

xxiii. Is organization satisfaction an important aspect of requirement prioritization?

xxiv. Should we check the sales impact of implementing each requirement in prioritization process?

xxv. Do you think that management is an important aspect of requirement prioritization?

xxvi. Is it important to consider the expertise of development team and prioritize the requirement accordingly?

xxvii. Should requirements be prioritizing according to quality impact of project?

5.3 The Proposed Framework

This research proposes a standard framework to resolve the conflicts between the prioritization issues between different stakeholders. The proposed framework prioritizes the requirements by multiple aspects. These aspects are identified from the literature review and then verified by doing a survey, after the survey a list of important aspects was compiled, then a focus group was conducted to validate the compiled list.

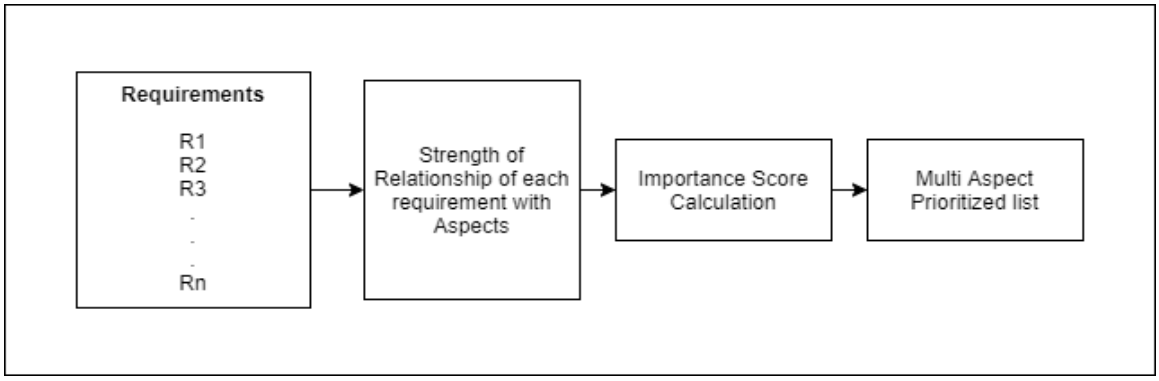

Figure 4.1: Proposed Framework for Requirement Prioritization

The proposed frameworks take a list of raw requirements as input. Then then the relation between each requirement is mapped with the presented aspects (0 for no relation, 1 for weak relation, 2 for moderate relation, and 3 for strong relation) and importance score is being calculated and then then the requirements are prioritized based on the score of importance. After that a multi aspect prioritize list is presented as output.

5.3.1 Example 1

An example from is taken from the research of [55] to perform the prioritization of requirements using the proposed framework. There is an online car showroom which needs to digitize their business by using a software, so the stakeholders have presented the list of following requirements.

5.3.2 List of requirements

This section of the study contains the list of functional requirements for a car rental organization, following are the list of un prioritized or raw requirements in further sections these list will be passed through the developed framework for prioritization.

R1: Login to system
R2: Update the car details (rental)
R3: Delete the car information
R4: Logout from system
R5: Change password
R6: Track new/used car information
R7: Update user details
R8: View rent car information
R9: Rent a car

5.3.3 Final List of Identified and validated aspects

This section contains the final identified aspects of requirement prioritization which are used in the developed framework.

A1: Importance

A2: cost

A3: time

A4: risk

A5: sophisticated nature

A6: complexity

A7: dependency

A8: scalability

A9: sensitivity

A10: error in requirement

A11: contradicting nature

A12: resource utilization

A13: value

A14: profit

A15: development approach

A16: result type

A17: mutual understanding

A18: stakeholder expectation

A19: importance for customer

A20: strategically planed

A21: expert opinion

A22: success rate

A23: organization satisfaction

A24: sales impact

A25: management

A26: development expertise

A27: quality impact

5.4 Framework Implementation

A multi-dimensional matrix is used to prioritize the requirement of case study according to the presented framework first column represents the requirements i.e. R1 represents requirement 1, and R2 represents requirement 2 and so on, the first row on other hand represents the aspects identified by this study and each cell contains the relation value to show how strong or how weak a relation is between all aspects with each requirement and importance score is calculated based on the sum of relation of a requirement with each aspect which presents a prioritize list as output.

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**	**A19**	**A20**	**A21**	**A22**	**A23**	**A24**	**A25**	**A26**	**A17**	**score**
R1	1	3	2	3	3	1	2	3	2	1	2	3	1	2	2	3	2	2	3	2	1	1	3	1	3	2	1	55
R2	0	2	3	0	1	1	0	2	2	3	1	2	3	3	1	3	2	1	2	1	1	2	3	1	1	2	1	44
R3	1	2	3	3	3	2	1	3	2	3	2	2	1	1	2	2	1	2	1	3	1	2	1	3	1	3	1	52
R4	2	2	1	2	1	3	2	1	1	3	1	2	1	3	1	3	2	1	2	1	3	1	2	1	3	2	2	49
R5	2	1	3	0	3	2	1	3	2	1	1	3	2	1	3	2	1	2	3	1	3	2	2	1	2	2	2	51
R6	2	1	2	3	3	2	1	2	3	3	1	1	2	2	1	1	1	1	1	1	1	1	2	2	1	3	3	47
R7	2	1	2	2	3	3	3	2	3	3	2	3	1	2	1	3	1	2	1	2	1	3	1	2	3	2	3	57
R8	1	2	2	1	2	2	2	0	1	3	2	3	2	1	2	3	2	3	2	1	1	2	3	1	2		1	47
R9	0	2	1	1	3	3	1	2	1	2	1	3	2	2	1	1	2	1	3	1	1	2	1	3	2	1	3	46

5.5 Prioritize List after passing requirements from framework

1: Update user details
2: Login to system
3: Delete the car information
4: Change password
5: Logout from system
6: Track new/used car information
7: Rent a car
8: View rent car information
9: Update the car details (rental)

After executing the proposed framework by passing the existing list of requirements, a compiled and prioritized list has been presented by the system. This list provides an efficient way to develop the project which will increase the quality of software and will increase the success rate of the project.

5.5.1 Example 2

Another example of online flight booking system is taken from [56] to execute the developed framework for requirement prioritization. This system has multiple requirements and all the requirements cannot be executed at once.

5.5.2 List of requirements

Following are the list of functional requirement of the selected system these are un prioritized requirements which needs to be prioritized before the execution of development process.

R1: Reserve a seat
R2: User Login

R3: Sign out

R4: Cancel a Seat

R5: User Sign up

R6: Modify a Booking

R7 Select Date of desired flight

R8: View List of available flights

R9: User Login

5.5.3 Framework Implementation

first column represents the requirements i.e. R1 represents requirement 1, and R2 represents requirement 2 and so on, the first row on other hand represents the aspects identified by this study and each cell contains the relation value to show how strong or how weak a relation is between all aspects with each requirement and importance score is calculated based on the sum of relation of a requirement with each aspect which presents a prioritize list as output.

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**	**A19**	**A20**	**A21**	**A22**	**A23**	**A24**	**A25**	**A26**	**A17**	**score**
R1	2	3	1	2	1	3	1	3	1	2	1	3	1	2	2	1	3	1	3	2	1	3	1	1	1	2	3	50
R2	1	2	1	3	2	3	1	1	2	3	2	2	1	2	2	1	1	1	1	2	2	2	3	2	3	2	1	49
R3	2	3	2	3	1	1	1	1	2	2	1	1	3	2	1	1	2	3	2	1	1	1	2	2	1	2	2	46
R4	1	2	2	3	2	2	1		2	1	1	1	2	2	3	2	2	2	1	2	2	3	2	1	2	3	3	50
R5	2	1	2	1	2	2	2	1	1	1	1	2	3	2	3	1	3	1	3	1	2	2	1	1	2	3	2	48
R6	1	2	2	2	2	1	1	1	1	1	3	2	3	2	2	1	2	3	2	3	2	1	2	2	1	3	2	50
R7	1	2	3	2	1	2	3	2	2	3	2	1	2	3	2	1	2	1	2	2	2	1	1	2	3	2	1	51
R8	2	1	2	1	1	1	2	3	2	1	2	1	2	1	3	2	1	1	2	3	2	2	2	1	1	1	2	45
R9	1	2	2	2	2	1	2	3		3	3	2		1	1	1	2	3	3	2	1	2	2	1	2	3	1	48

5.5.4 Prioritize List after passing requirements from framework

After executing the proposed framework by passing the existing list of requirements, a compiled and prioritized list has been presented by the system.

1. Select Date of desired flight
2: Reserve a seat
3: Cancel a Seat
4. Modify a Booking
5: User Sign up
6: User Login
7. Sign out
8. View List of available flights

5.5.5 Execution of the proposed framework

There are some steps involve in execution for the proposed framework, all first step is to write all the requirements in the left column of the matrix and the identified aspects which are identified by systematic literature review and has been filtered and been verified the experts in the top most row.

Each identified aspect has its own priority from 1-n. n is the last number of identified aspects. After writing the matrix each cell is filled with its requirements and aspect relation by experts, (0 for no relation, 1 for weak relation, 2 for moderate relation, and 3 for strong relation) and importance score is being calculated and then then the requirements are poetized based on the score of importance.

5.6 Summary

Combined Results of survey and focus group has been explained in this chapter, in previous chapter number of aspects was identified from the literature review using systematic literature review.

Identified aspects which are present in literature review but not selected by the respondents of survey are however excluded from the study. Filtered aspects are then verified by the survey method and a framework has been proposed based on the filtered aspects, this framework covers all the possible dimension of the aspects and ensures the quality of product by providing an efficient way for requirement prioritization. Unlike other methods this framework covers most of the dimensions while other framework only included some dimensions.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Introduction

In this concluding chapter we summarize the contributions of this thesis and the possible impact as we see it, and discuss the important directions of future work. This chapter of the thesis explains the identification of multiple aspects and a framework which depends on these identified aspects has been proposed as a result of this study. This identified framework enhance the efficiency and covers the limitations of old requirement prioritization methods.

The main goal of research was to identify the most important aspects to enhance the requirement prioritization process, the identified aspects will help the stakeholders to do the prioritization efficiently, so that, the quality of the projects can be improved and the probability of the success of projects can be increased. And to provide a framework that can help the stakeholders to perform the requirement prioritization process efficiently.

6.2 Research Design

A systematic literature review has been conducted to identify the maximum number of aspects. A proper review protocol has been developed before conducting the systematic review. The objective of research and how the review will be conducted has

Been defined. Process of research identification, the selection of study, standard of quality assessment, and the data of extraction and synthesis process has been performed according to the defined review protocol During these processes, the relevant primary studies are identified, the quality of each identified primary study is assessed, the data are extracted from the primary studies, and the extracted data are synthesized.

6.3 Identification of aspects

After conducting the systematic literature review with defined protocols, a list of requirement prioritization aspects has been identified, and identified the requirement prioritization process and how quality of software can be enhanced. It has been also explained that how this process contributes towards the success of project. Different available methods for requirement prioritization have been studied.

It is concluded that each of these methods address some specific aspects of requirement prioritization. There is no integration between these methods, as it is already explained in the previous chapters that a software project has number of stakeholders and each stakeholder have their own expectations, therefore with the presence of old requirement prioritization methods the multiple stakeholders cannot be satisfied because each technique address some specific issues or stakeholders.

Therefore, a need of a new technique has been identified from the literature. Which shoes that there is a gap in the literature of requirement prioritization methods and it elaborates the need of a framework which will provide the integrated method to fulfil the expectations of different stakeholders in the project, this proposed framework also decreased the chance of software failure.

6.4 Development of Framework

By conducting a literature review and survey a list of aspects was compiled, after that focus group has been performed for better results, the previous research also showed

that there is a gap in old methods of prioritization. After performing the mixed method of research, it has been verified and validated that the existing methods do not provide an integrated solution for multiple stakeholders. Based on the identified aspects a framework has been proposed which helps the stakeholders to prioritize the requirements based on the multiple aspects.

The proposed framework takes the non-prioritized list of requirements as input and after performing the steps provides a multi aspect prioritized list. By using this framework, the list of requirements can be prioritized efficiently.

6.5 Results Verification and Validation

After performing the systematic literature review a survey has been conducted to filter out the identified aspects. The result of survey verified the aspects for requirement prioritization and from survey it has been verified that there is a need to develop a framework to enhance the software requirement process and to minimize the risks of failure in software project.

After performing the survey and verifying the aspects, a focus group studied has been performed to validate the results came from the survey, a group of 7-8 experts was chosen and a session was performed, focus group was chosen because this method helps to discuss the topics and questions openly, the identified and filtered out list was than verified.

6.6 Research Contribution

The first question of the research was to identify the different aspects of requirement prioritization process and from systematic literature review number of aspects has been identified this identification has contributed towards our framework development. The developed framework has provided the solution to prioritise the requirements by multi

aspects, which provided the solution of the integration of different stakeholder's expectations,

This developed framework will also help in the quality of software as explained in previous chapters that the prioritization process helps to enhance the quality of software and our proposed framework enhances the process of requirement prioritization which helps to enhance the quality of software, If the requirements are not prioritised the chances of software failure increases very much and from the previous reports of software failure it is known that number of software fails because of the requirement prioritization, as our developed framework in the research increases the efficiency in requirement prioritization process thus the chances of failure of software can be decreased.

6.7 Future Work

The identification of multiple aspects opens the door for future work, these aspects can be used to develop new methods to enhance the prioritization process. The proposed framework has also opened the door towards the enhancement of new technique and in future different versions of the framework can be developed and introduced to increase the efficiency of prioritization process. An algorithm and a software can be developed to automate the framework process.

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