

A Hybrid S/W Requirements Elicitation Approach to Improve Quality of Gathered Requirements



By

Inam Ul Haq

(Registration No.: 00000318577)

Supervisor: Dr. Wasi Haider Butt

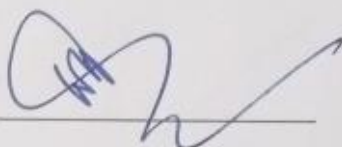
DEPARTMENT OF COMPUTER & SOFTWARE ENGINEERING
COLLEGE OF ELECTRICAL & MECHANICAL ENGINEERING
NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY

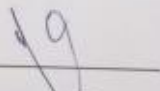
ISLAMABAD

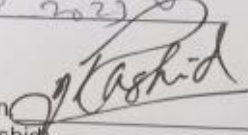
September 2023

THESIS ACCEPTANCE CERTIFICATE

Certified that final copy of MS/MPhil thesis written by NS Inam UI Haq Registration No. 00000318577, of College of E&ME has been vetted by undersigned, found complete in all respects as per NUST Statutes/Regulations, is free of plagiarism, errors and mistakes and is accepted as partial fulfillment for award of MS/MPhil degree. It is further certified that necessary amendments as pointed out by GEC members of the scholar have also been incorporated in the thesis.

Signature: 
Name of Supervisor: Dr Wasi Haider Butt
Date: 21-09-2023

Signature of HOD: 
(Dr Usman Qamar)
Date: 21-09-2023

Signature of Dean: 
(Brig Dr Nasir Rashid)
Date: 21 SEP 2023

Dedicated to my mentor Dr. Wasi Haider and loving Parents,
who equipped me with pearls of knowledge and showed me the
way of spiritual and personal enlightenment in this world and the
world hereafter.

ACKNOWLEDGMENT

All Praise and thanks be to Allah! We praise and thank Him, ask Him for His Help and Forgiveness, and we seek refuge in Allah from the evils of our souls and the mischief of our deeds. He whom Allah guides will not be misled, and he whom Allah misleads will never have a guide. I testify that there is no deity but Allah alone, without any partners, and that Muhammad is His Messenger.

No words can express gratitude and thanks to the blessings, support, and love of parents as parents are the greatest gift from Allah to any Human being, Bundle of gratitude to their support and guidelines by which we are standing here to complete our degree. And to friends and siblings who are always there to support us in this crucial and important step of our life to accomplish it.

We owe a lot of gratitude to our revered to our teachers and specially our supervisor Dr. Wasi Haider Butt with his true support, positive criticism, and guidelines we were able to accomplish the MS thesis, he has become our source of inspiration and light of guidance throughout this project, without whom this was not possible for us to complete.

Finally, I am thankful to all my friends who assisted me in this thesis and throughout the whole research process.

ABSTRACT

The discipline of Requirement Engineering is associated with a great number of problems, starting from the elicitation phase to the implementation of these requirements in the software industry. Although many approaches have been proposed by the researchers, but very small number of approaches are used in software industries. It is known that requirements which are not well understood and unrestricted changes to the scope of requirements lead to numerous software projects failure. So, good requirements are very important for project success. Thesis helps in exploring effective approach for text chat application requirement gathering purpose. The aim of this thesis is to focus on approaches used in software industry for elicitation purpose of text chat application. For this we selected five different approaches of requirement gathering and fixed the number of requirements to eight. We gathered requirements randomly for different people, but we make sure that all of the respondents are familiar with the chat applications. One thing is understood that if the requirements of the system are not best understood then they will lead towards project failure. We gathered requirements by different approaches and checked the requirements with good quality attributes of requirements, the approach that produces high value, considered as the good approach for requirement gathering purpose for text chat applications. Lastly, we merged two approaches and make a single hybrid approach to check the results of requirement obtained with this hybrid approach. These findings need to be demonstrated in the context of this research. We concluded that good results can be achieved by merging the two approaches. In our scenario brainstorming along with interview produces the best results.

Keyword: *Requirement Elicitation Approaches, Stakeholders, Traditional Approaches, Contextual Approaches, Software Requirement, Requirement Engineering, Collaborative Approaches.*

TABLE OF CONTENTS

DEDICATION.....	II
ACKNOWLEDGMENT.....	III
ABSTRACT.....	IV
LIST OF FIGURES.....	VIII
LIST OF TABLES.....	IX
LIST OF ABBREVIATION.....	X
CHAPTER 1: INTRODUCTION.....	1
1.1 Why Software Projects Fails?.....	1
1.2 Right Gadget For Right Task.....	3
1.3 Research Objective.....	3
1.4 Research Design.....	4
1.5 Formation of This Research Thesis.....	4
CHAPTER 2: SOFTWARE REQUIREMENT ENGINEERING.....	5
2.1 Software Requirements.....	6
2.2 Role of Requirements.....	6
2.3 Why Requirements are Important?.....	7
2.3.1 Software Defects and Their Impact.....	9
2.4 Requirement Engineering.....	10
2.5 Requirement Engineering Process.....	10
2.5.1 Requirement Development.....	11
2.5.1.1 Requirement Elicitation.....	12
2.5.1.2 Requirement Analysis.....	13
2.5.1.3 Requirement Specification.....	14
2.5.1.4 Requirement Validation.....	15
2.5.2 Requirement Management.....	16
2.5.2.1 Requirement Management Process.....	16
2.6 Pictorial Depiction of Requirement Engineering Process.....	17
2.7 Benefits of Quality Requirement Engineering Process.....	17
2.8 Root Causes of Project Success and Failure.....	18
2.8.1 Three Largest Problems in Software Industry.....	18

2.8.2 Three Basic Success Factors	18
2.9 Importance of Requirement Engineering.....	18
CHAPTER 3: LITERATURE REVIEW	19
3.1 Planning Review.....	20
3.1.1 Research Questions	20
3.1.2 Data Sources	20
3.1.3 Searching Strings	21
3.1.4 Inclusion Criteria	21
3.1.5 Exclusion Criteria	21
3.1.6 Quality Evaluation	22
3.2 Conducting Review	22
3.2.1 Initial Study Selection.....	22
3.2.2 Data Extraction and Data Synthesis.....	23
3.3 Reporting Review	23
3.3.1 Temporal Distribution of Selected Primary Studies	24
3.3.2 Result and Discussion.....	25
CHAPTER 4: REQUIREMENT ELICITATION & ELICITATION APPROACHES	27
4.1 Classic Elicitation Approaches.....	27
4.1.1 Interviews.....	27
4.1.2 Questionnaire	28
4.1.3 Social Analysis.....	29
4.2 Modern Elicitation Approaches.....	30
4.2.1 Requirement Reuse	30
4.2.2 Brainstorming	31
4.2.3 Reading Based	31
4.2.3 Workshops	32
CHAPTER 5: METHODOLOGY.....	33
5.1 Quantitative Research.....	33
5.2 Qualitative Research.....	33
5.3 Mixed Approach.....	33

5.4 Proposed Methodology	34
CHAPTER 6: ANALYSIS AND RESULTS	36
6.1 Questionnaire Approach	36
6.2 Interview Approach	38
6.3 Workshop Approach.....	40
6.4 Brainstorming Approach	41
6.5 Observational Approach	43
6.6 Proposed Method (Brainstorming + Interviews)	44
CHAPTER 7: CONCLUSION AND FUTURE EXTENSION	47
REFERENCES	49

LIST OF FIGURES

Figure 1: Customers' Needs and Expectations	2
Figure 2: Brief Representation of Requirement Engineering Process	3
Figure 3: Graphical View of Thesis Research	4
Figure 4: Graphical Representation of Software Engineering Goals.....	5
Figure 5: Different Stakeholders in Software Engineering.....	6
Figure 6: Importance of Product Requirements	8
Figure 7: Defect Repairing Cost at Different Stages of SDLC	10
Figure 8: Requirement Engineering Process.....	11
Figure 9: An Example of Requirement Specifications	12
Figure 10: Elicitation & Analysis Process	14
Figure 11: An Example of Requirement Specification	15
Figure 12: An Example of Requirement Validation	16
Figure 13: Requirement Engineering Process Inputs & Outputs	17
Figure 14: Phases of Literature Review	19
Figure 15: Kitchenham Approach Refining Articles	24
Figure 16: Temporal Distribution of Research Articles.....	24
Figure 17: Temporal Distribution According to Year Wise	25
Figure 18: Requirement Reuse Diagram.....	30
Figure 19: Brainstorming	31
Figure 20: Workshop Conducted for Requirement Gathering.....	32
Figure 21: Hybrid Approach of Research	34
Figure 22: Proposed Approach.....	34
Figure 23: Complete Analysis Process	36
Figure 24: Graph Showing Details about Questionnaire Approach.....	38
Figure 25: Graph Showing Details about Interview Approach.....	39
Figure 26: Graph Showing Details about Workshop Approach	41
Figure 27: Graph Showing Details about Brainstorming Approach	42
Figure 28: Graph Showing Details about Observational Approach.....	44
<i>Figure 29: Graph Showing Details about Proposed Approach.....</i>	<i>46</i>
Figure 30: Requirements Vs Quality Characteristics	46
Figure 31: Graph Showing Detailed Comparison of all Approaches.	48

LIST OF TABLES

Table 1: Source Locations of Getting Information	13
Table 2: Data Sources Details	20
Table 3: Searching Strings	21
Table 4: Quality Criteria Details	22
Table 5: Tollgate Approach	22
Table 6: Requirements Description Obtained by Questionnaire Approach.....	36
Table 7: Quality Attributes with Requirements Gathered by Questionnaire Approach	37
Table 8: Requirements Description Obtained by Interview Approach	38
Table 9: Quality Attributes with Requirements Gathered by Interview Approach	39
Table 10: Requirements Description Obtained by Workshop Approach.....	40
Table 11: Quality Attributes with Requirements Gathered by Workshop Approach ...	40
Table 12: Requirements Description Obtained by Brainstorming Approach	41
Table 13: Quality Attributes with Requirements Gathered by Brainstorming Approach	42
Table 14: Requirements Description Obtained by Observation Approach.....	43
Table 15: Quality Attributes with Requirements Gathered by Observational Approach	43
Table 16: Requirements Description Obtained by Proposed Approach	44
Table 17: Quality Attributes with Requirements Gathered by Proposed Approach	45

LIST OF ABBREVIATIONS

SE: Software Engineering.
RE: Requirement Elicitation.
SW: Software.
GIA: Group Interaction Approaches.
IPA: Individual Participation Approaches.
RBA: Reading Based Approaches.
OEA: Other Elicitation Approaches.
SLR: Systematic Literature Review.
SDLC: Software Development Life Cycle.
RMP: Requirement Management Plan.
SRS: Software Requirement Specification.
ER Diagram: Entity Relationship Diagram.
DFDs: Data Flow Diagrams.
FDDs: Functional Decomposition Diagrams.
SH: Software House.
I: Individual.
P: Paper.
CEME: College of Electrical & Mechanical Engineering.
NUST: National University of Science & Technology.

CHAPTER 1: INTRODUCTION

Requirement elicitation is an essential task in the development of any new software product. Many software systems fail or do not work accordingly due to the poor requirement gathering process and practices. Requirement can be considered as a necessity, a demand of user or a consumer need. In the field of software engineering, requirement can be characterized as interpretation of system properties, or you can say (what system should perform). Software application might have very large number of system requirements. So, if we exclude requirement elicitation approaches then it becomes almost impossible to discover customers' needs and system requirements. Requirement elicitation approaches provides a base to the development team for construction of structure of the proposed system by keeping consideration of the stakeholders or customers wish list [1].

1.1 Why Software Projects Fails?

A very large number of software projects fails and if someone is interested in IT field then he will definitely know this thing of software project failure. In 1995, Standish Group reported that the ratio of successful computer software projects was only 16%, ratio of canceled software projects before compilation was 31.1% and 52.7% software projects were challenged (due to cost overrun from the initial estimated cost or budget or also due to content inadequacy). Furthermore, they said that the 222% is the average computer software system that runs late, 189% overrun cost from initial estimated cost and provides only 61% of system defined functionalities. In 2008, Ernst & Young research reported that almost 50% of computer software projects failed due to the reason that they do not fulfil stakeholders needs and anticipations. In the survey report of InfoTech Research Group an IT analyst institution, 50% of software systems redevelop, reason was the controversy of consumer's or stakeholders needs and 70% IT project fails, reason was poor requirements. Another study stated that 80% projects exceed the estimated cost do to wrong set of the project objectives. Failure of software project has become norm in the computer IT industry. Addressing some essential and vital rationales of software projects failure is basically an effective and efficient starting point. In 2005, Robert N. Charette stated that one reason for project failure is basically poorly defined project requirements. It looks that large number of delivered computer

software's do not fulfil or completely fulfil end users or stakeholders needs and expectations.

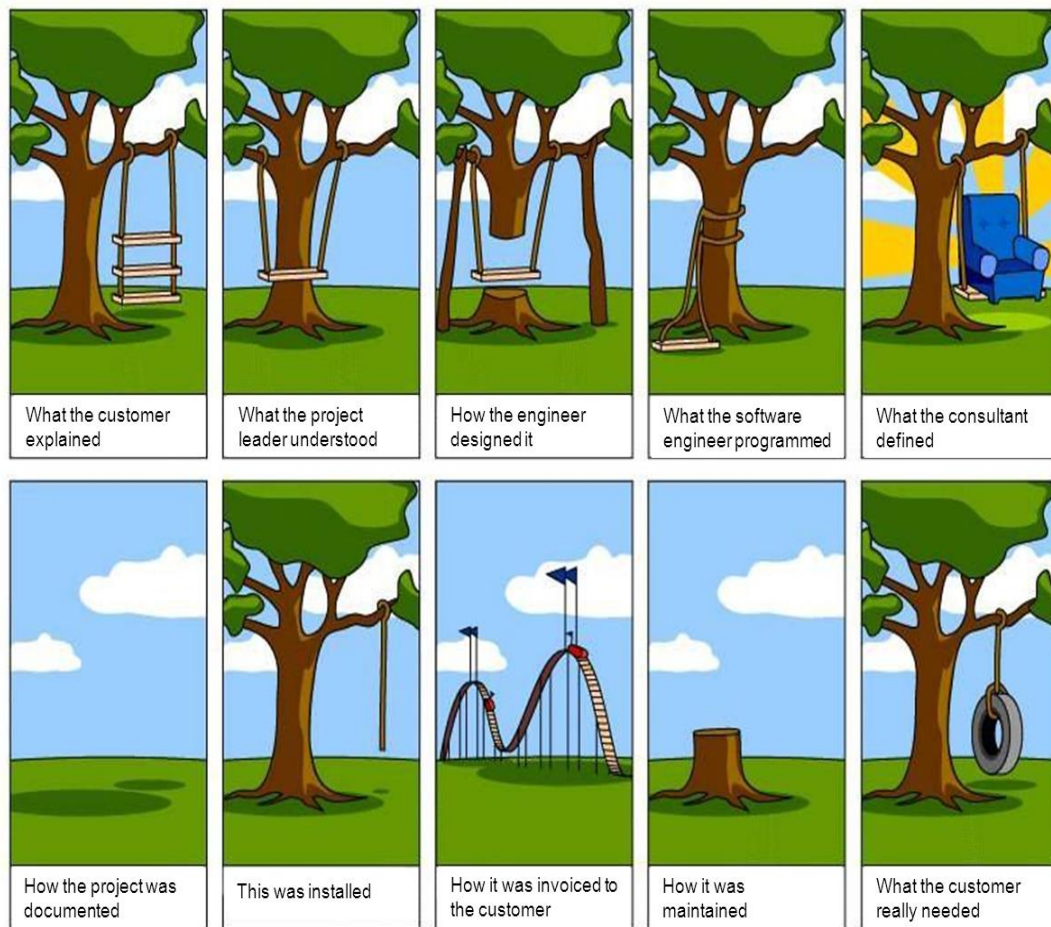


Figure 1: Customers' Needs and Expectations

In 2000, Nuseibeh and Easterbrook stated that system requirements that are defined improperly or poorly are due to the inadequate and incompetent collection process of system requirements. Requirement gathering is a stage of requirement engineering process [2]. In 2002, according to Jeffery, Martin, Paech and Aurum: process of requirement engineering is illustrated as linear incremental approach and elicitation of requirement is first stage of this process. Figure 2 shows brief representation of this process. The process of requirement collection for software system from customers, end users or stakeholders is known as requirement elicitation. More often during practice requirement elicitation process is not linear as shown in the figure 2. Mainly, in the validation stage a reverse loop to the elicitation stage and analysis stage present (in other stages as well). While in practicing, sometimes you will observe that some of these stages being fully omitted. In most of the cases analysis stage and specification stage are not executed.

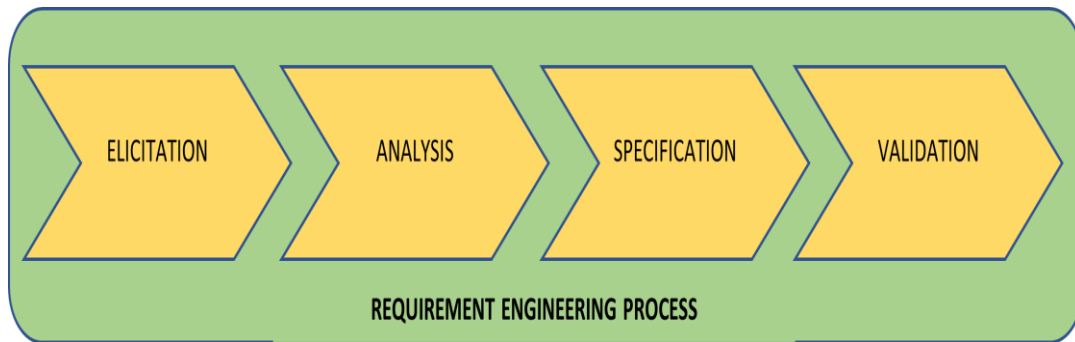


Figure 2: Brief Representation of Requirement Engineering Process

1.2 Right Gadget For Right Task

It is mentioned earlier, there are probably several rationales for the failure of software developing projects. In section above, we discussed the one rationale that is poorly defined computer software project requirements, and this is due to inefficient and improper gathering of project requirements. Focus of this thesis is on different requirement elicitation approaches that are being used for requirements gathering or text chat application.

A number of distinct elicitation approaches exists. Every approach has its own advantages and flaws. An adequate approach used for elicitation of requirements will produce or execute a complete and comprehensive bunch of system requirements. This thing will produce better consistency among delivered computer software and stakeholders or end user's expectations. As, inconsistency among end user's needs and delivered computer software systems is a cause of project failure.

1.3 Research Objective

For successful accomplishment of computer software projects adequate elicitation of the project requirements is very essential [3]. Good knowledge of elicitation and aspects or components that are important in selection of elicitation approaches plays an important role in software development process and also improves elicitation process quality. Furthermore, this results in an increase in success rate of software projects. Aim of research is to propose a hybrid approach for requirement elicitation for text chat application that helps in gathering quality requirements by meeting quality characteristics of good requirements.

1.4 Research Design

A proper research procedure is used for the execution or fulfillment of thesis research in a well methodical and organized way. Main stages of this research:

1. Research starts with definition of problem that needs a solution.
2. In next step this research problem will be translated to the research objective.
3. Design research questions depending on the definition of problem.
4. Analyze data (collected by survey) and then answer the defined questions.
5. Draw out your conclusion and develop your suggestions depending on your results or answer found.

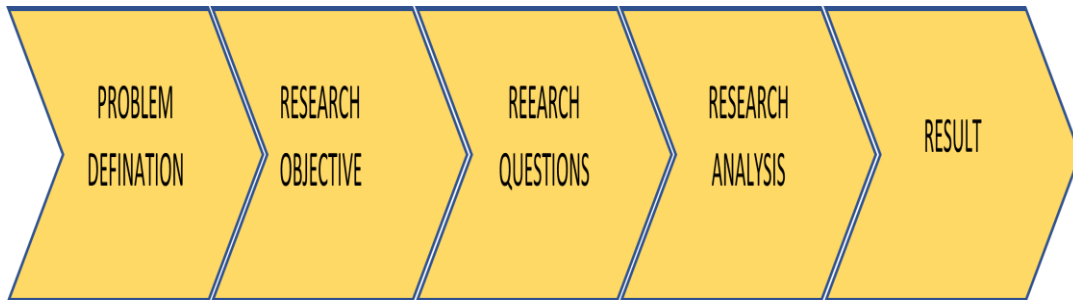


Figure 3: Graphical View of Thesis Research

1.5 Formation of This Research Thesis

Rest formation of this research thesis is as follows:

Section 2.

Section 3.

Section 4.

Section 5.

Section 6.

Section 7.

CHAPTER 2: SOFTWARE REQUIREMENT ENGINEERING

Software engineering is an organized technique for the development of quality software [4]. The goal of software engineering is to build up superb, outstanding quality software's within specified time interval and also within estimated cost that fulfills consumer's necessities. Figure 4 shows goals of software engineering.

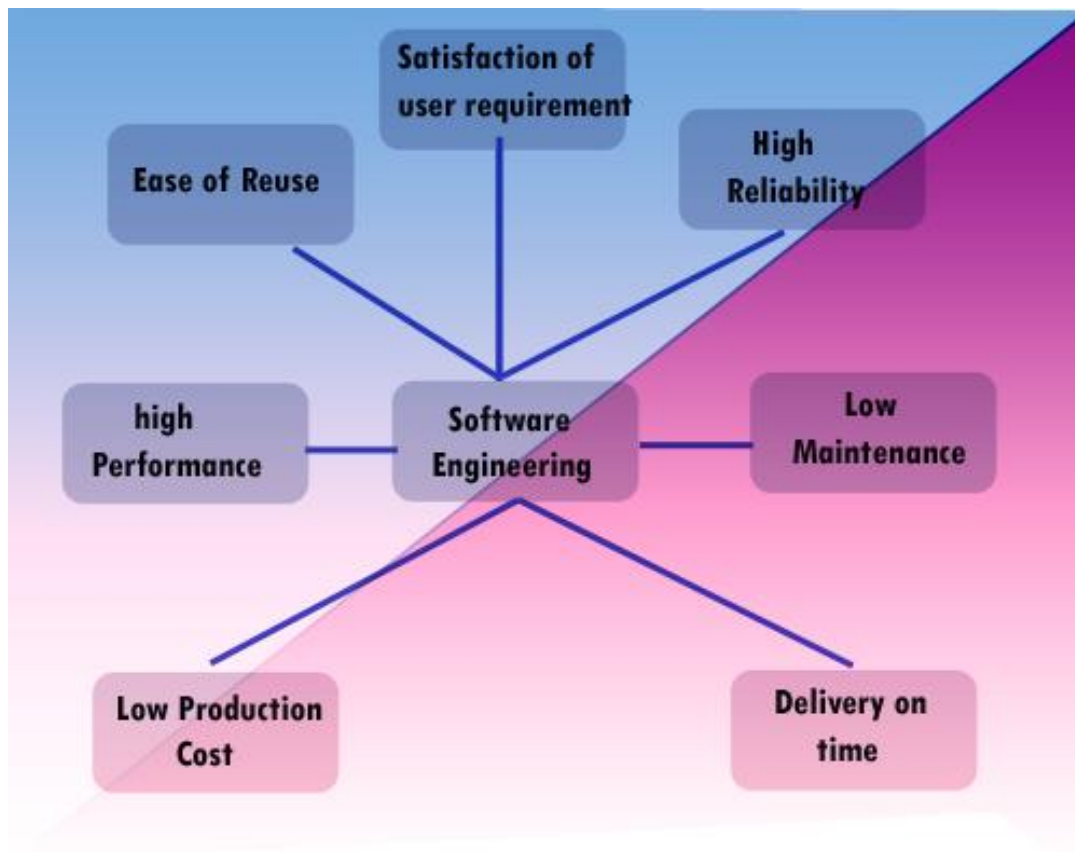


Figure 4: Graphical Representation of Software Engineering Goals

A software is acceptable and said to be good or of quality software only in a condition if it fulfills customers' needs and expectations. Several stakeholders take part in the process of development of software and also in this field [5]. Figure 5 shows stakeholders involved in the software engineering field.

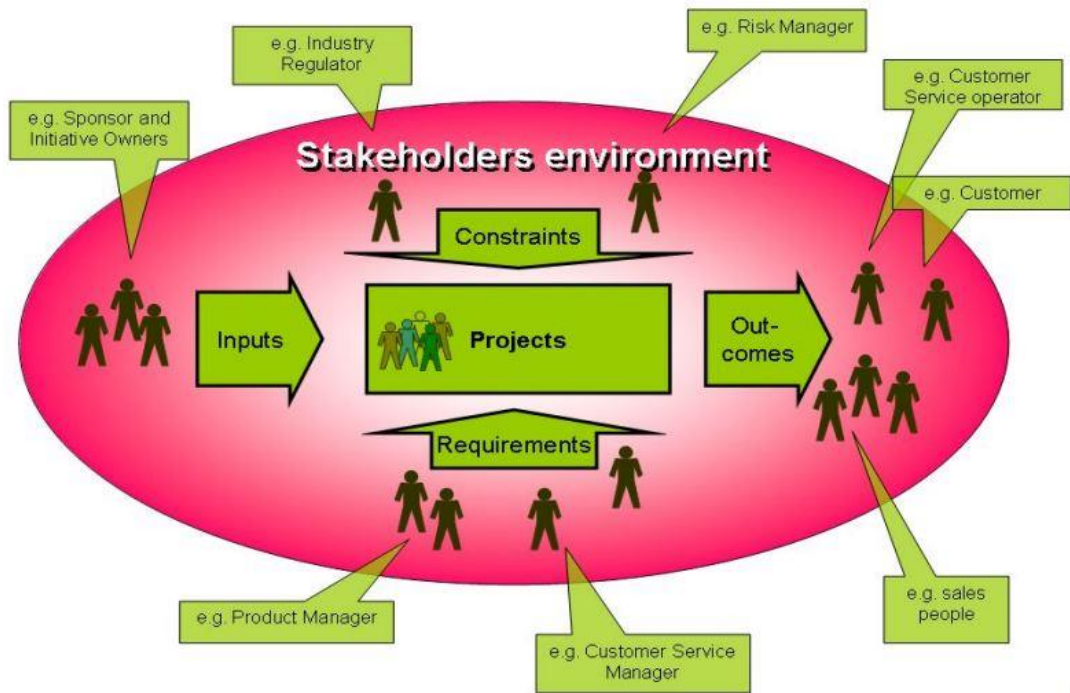


Figure 5: Different Stakeholders in Software Engineering

2.1 Software Requirements

According to 1990s software engineering accents by Institute of Electrical and Electronics Engineers:

1. “Requirements are capabilities or constraints required by consumers in order to resolve an issue or attain any objective.”
2. “Requirement is a capability or a constraint that have to be fulfilled or acquired by system module/element in order to fulfill an agreement, quality instructions or other conventionally prescribed document [6].”

In 1997, according to Sommerville and Sawyer:

1. “Requirements are statements or descriptions of what must be executed. Requirements are explanations of system behavior, or system aspects. Requirements might be restrictions on evolution or buildup process of system.”

2.2 Role of Requirements

The collection of requirements represents an agreement among clients and software development team [7]. Basically, requirement document is the channel that is used

for communicating system requirements to the professional or technical team, who is responsible for the development of the software system [8]. Requirement documents are used acquire design phase of software and also it acts as a support for test planning. Lastly, requirement document helps in project planning (in schedule estimation and in the estimation of cost etc.).

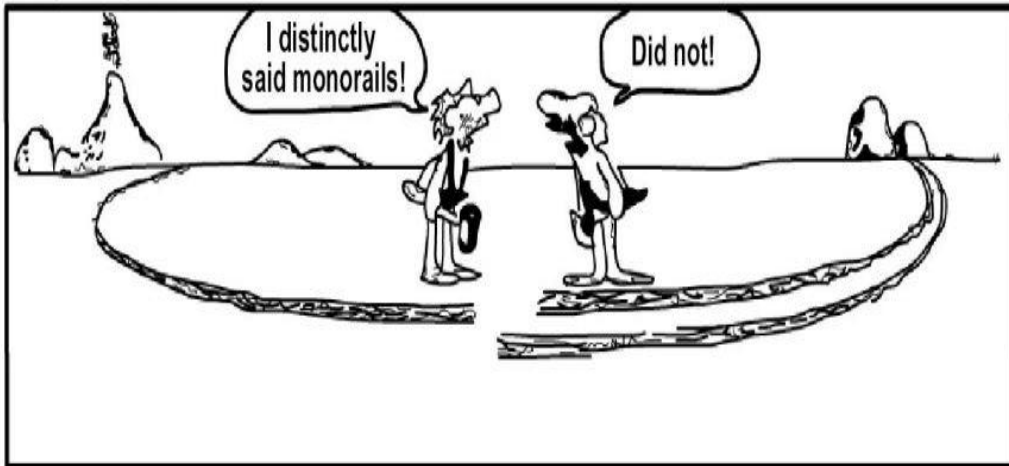
2.3 Why Requirements are Important?

Requirements constitutes contract among stakeholders and the requirement team on system functionalities. So, by neglecting description of software system functionalities (what functionalities will be needed) and details about (how these functionalities will work), customers of system will not be able to decide whether software system will fulfill their requirements or not.

Basically, software requirement provides a base for software product vision, product schedule, product scope, cost of system and especially it targets performance and quality of the finished product [9, 10]. Product requirements determines stakeholders uniform vision and their goals. It is not necessary to document the requirements of system in extremely detailed manner (detail document), but requirements should endure in some form. Requirements or documented requirements are basically record that makes sure that all the stakeholders are on the same point. If requirements would be done and documented properly then all stakeholders will comprehend and influence rational or practical suppositions for final product. Final product will be as needed with no surprises and this yield to successful software product lunch. Lack of project expert, scope creep, and lack of communication to stakeholders in a project are some of the reasons why projects fail [11]. These all devotes to project failure. If requirements are not communicated properly, then project will be developed in such a way that it will not fulfill needs and expectations of stakeholders. This leads to project failure.

“I don't have time for requirements”

B.C. by Johnny Hart



.....But somehow there is always time to fix it later

Figure 6: Importance of Product Requirements

Following are the some of the reasons why requirements are important:

- Without good quality requirements do not recognize what to test.
- Developers do not recognize what to consider.
- Good requirement definitions allows better judgement about final product.
- Customers do not recognize what to look for or expect.
- Product developed with quality requirements will contain less errors with cleaner design.
- Good requirements definitions expose hidden and supposed requirements [12].
- Ambiguous requirements lead to project failure.
- Identification of important requirements from beginning of project is be crucial.
- Accurately describe product deliverables and construct only required operations or functionalities.

- reduce technical issues and risks before product release.
- Reduce rework.
- Reduce cost.

2.3.1 Software Defects and Their Impact

Several studies shows that errors of the requirements are very expensive. Finding and fixing requirement defects earlier in a project is common wisdom. Requirement defects are irritating. Software defects are basically discrepancy between produced output and expected output [13].

Basically, software defects occur due to:

- Absence of clear and concise requirements information about software.
- Communication gaps between stakeholders, requirement team and developers.
- Divergence from product requirements.
- Absence of testing the code.
- Software design and logic defects.
- Inappropriate documentation.

Figure 7 shows relative cost of repairing defects at different stages of software development life cycle (SDLC). It shows that if the cost of repairing a defect at coding stage is 1. Then cost of repairing the same defect at maintenance stage is 20 times higher than the cost of repairing it at coding stage.

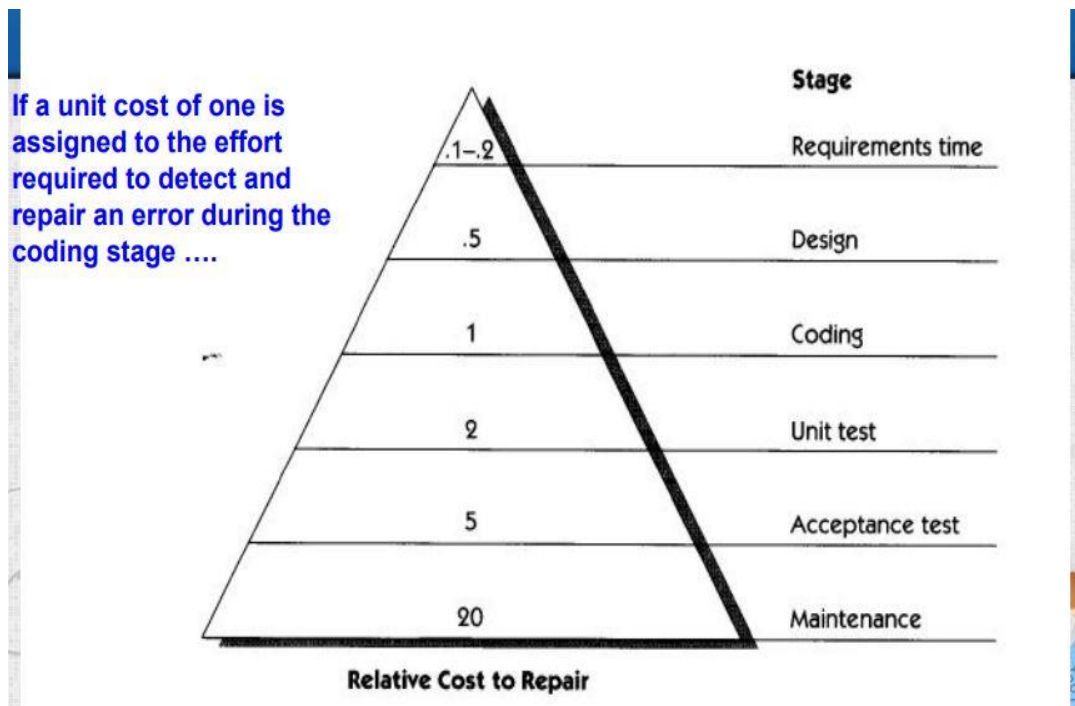


Figure 7: Defect Repairing Cost at Different Stages of SDLC

2.4 Requirement Engineering

It is a branch of software engineering which deals with software requirement process [14]. Basically, it is a process defining requirements of the system, maintaining them and documenting those requirements in engineering design phase or process. RE gives proper suitable procedure to recognize stakeholder's desires, analyze the needs, evaluating feasibility, arranging rational or sensible solutions, describing outcomes properly, perform validation of specifications and perform arrangement of the requirements as they can be converted in to the working software systems. So, requirement engineering is castigating application of demonstrated procedures, symbols, principles, and tools to explain recommended system intensive behavior and related limitations.

2.5 Requirement Engineering Process

Requirement engineering process includes some stages that must be fulfilled for collecting the specification of software system. Development of software is act of developing software product that resolved user's issues, or fulfill user necessities, whenever it is used by the consumer. Activities of the requirements are carried out apparently at the starting of development process. Anyhow, act of requirements

gathering should be carried out regularly due to unavoidable offensive or aggression of repeatedly changing user needs [15]. Figure 8 shows requirement engineering process. Requirement engineering is basically divided into two broad categories:

- Requirement Development.
- Requirement Management.

Requirement development is further subdivided into four activities that involves:

- Requirement Elicitation.
- Requirement Analysis.
- Requirement Specification.
- Requirement Validation.

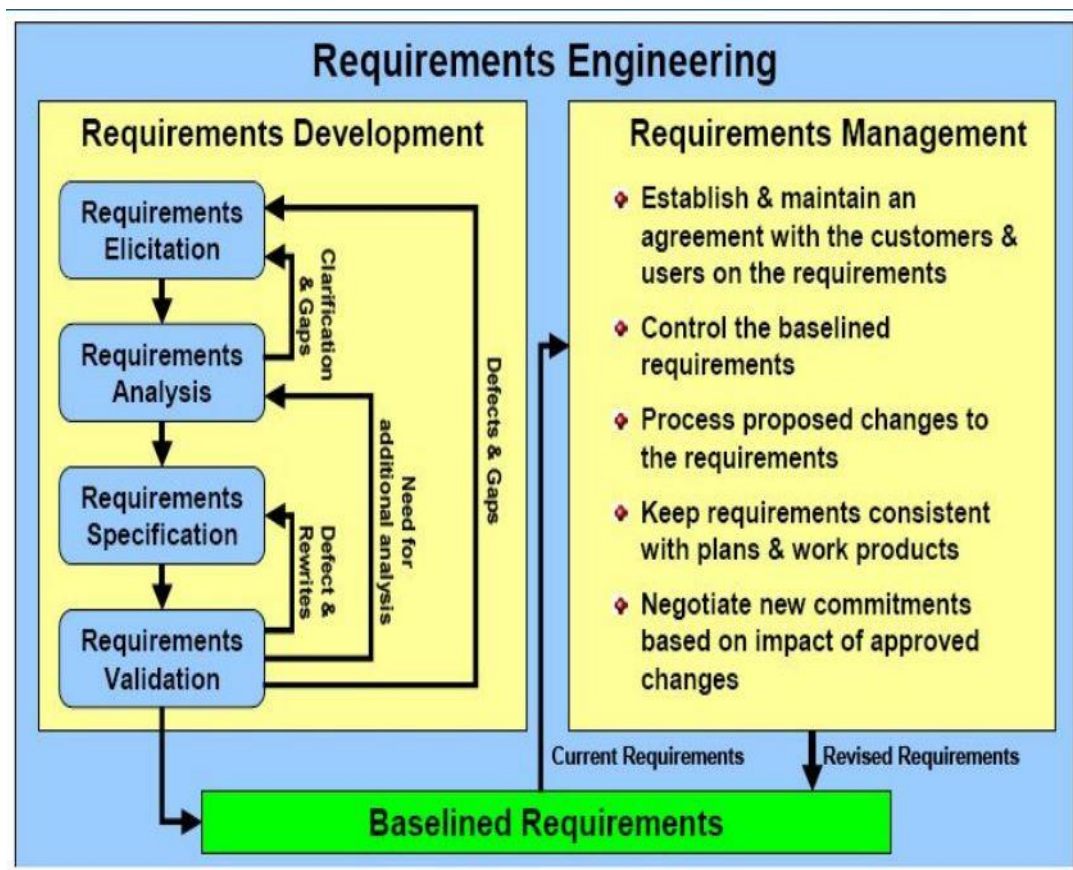


Figure 8: Requirement Engineering Process

2.5.1 Requirement Development

Requirement development involves all the tasks and endeavor related to discovering, documenting, evaluating, validating and recording the needs of user or requirements

of software system or a particular project [16, 1]. Enterprise architect has a large number of tools and attributes which helps the requirement engineers or analysts in discovering, analyzing, specifying, and validating the requirements. The essence of development of requirements is basically specification manager, who allows the analyst or requirement engineer for entering, viewing and managing system requirements in the documented form in the pattern of spreadsheets.

Item	Priority	Status	Difficulty
1 REQ019 - Manage Inventory	Medium	Approved	Medium
The system MUST include a complete inventory management facility to store and track stock of books for the on-line bookstore.			
1.1 REQ122 - Inventory Reports	Medium	Proposed	Medium
Inventory reports are required that detail the available stock for each item including back orders. Future stock level reports should be able to predict the quantity of stock at a specified future date.			
1.2 REQ023 - Store and Manage Books	Low	Mandatory	
A book storage and management facility will be required.			
1.2.1 REQ022 - Order Books	Medium	Implemented	Medium
A book order facility will be required to allow on-line ordering from major stockist's.			
1.2.2 REQ021 - List Stock Levels	Medium	Approved	Medium
A facility will exist to list current stock levels and to manually update stock quantities if physical checking reveals inconsistencies.			

Figure 9: An Example of Requirement Specifications

2.5.1.1 Requirement Elicitation

Elicitation is method of gathering requirements or finding data. This data will basically be in the raw form and also in heterogenous data form. This data can not be considered as actual requirements of the system before analysis phase. Actual requirements came from after analyzing this raw data [17]. Identification of system requirements can be done from customers or from the existing system functions, in case of availability existing system availability. Elicitation can be done in many different ways and requires all the efforts of requirement engineer or analyst for determining which methods, documents and tool is needed for discovering the data about system requirements. Below tables shows some of the information sources:

Table 1: Source Locations of Getting Information

Observing User	Observing workers in their workplace or working environment by doing work is an effective mean of gathering data about requirement and this method also uncover details that cannot be gathered by interviewing users [18].
System Issues	Documented data related to errors, system issues and faults within the present system will give base for system requirements for replacement system.
Business Document	Several business documents like business case, business vision document or document of the operations concept will be used as a means of gathering business requirements.
Stakeholders Workshop	Getting important stakeholders in workshop is productive method for getting information about requirements. Fruitful and powerful conversation provides base for extracting requirements [16, 19].

2.5.1.2 Requirement Analysis

Requirement analysis begins with elicitation of requirements. Requirement analysis stage confirms that gathered requirements in elicitation stage have been stated accordingly and are in correct form or pattern. Basically, requirements of project are analyzed in order to find omissions, instability and defects etc. [20]. Requirements are analyzed to resolve conflicts as well.

Some elicitation & analysis issues are given below:

- Conflicting requirements of different stakeholders.
- Requirement inconsistency during analysis.
- Stakeholders do not know about their needs.
- Stakeholders articulate requirements in the way they understand.
- Language & terminology differences between stakeholders and requirement team.

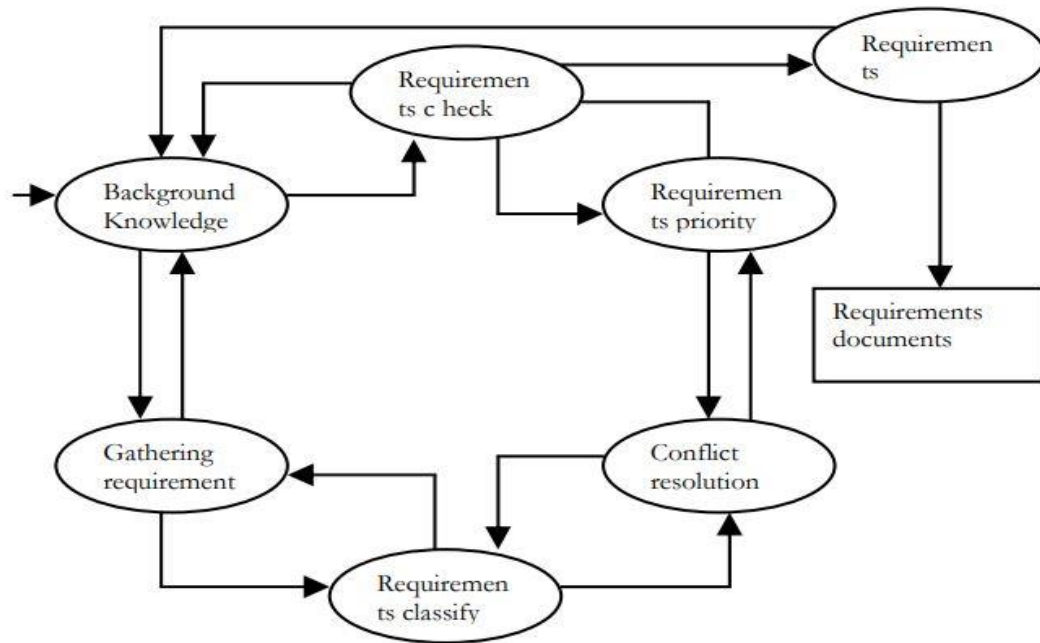


Figure 10: Elicitation & Analysis Process

2.5.1.3 Requirement Specification

Software Requirement Specification (SRS) is a document that is designed after requirement gathering by the requirement engineer or analyst from different sources [21]. Structuring customers input and requirements into written document and also in diagrams is known as specification of requirements [21, 22]. Analyst received requirements from customers or stakeholders in simple ordinary language form. So, it's the duty of requirement analyst to rewrite requirements in the technical form so that requirements can be understandable by development team. Assuring consistency and high quality of requirements is crucial for project success.

Models used in specification stage of requirement engineering process includes functional decomposition diagram, data dictionaries, data flow diagrams and entity relationship diagrams.

ER Diagram: It is logical representation of data for company. It has three main objects; one is entities, second is relationship and third one is associations.

DFD Diagram: This diagram is used to show data flow of system.

Data Dictionaries: These are repositories for storing information & data about data objects that are defined in the data flow diagrams (DFD). Figure 11 shows an example of requirement specification.

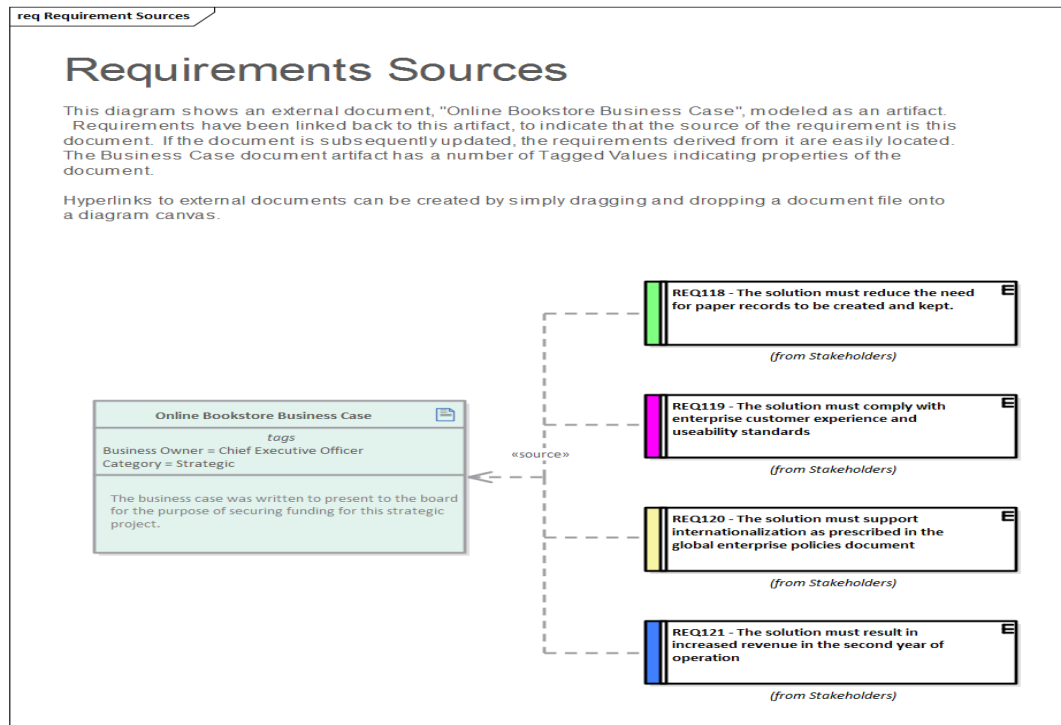


Figure 11: An Example of Requirement Specification

2.5.1.4 Requirement Validation

In this phase, all those requirements that are discussed in requirement specification phase are validated. Validation is important in order to confirm that requirements properly define customer's needs and demands, they are of good quality and are enough for development team for designing and implementing the product [23]. Furthermore, you will confirm from stakeholders or users that all that you have written and understand is absolute, thorough, and accurate. You will also check that user needs are legal, and their solution is possible. Some of the validation techniques are listed below:

- **Prototyping.**
- **Consistency Analysis.**
- **Requirement Inspection.**
- **Testcase Generation.**

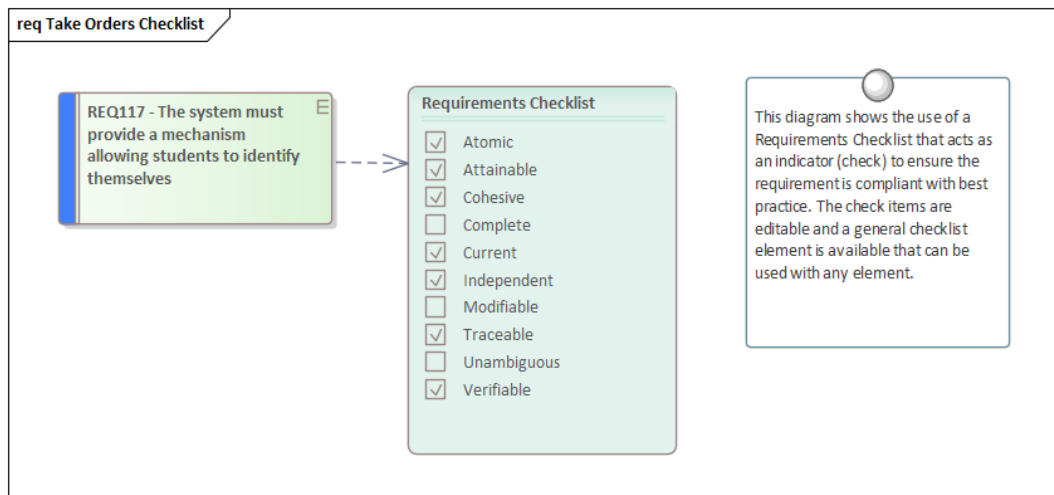


Figure 12: An Example of Requirement Validation

2.5.2 Requirement Management

The aim of managing requirements is to confirm software project development objectives met properly as stated [24]. Basically, requirement managements is a set of approaches to document, analyze, prioritize and to agree on requirements in order to have contemporary and endorse set of requirements or approved set of requirements [25]. This would mitigate errors and issues by keeping path of changes in needs and bring up communications with the customers from starting of software project till development lifecycle.

2.5.2.1 Requirement Management Process

A classic or normal requirement engineering process integrates V model [26].

- Collection of initial requirements and basic information about project from the stakeholders.
- Analyze the requirements that are collected initially.
- Define and document these system requirements.
- Assign some priority to these requirements based on their importance.
- Approve requirements.
- Trace these approved requirements to work objects or items.
- Query customers after execution of required changes in requirements.
- Make use of test management in order to confirm and approve requirements.
- Evaluate effects of changes.
- Amend requirements.

- Document new changes.

2.6 Pictorial Depiction of Requirement Engineering Process

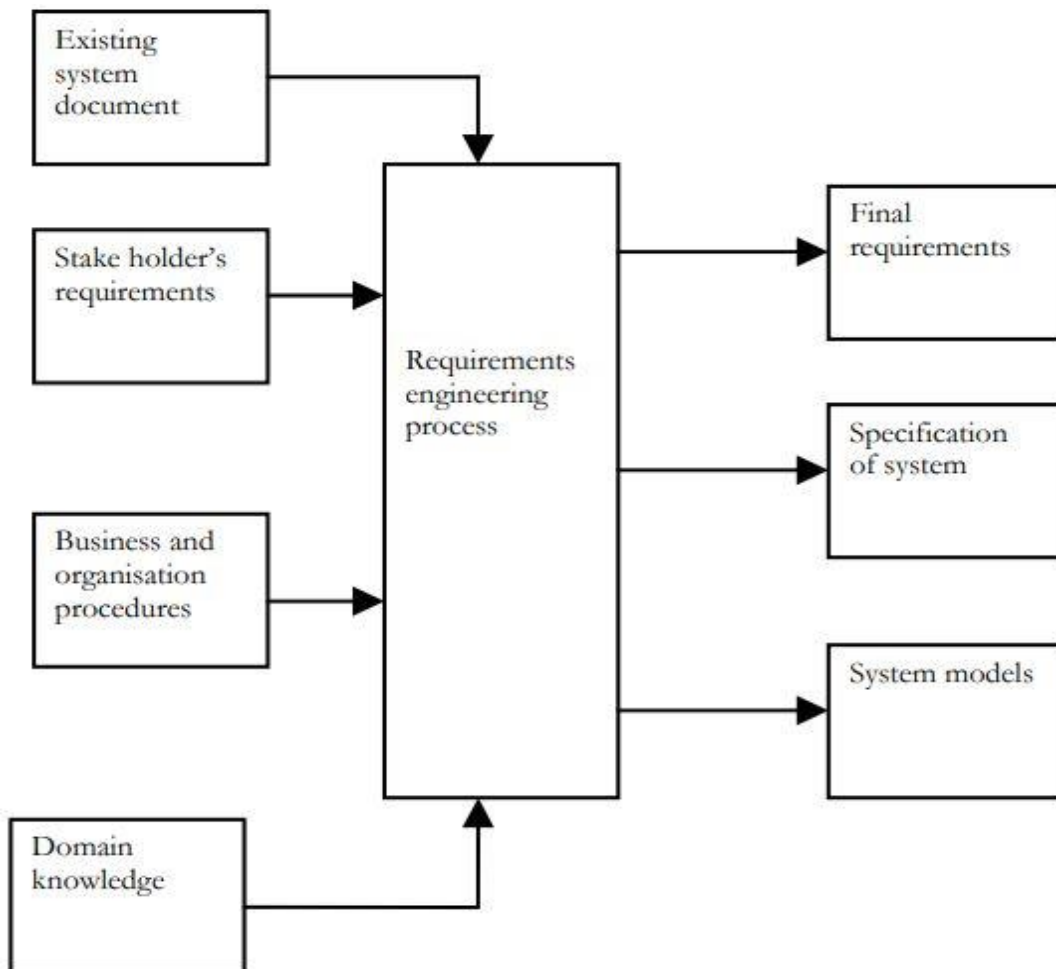


Figure 13: Requirement Engineering Process Inputs & Outputs

2.7 Benefits of Quality Requirement Engineering Process

If requirement engineering process can be done accurately then it will benefit the implementation team in many ways. Some of them are listed below, if done properly then this will:

- Expose unknown & assumed needs.
- Defines project functionalities & deliverables clearly.
- Have less defects and has a clear design.
- Minimize project rework.
- Reduce technical issues before product delivery [27].
- Reduce cost of project.

2.8 Root Causes of Project Success and Failure

According to Standish Group root causes of project success and project failure are listed below.

2.8.1 Three Largest Problems in Software Industry

- Limited user input about their needs.
- Incomplete software requirements specification about project.
- Unrestricted requirement changes in requirement specifications.

2.8.2 Three Basic Success Factors

- User involvement.
- Support of the executive management.
- Clear & confined requirement specifications.

2.9 Importance of Requirement Engineering

The vigorous chunk of developing a software product is determining what to develop. By appropriate requirement engineering, we can identify what system is supposed to do, we can retain path or follow current status of software project requirement and discover the effect of requirement changes. If the requirement engineering is done properly, it will give a better chance to reduce software project cost and also improves software system quality. If this part is done poorly, it leads towards software project failure and customers dissatisfaction [28].

CHAPTER 3: LITERATURE REVIEW

Systematic Literature Review refers to the systematized method of exploring literature for specific problem. It basically accumulates and essentially analyze numerous research papers by using a structured approach. In this SLR, we conducted a pilot study and identified that several distinct approaches exist for the process of requirement elicitation purpose in the domain of mobile application. It's important to produce a description of some of the basic ideas discussed in our SLR before starting our literature review research for ensuring its effectiveness. The basic concept used to discuss in this research is defined below:

- I. Requirement Elicitation Approaches used in the development of the mobile application (like chat applications).

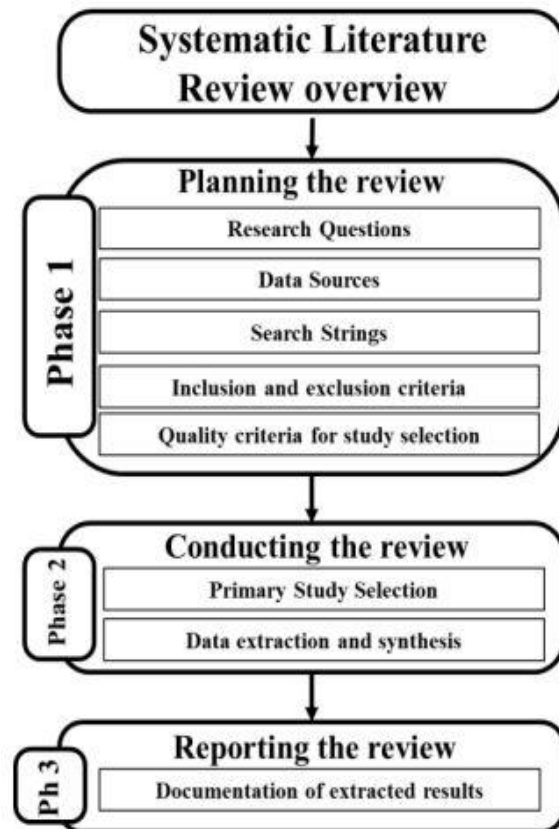


Figure 14: Phases of Literature Review

NASA stated in their research that managing requirements is an essential and important factor of project success and if not done properly then project may face difficulties in its completion. The very first stage of any software project starts with elicitation of requirements. In the development of mobile applications, the requirement elicitation process assists the development team in getting complete understanding of the required system and its users. Objective of requirement elicitation process is to gather as many needs of the user as possible. User needs are the constraints and demands that the stakeholders want in the target new system. SLR consists of the following phases as shown in the figure. Phases 1 involves planning the review, phase 2 involves conducting the review and phase 3 involves reporting the review.

Some requirement elicitation approaches are listed in below chapter:

3.1 Planning Review

Depending upon our goals we suppose some questions that need to be addressed in this SLR. Answer to these questions will assist us in proposing our findings or outcomes. For answering the questions, first we will select some data repositories for downloading or reading the relevant work. After selecting repositories, searching words needs to be define. Reason is to get most appropriate related work from repositories. After this including and excluding criteria's need to be defined. After all, the final research papers should pass through QAS that is quality assessment criteria for getting high quality researches and using those in our research.

3.1.1 Research Questions

In our research aim is to explore the suitable requirement elicitation approaches used for chat applications or mobile applications. For this we design some research questions that are relevant to objective of our study.

RQ1: What approaches are used for requirement elicitation purpose in developing chat applications?

RQ2: Which approaches improve effectiveness of elicitation methods during chat application development?

3.1.2 Data Sources

SLR process needs searching multiple electronic multiple data sources. For this, details about resources from where we collected data and research papers are listed below:

Table 2: Data Sources Details

Data Sources	Google Scholar	https://scholar.google.com/
	IEEE Xplore	https://ieeexplore.ieee.org/
	Science Direct	https://www.sciencedirect.com/

	ACM Digital Library	https://dl.acm.org/
Language	English	
Publication Period	2013-2022	

3.1.3 Searching Strings

From the above research questions following terminologies were extracted. Requirements, Characteristics, Effective, elicitation and approaches. So depending upon the two research questions listed above we construct the search terms.

Table 3: Searching Strings

Keywords	Alternatives
Elicitation	“Obtaining” or “Gathering” or “Extracting”.
Requirements	“Needs” or “Necessities” or “Demands”.
Techniques	“Approaches” or “Methods”.

3.1.4 Inclusion Criteria

A suitable criterion has been constructed before adding research papers to this study.

- ❖ Include only those papers that must be published in any conference, book or journal.
- ❖ Paper published between the duration from 2013 to 2021.
- ❖ Papers published language must be English.
- ❖ Paper discussing requirement elicitation approaches in requirement engineering.

3.1.5 Exclusion Criteria

Since pivot is elicitation approaches and their effectivity so the exclusion criteria for that is listed below:

- ❖ Slide Presentations were not included.
- ❖ Personal opinions.
- ❖ Material out of computer field.

❖ Workshops and point of view.

3.1.6 Quality Evaluation

After the phase of extracting papers literature has been assessed depending on quality criteria. For evaluating selected papers, a checklist of two questions is listed below in table depending upon which study score was assigned.

Table 4: Quality Criteria Details

Quality Score	Criteria of Quality
Was research objective clearly explained?	Yes=1 Moderate=0.5 No=0
Was presented technique appropriately explained?	Yes=1 Moderate=0.5 No=0

3.2 Conducting Review

As the stages of review has multiple phases so detail of sub phases are listed below:

3.2.1 Initial Study Selection

At the initial stage we 550 research articles are extracted from online data sources by using different search words. After refining again and again depending upon inclusion and exclusion criteria we come across at 30 (5.5%) research articles. These 30 articles are considered in our research.

Table 5: Tollgate Approach

Data Sources	Step 1	Step 2	Step 3	Step 4	Step 5	% (T=30)
IEEE Xplore	150	103	45	20	5	16.6%
Google Scholar	250	150	75	28	15	50%
ACM	120	95	30	14	8	26.6%
ScienceDirect	30	20	12	4	2	6.6%

Total	550	368	162	66	30	100%
-------	-----	-----	-----	----	----	------

3.2.2 Data Extraction and Data Synthesis

The Kitchenhem technique has been used to establish the data extraction procedure in order to address the study questions. The tables were created using a spreadsheet. The data that was taken is as follows:

- ❖ Reference labels Referencing Appendix A
- ❖ The publication year
- ❖ Study type (journal conference format)
- ❖ Only requirements elicitation-based methods.

The approach employed, its correctness, model evaluation, and other data mining elements that need to be discussed in publications were all carefully examined. In the study quality table reference, the validity of the study has been examined.

3.3 Reporting Review

This study's main objective was to provide answers to the research queries on requirement elicitation techniques used to compile requirements for mobile applications. Therefore, only the work that discusses inclusion and exclusion criteria as well as software engineering and requirement engineering has been extracted. To address the study issues, papers that used elicitation techniques were further improved. The various elicitation techniques were employed in all 30 of the included articles in this analysis to collect project requirements.

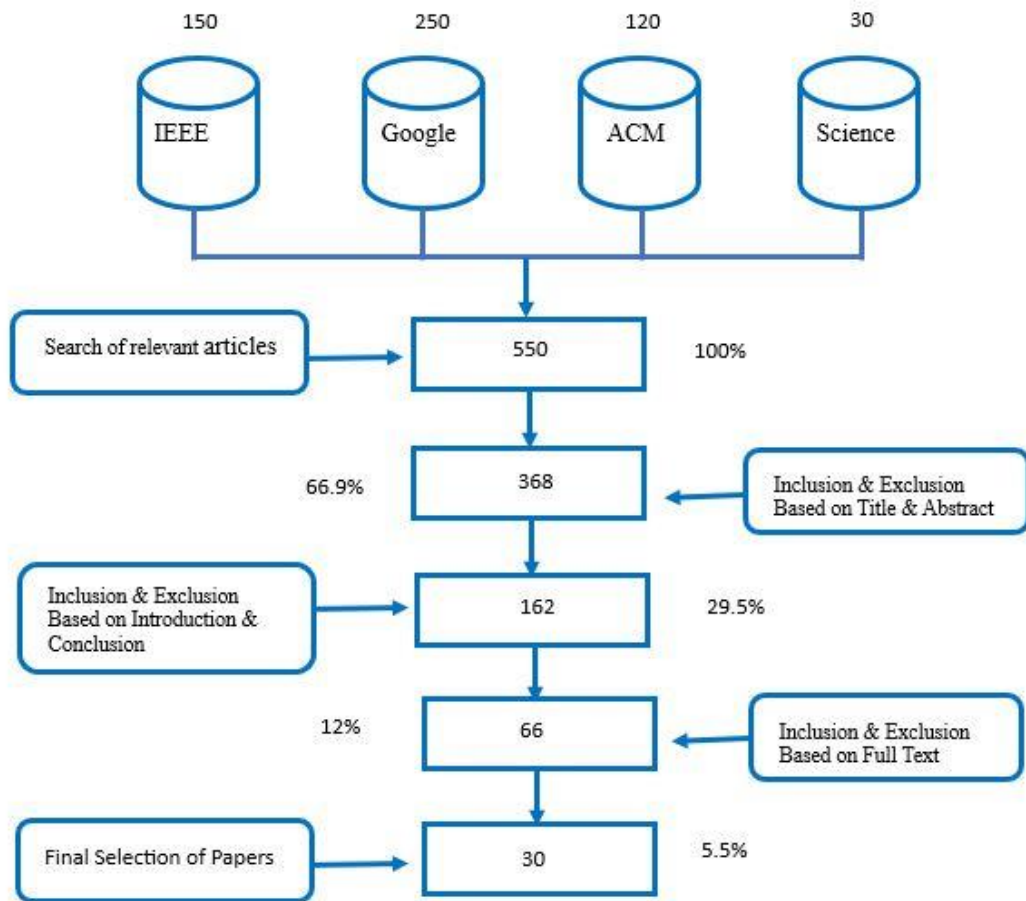


Figure 15: Kitchenham Approach Refining Articles

3.3.1 Temporal Distribution of Selected Primary Studies

All selected papers have been completely separated in two classes, possibly a journal distribution or a conference distribution. After which articles has been separated in view of the year of distribution.

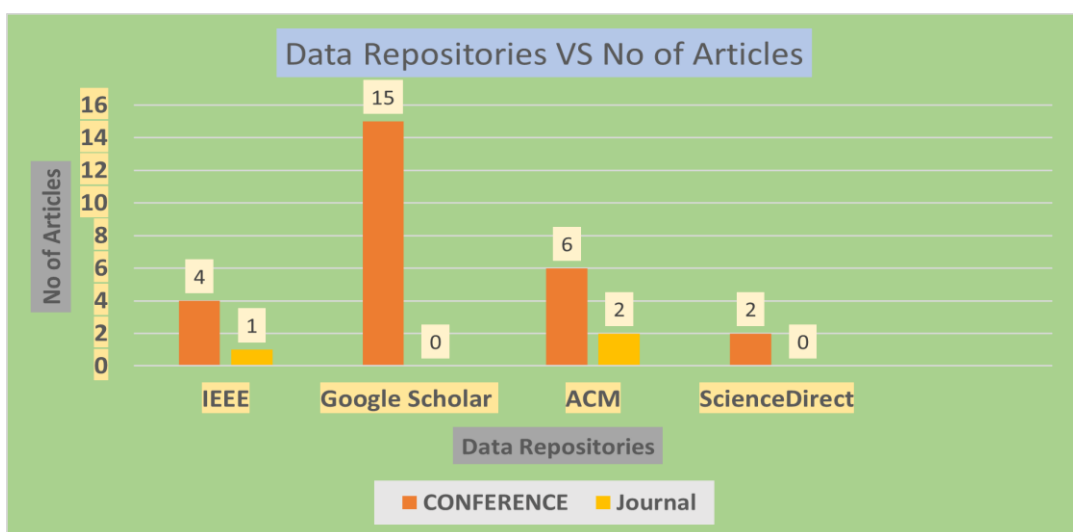


Figure 16: Temporal Distribution of Research Articles

It has been seen that out of 30 articles 27 lies in a category of conference distribution and 3 lies from journal category.

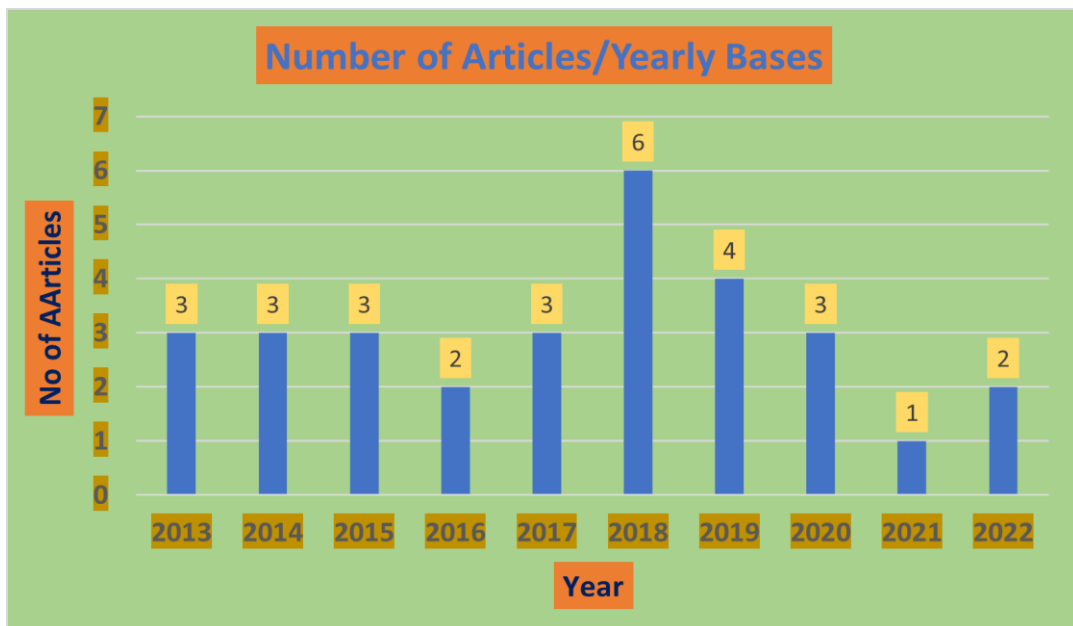


Figure 17: Temporal Distribution According to Year Wise

The greater part of the papers distributed in year 2018 as displayed in graph below.

3.3.2 Result and Discussion

The selected study has been carefully analyzed to extract most used requirement elicitation approaches. As shown in graph interview has been used most of the time in selected 30 studies, 5,4,4,2 times workshop, brainstorming, questionnaires, and observations respectively.

Interviews effectiveness was assessed on question designed in the interviews. Additionally, interviews can be used as vital approach when these are paired with other approaches like questionnaires and brainstorming, then requirements quality will become improved. Workshops were considered useful when they helped stakeholders in productive negotiation and cooperation. For developing scientific applications, JAD/workshops are considered to be more effective and useful as they involve subject matter experts from that particular fields. Questionnaires are more useful in the case of developing general applications and projects where time interval and budget constraints are excessive. Professionals believe and accept that requirements elicitation activities are very important and useful for project success

while individuals with less experience and less knowledge about this process and its importance stuck in project development and this leads to project failure. Furthermore, brainstorming workshops are useful when time interval and budget is limited while interviews approach is suitable where populations of interviewee are limited or in less numbers. Lastly, it is analyzed that hybrid model by using multiple approaches at the same time can be more effective and useful for the collection of project requirements, as it reduces the confusions and misunderstandings among requirement analysts and the stakeholders, and this leads to increase the chances of project success.

CHAPTER 4: REQUIREMENT ELICITATION & ELICITATION APPROACHES

Process of requirement gathering involves group of actions that interconnect with each other in order to construct requirement documentations. Elicitation process lifecycle is presented above in figure 10. Elicitation approaches are practices used for oral and gestural provoke to persuade a particular to give insensitive and baseless response that give understanding an initial personal comprehension of that particular. According to Nuseibeh and Easterbrook selection of elicitation approach rely on available time and resources to analyst or to requirement engineer [2]. It also relies on type of information that requires to be gathered. We differentiate between 7 elicitation approaches.

4.1 Classic Elicitation Approaches

These requirement gathering approaches have been utilized from very long period of time. Mostly, all these approaches are testified and verified approaches. Some of different classic or old requirement gathering approaches are listed below:

4.1.1 Interviews

Interviews are considered to be the most common, most familiar and most frequently used approach for the purpose of eliciting requirements of project [29]. In this approach requirement engineer and requirement analyst talk and deliberate different kinds of project stakeholders for understanding the system requirements, needs of stakeholders, purpose of the system, and the aim they need to accomplish in the project for its success [16, 17]. Typically, interviews are of two types. These two types are discussed below.

- Close Ended Interview.
- Open Ended Interview.

Closed Ended Interview: Within this interview type requirement engineers make few predefined set of questions, ask these questions from different stakeholders and make efforts or endeavor to obtain answers of these quarriers from different stakeholders.

Open Ended Interview: Within this interview type requirement engineers don't make predefined set of questions. Basically, in this type of interviews requirement engineers make efforts to obtain the desired information related to project from different stakeholders with the help of open consultation or discussion. They often try by focusing on discovering stakeholder's assumptions on the project.

In general, interviews begin with predesigned questions [29]. Even so, while doing this process several different substantial activities might appear, and these activities leads to the open conversation. Basically, this process is productive in understanding issues of existing systems and also in finding the common requirements or needs of different stakeholders. Although, it's not an easy task to determine the borderline of suggested system and organizational processes by using this approach. To make interviews more appealing and productive stakeholders or interviewee and analyst or requirement engineer needs to do in this way:

- Interviewer or requirement engineer should be very polite and calm in listening stakeholders or interviewee needs, views and requirements. Interviewer must be open minded.
- Stakeholder and interviewee must be expressive and passionate while providing details in interview. So that the interviewee will deliver his/her views in perfect and clear context.

4.1.2 Questionnaire

This approach of requirement elicitation is less expensive [30]. This approach reaches a very large population in lesser time and less cost. Outcomes elicited by using this approach should be directly investigated. The outcomes gained by using this approach relays on two components.

- Strength, design, and persuasiveness of questionnaire.
- Truthfulness and reliability of the interviewee.

A properly designed and adequate questionnaire can be required for determining the actual consumers needs, aims and constraints [31]. An organized questionnaire guide individuals to respond to answers honestly and truthfully. Thus, this thing makes it possible to elicit authentic outcomes from large population of interviewee. Data

gathered by using questionnaires approach can be utilize for analyzing the outcomes by both means practically and also quantitatively [31]. Questionnaire design is a process with multiple stages and can be judged accordingly.

Stages included in administrating and composing questionnaire approach are [32, 29]:

- Survey objective should be explained.
- Determining sampling population of survey.
- Preparation and development of questionnaire.
- Performing the process of questionnaire survey.
- Elicit and analyze the outcomes of questionnaire.

4.1.3 Social Analysis

Observation is also considered to be as social analysis. In simple words observation approach for eliciting requirements means gathering requirements of information looking and noticing individuals performing their normal activities. This approach is useful for finding the extra requirements required by the consumers, whenever they are not able to articulate their required needs and expectations from new system and issues with previous system.

There are four types of social analysis (observations). They are:

Active Observation: Active observation is performed by direct participation or collaboration of spectator or observer [33]. Existing product or the new dummy product is provided to the peoples to do operations and functions on given product. Observer gives domain understandings to the people or users for doing the work with new provided product and note down the user's requirements by observing the users doing work with new product.

Passive Observation: Passive observation is performed without the direct participation or collaboration of spectator or observer in working environment. Surveillance cameras, videotapes and video cameras are used for recording peoples doing their work for the purpose of observation. These recordings are used for constructing and developing the requirements and documenting the issues and problems.

Explanatory Observations: This is the type of observation in which product users speak loudly, demonstrating about what he/she is doing while performing tasks on product. Analyst or observer gain understanding and make notes from explanation provided by the product users.

Ethnography: In this type of observation, observer fully immersed in a specific organization for observing the interactions of user with the system and behavior or working of the system. Observer basically performs deep observations of organization and users work. This method does not have a specific formula but it is expensive as well time consuming way for gathering requirements [34].

4.2 Modern Elicitation Approaches

There are many kinds of modern requirement gathering approaches. Some of these requirement gathering approaches are listed below:

4.2.1 Requirement Reuse

In software engineering industry, this method for collection of requirements is most used. Having information of the existing product for developing new product benefits in less cost needed for developing the product and less time needed for its completion [35]. In today's era of software field, almost half requirements of new product are obtained from the requirements of existing products. However, new requirements are first checked before using in developing the new product, but reused requirements reduce testing time of requirements as they are previously analyzed and tested.

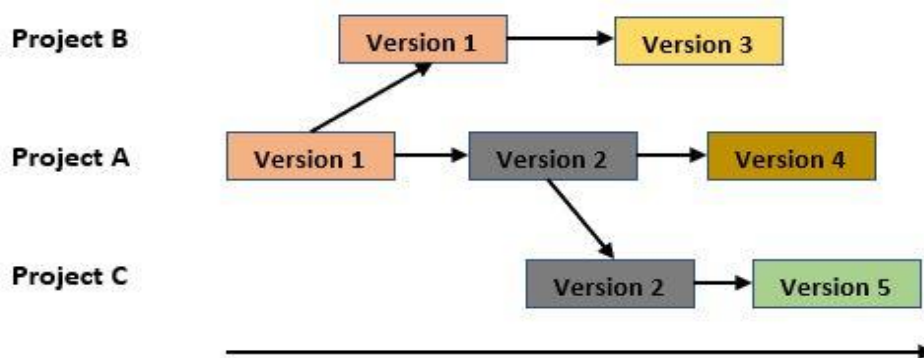


Figure 18: Requirement Reuse Diagram

It's hard to suppose that specific proposed project is fully distinct from previous or existing system, because it's very easy to discover reused requirements from any software requirement specifications of existing project.

4.2.2 Brainstorming

According to *PMBOK® Guide* brainstorming is an approach adopted to initiate and gather numerous ideas associated with product requirements. Brainstorming is basically a group creativity approach which can be used as a very efficient beginning point for gathering the product requirements. This approach is used for the purpose of requirement gathering for getting as numerous ideas as possible from a group of individuals. With the help of a single tool like a whiteboard, anyone can rapidly begin a brainstorming session and all ideas that come in your mind and then note down those ideas. It basically allows individuals to share one another's ideas.



Figure 19: Brainstorming

4.2.3 Reading Based

This method involves gathering requirements by reading and investigating old or existing documents and determining information regarding the requirements. Document analysis includes analyzing existing documents like design documents, business plans, repositories, user manuals, repositories, and also business rules etc. These documents can give a better knowledge and understanding of old system functions and also help in identifying gaps from existing requirements documents.

Reading documents is conducted prior conducting more detailed requirement gathering sessions or meetings with the project stakeholders.

4.2.3 Workshops

Workshops are more suitable in case of complex projects and more suitable where you have multiple stakeholders for gathering requirements. Passionate, concentrated and more fruitful workshops have an important part for achieving all the stakeholders on same common understanding. This method helps stakeholders and experts to resolve conflicts, to cooperate with each other and make an agreement [34].



Figure 20: Workshop Conducted for Requirement Gathering

CHAPTER 5: METHODOLOGY

This section of document provides a general overview of research methodology used in the thesis. It basically refers to systematic way for resolving research issues or a problem by collecting the data with different approaches and then giving analysis of the gathered data and figuring out the conclusion of that gathered and analyzed data [36]. according to Bhojanna and Murthy “it is blueprint of the study or any research”.

5.1 Quantitative Research

In quantitative research method focus is on evaluating the collected and analyzed data. Aim of this method is to establish and use mathematical theories, patterns and hypotheses referring to phenomena [37].

5.2 Qualitative Research

This method is used to create a finalized and detailed interpretation of researcher's observations. Instead of giving temporary clarification and guesses, this method provides viewing things or data in specific context and interpreting gathered data.

5.3 Mixed Approach

It is a modern approach obtained by combining both quantitative and qualitative research approaches [37 38]. This approach basically includes collecting and evaluating data obtained by the means of both quantitative and qualitative approaches in order to get better understanding of the phenomena and to answer the research questions.

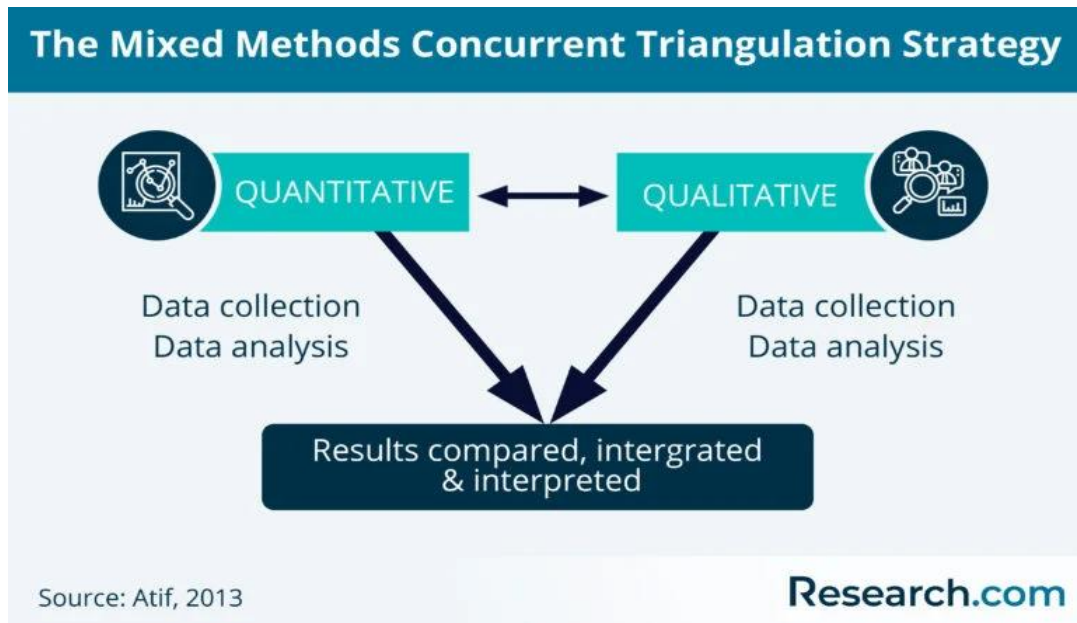


Figure 21: Hybrid Approach of Research

5.4 Proposed Methodology

We have selected the mixed approach for our data. As some of the data gathered is qualitative and other lies in the category of quantitative data.

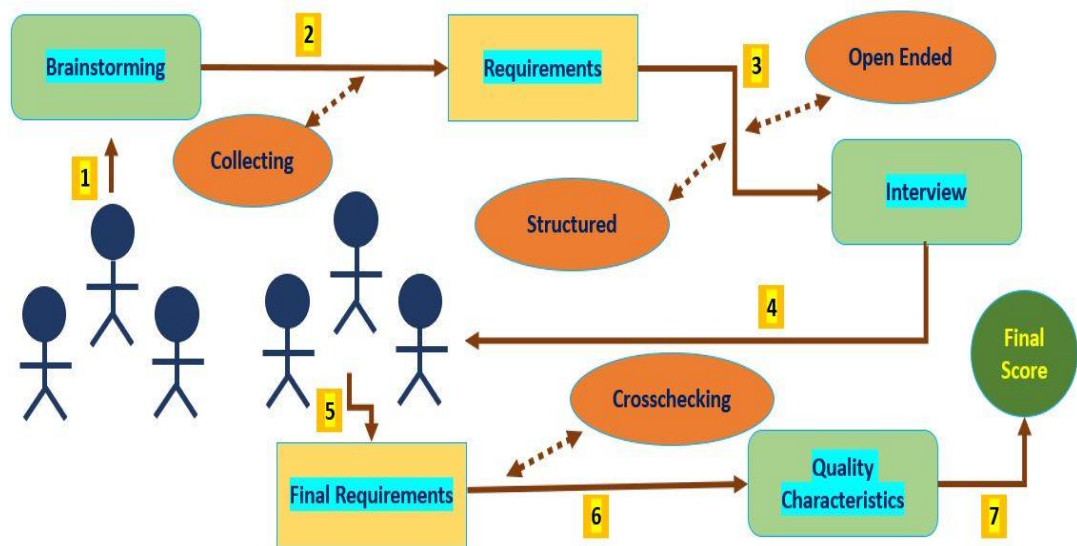


Figure 22: Proposed Approach

We collected requirements for developing a chat application by six different approaches including questionnaire, interview, brainstorming, workshop, observation, and a proposed methodology. We fixed down that number of requirements must not be more than or less than eight. So, requirements are fixed to eight. After collection of requirements, we check these requirements with

characteristics of good quality requirements in order to check which approach has better results or produces good quality requirements. Characteristics of good quality requirements include complete, correct, feasible, necessary, prioritize, unambiguous, realistic, and verifiable. If the requirement collected fulfills a characteristic, we assign value of 1 to that requirement otherwise 0. Finally, we sum up the total value of each requirement and divide it by the number of characteristics for getting the average value and on that value, we suggest which approach produces better results. Later on, we suggested a way in which we merged two approaches brainstorming and interviews and compared the results of this hybrid approach with all other five approaches to know which approach produces better score and quality requirements. We have collected requirements from ordinary people randomly but all of them are familiar with chat applications. We also provided one sample table in which we validate requirements with quality characteristics.

CHAPTER 6: ANALYSIS AND RESULTS

As number of characteristics are eight so each requirement will be checked with all these characteristics and then sum up all the values at the bottom of each column that will be used for calculating the average and later on this average is used for comparison with average of other approaches. Every requirement has an ID like RQ1 (means requirement 1). Graphs showing details are listed below and details about which requirement fulfills which characteristic is shown in the graph of each approach.

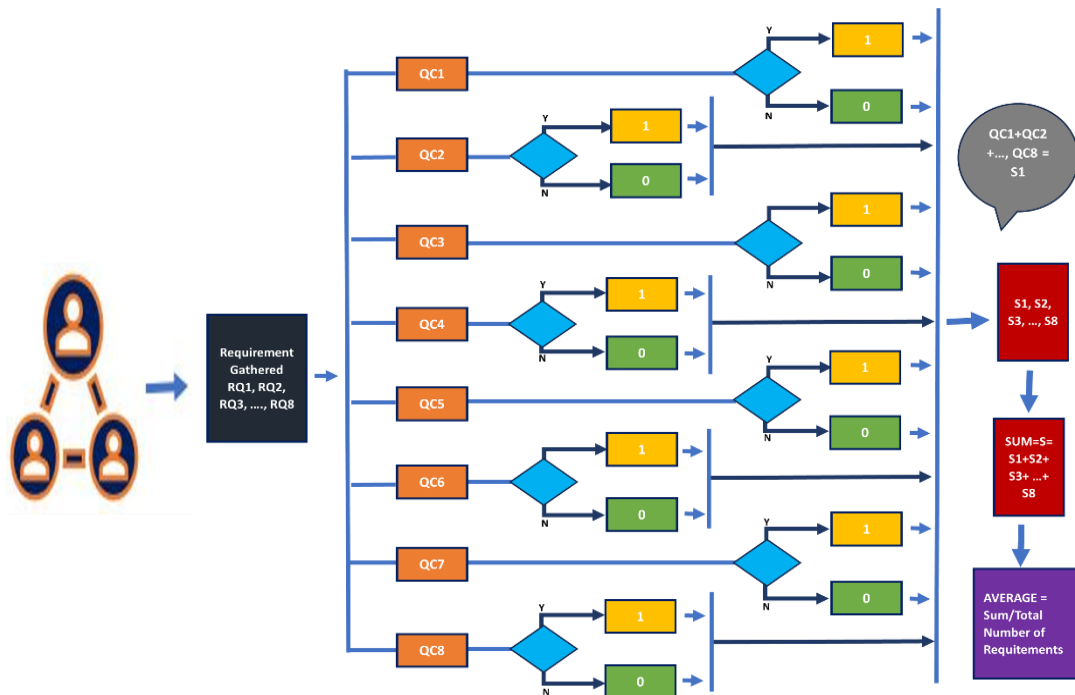


Figure 23: Complete Analysis Process

6.1 Questionnaire Approach

Table 6: Requirements Description Obtained by Questionnaire Approach

ID	DESCRIPTION
RQ1	Users can register themselves.
RQ2	User can send and receive text messages to another user individually (1 to 1).
RQ3	User can create a group of individuals and any member of the group can send and receive messages in the group and all other can receive that message.

RQ4	User may send and receive images, audios, documents, or videos etc.
RQ5	Users can see online status of each other and last active session of himself and others.
RQ6	Application requires low latency as it would be real time app so other receiver must be able to receive and see that message immediately.
RQ7	Application should be available for use 24/7 and should never go down in any case.
RQ8	Application should never go down in any case.

Table 7: Quality Attributes with Requirements Gathered by Questionnaire Approach

Attributes/ Req ID	RQ1	RQ2	RQ3	RQ4	RQ5	RQ6	RQ7	RQ8
Complete	0	1	1	1	1	0	1	1
Correct	1	1	1	1	1	1	1	1
Feasible	1	1	1	1	1	1	0	1
Necessary	1	1	1	0	0	1	1	1
Prioritize	1	1	0	0	0	1	1	1
Unambiguous /Clear	0	1	0	1	1	1	1	1
Verifiable	1	1	1	1	1	1	0	1
Realistic	1	1	1	1	1	1	0	0
Total	6	8	6	6	6	7	5	7
Average = Sum of All Totals / Total Requirements								6.375

Requirement **RQ1**, **RQ3**, **RQ4** and **RQ5** all four requirements gathered with this approach supports six characteristics each out of eight. Requirement **RQ2** supports all eight characteristics of good quality requirements. Furthermore, **RQ6** and **RQ8** fulfill seven characteristics. Lastly, **RQ7** supports five characteristics of good quality requirements. So, the average score of this approach is **6.375**. Graph showing the details is listed below.

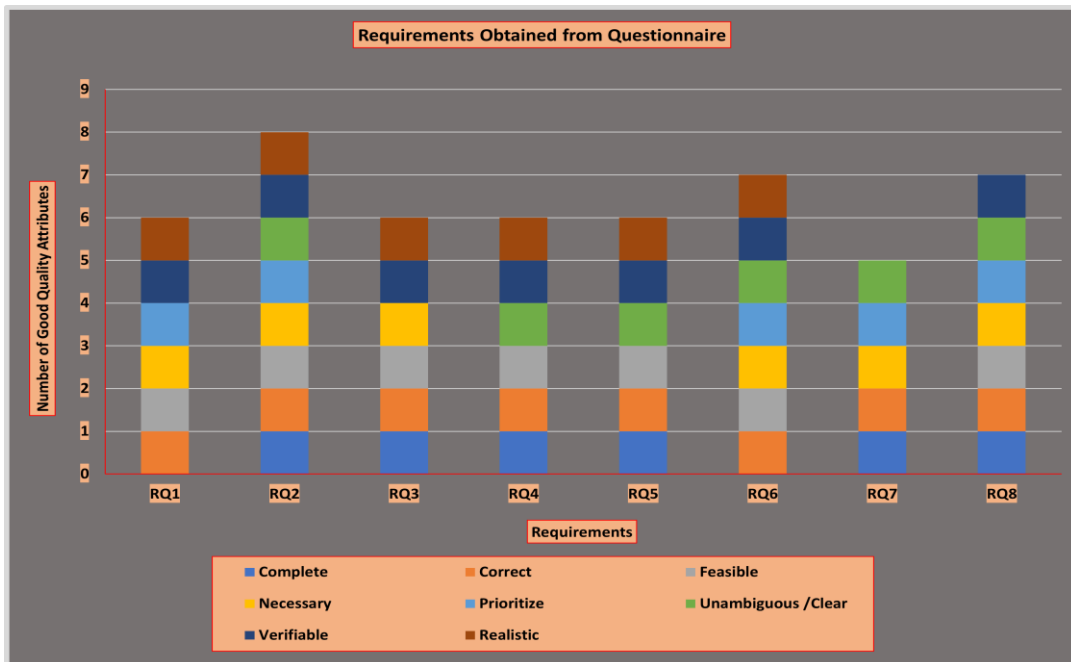


Figure 24: Graph Showing Details about Questionnaire Approach

6.2 Interview Approach

Table 8: Requirements Description Obtained by Interview Approach

ID	DESCRIPTION
RQ1	Firstly, user can create account through valid phone number and (if do not provide valid no then application must closed).
RQ2	User must login with credentials like phone number to get access to account.
RQ3	User can send all type of media messages to other saved contacts individually.
RQ4	Application has styling and different fonts for the text writing.
RQ5	User can clear the data of a particular contact.
RQ6	Application should have the functionality to add and delete or remove contact from contact list.
RQ7	User can set profile info like picture and name.
RQ8	User have functions to block any contact.

Table 9: Quality Attributes with Requirements Gathered by Interview Approach

Attributes/ Req ID	RQ1	RQ2	RQ3	RQ4	RQ5	RQ6	RQ7	RQ8
Complete	1	1	1	0	0	1	1	1
Correct	1	1	1	1	1	1	1	1
Feasible	1	1	1	1	1	1	1	1
Necessary	1	1	1	0	1	1	0	1
Prioritize	1	1	0	0	1	1	0	1
Unambiguous /Clear	1	1	1	0	0	1	1	1
Verifiable	1	1	1	1	1	1	1	1
Realistic	1	1	1	1	1	1	1	1
Total	8	8	7	4	6	8	6	8
Average = Sum of All Totals / Total Requirements								6.875

Simple one to one interview was considered for obtaining requirements. This approach provides much better results as compared to the questionnaire. Requirements **RQ1**, **RQ2**, **RQ6** and **RQ8** all support all eight characteristics while **RQ3** fulfills seven characteristics, **RQ4** fulfills four characteristics and **RQ5** and **RQ7** fulfills six characteristics each. This approach provides an average score of **6.875**. Graph showing details is listed below.

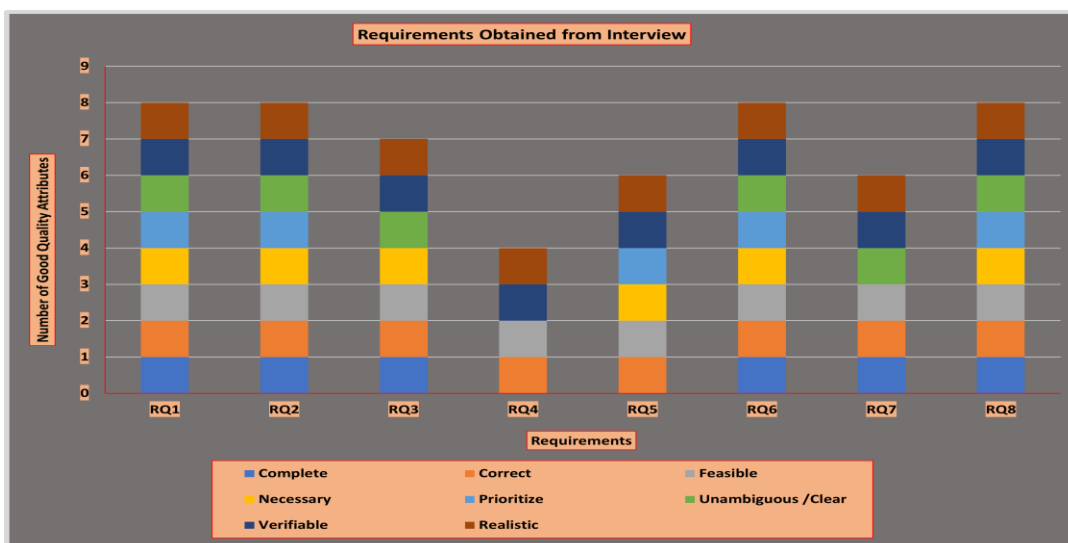


Figure 25: Graph Showing Details about Interview Approach

6.3 Workshop Approach

Table 10: Requirements Description Obtained by Workshop Approach

ID	DESCRIPTION
RQ1	User register himself.
RQ2	User cand send and receive messages.
RQ3	Users can clear chat history.
RQ4	User can add contacts and delete contacts and app detects updated contacts list from phone directory.
RQ5	User can block any contact.
RQ6	User might contact maintenance team for help.
RQ7	User can see last active season of other contact.
RQ8	Chat Application should be secure from hackers.

Table 11: Quality Attributes with Requirements Gathered by Workshop Approach

Attributes/ Req ID	R1	R2	R3	R4	R5	R6	R7	R8
Complete	0	1	1	0	1	1	1	1
Correct	1	1	1	1	1	1	1	1
Feasible	1	1	1	1	1	1	1	1
Necessary	1	1	0	1	1	0	0	1
Prioritize	1	1	0	0	1	0	0	1
Unambiguous /Clear	0	0	1	1	1	1	1	1
Verifiable	1	1	1	1	1	1	1	1
Realistic	1	1	1	1	1	1	1	0
Total	6	7	6	6	8	6	6	7
Average = Sum of All Totals / Total Requirements								6.5

Three participants are considered for performing this task. **RQ1, RQ3, RQ4, RQ6** and **RQ7** all these requirements support six characteristics each while **RQ2** and **RQ8** support seven characteristics and requirement **RQ5** fulfills eight characteristics of

good quality requirements. This approach produces an average of **6.5**. The reason why the score is less was the contradiction among the needs of participants (stakeholders), as they were not coming on common understanding. Graph showing details is listed below.

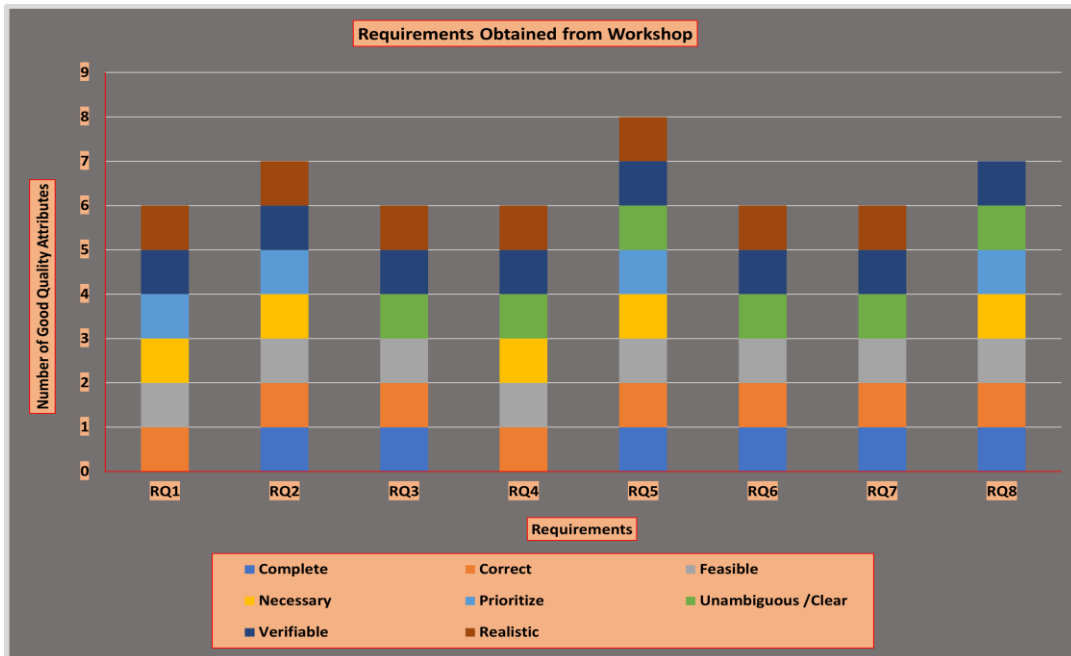


Figure 26: Graph Showing Details about Workshop Approach

6.4 Brainstorming Approach

Table 12: Requirements Description Obtained by Brainstorming Approach

ID	DESCRIPTION
RQ1	User should register the valid phone number to use the application.
RQ2	For using the app u need to provide valid credentials to login in your account.
RQ3	User can send messages images vid and voices with single individual like private chatting.
RQ4	User Add new contacts by putting number and name. app may detect saved contacts from the contact list.
RQ5	User should create groups of contacts and send message to these groups.
RQ6	User can block a contact that he/she wants by sending it to block list.
RQ7	Application should work instantly and it works 24/7 without any error.
RQ8	Application may have a video calling option as well.

Table 13: Quality Attributes with Requirements Gathered by Brainstorming Approach

Attributes/ Req ID	R1	R2	R3	R4	R5	R6	R7	RQ8
Complete	1	1	1	0	1	1	1	1
Correct	1	1	1	1	1	1	1	1
Feasible	1	1	1	1	1	1	0	1
Necessary	1	1	1	1	0	1	1	0
Prioritize	1	1	1	0	0	1	1	0
Unambiguous /Clear	1	1	1	0	0	1	1	1
Verifiable	1	1	1	1	1	1	1	1
Realistic	1	1	1	1	1	1	0	1
Total	8	8	8	5	5	8	6	6
Average = Sum of All Totals / Total Requirements								6.875

RQ1, RQ2, RQ3, and RQ6 support all eight characteristics of good quality requirements. **RQ4** and **RQ5** fulfill five characteristics, **RQ7** and **RQ8** each requirement supports to six characteristics. With this approach we got an average score of **6.75** which is the second highest in our research after interview approach. Graph showing details is listed below.

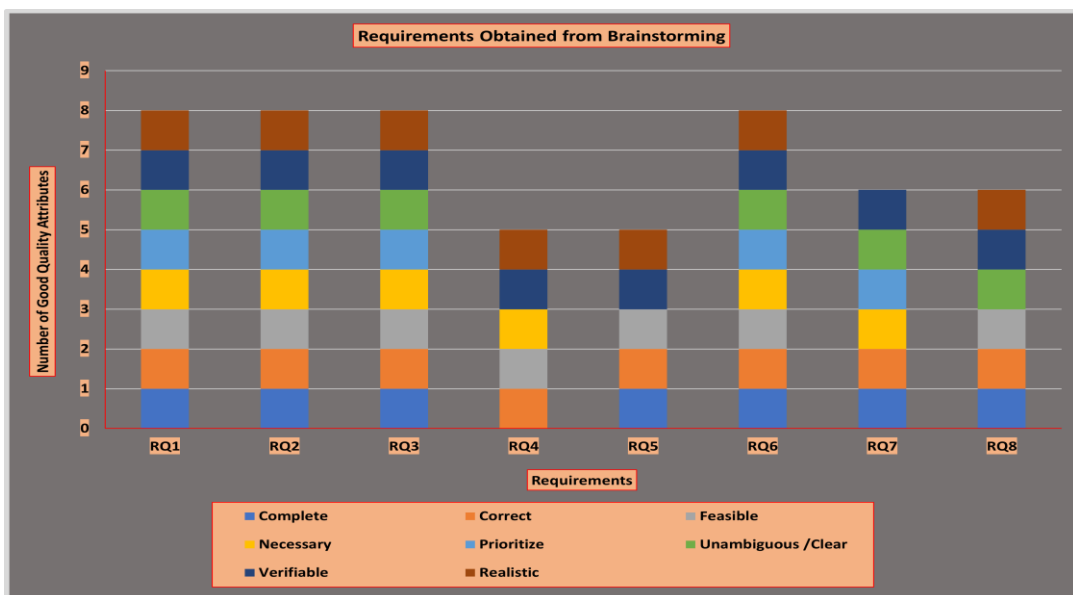


Figure 27: Graph Showing Details about Brainstorming Approach

6.5 Observational Approach

Table 14: Requirements Description Obtained by Observation Approach

ID	DESCRIPTION
RQ1	User register themselves by providing phone number.
RQ2	User can create and left group conversations.
RQ3	User can send and receive message including txt images vid and voice rec etc privately.
RQ4	User should add new contacts by adding name and numbers and app detect them automatically.
RQ5	Online aspect of users. This shows who is online at the current time.
RQ6	User should send messages to other saved contacts.
RQ7	User should delete account by providing register number.
RQ8	GUI should be user friendly and easier for users to use. Buttons should be displayed rather than command line interface.

Table 15: Quality Attributes with Requirements Gathered by Observational Approach

Attributes/ Req ID	RQ1	RQ2	RQ3	RQ4	RQ5	RQ6	RQ7	RQ8
Complete	0	1	1	0	0	0	1	1
Correct	1	1	1	1	1	1	1	1
Feasible	1	1	1	1	1	1	1	1
Necessary	1	0	1	1	0	1	1	1
Prioritize	1	0	1	0	0	1	1	1
Unambiguous /Clear	0	1	1	1	1	0	1	1
Verifiable	1	1	1	1	1	1	1	1
Realistic	1	1	1	1	1	1	1	1
Total	6	6	8	6	5	6	8	8
Average = Sum of All Totals / Total Requirements								6.625

In this approach **RQ1, RQ2, RQ4** and **RQ6** fulfills six characteristics each while **RQ3, RQ7** and **RQ8** fulfills all characteristics of good quality requirements and **RQ5** supports to five characteristics. This approach provides an average score of **6.625**. Graph showing details is listed below.

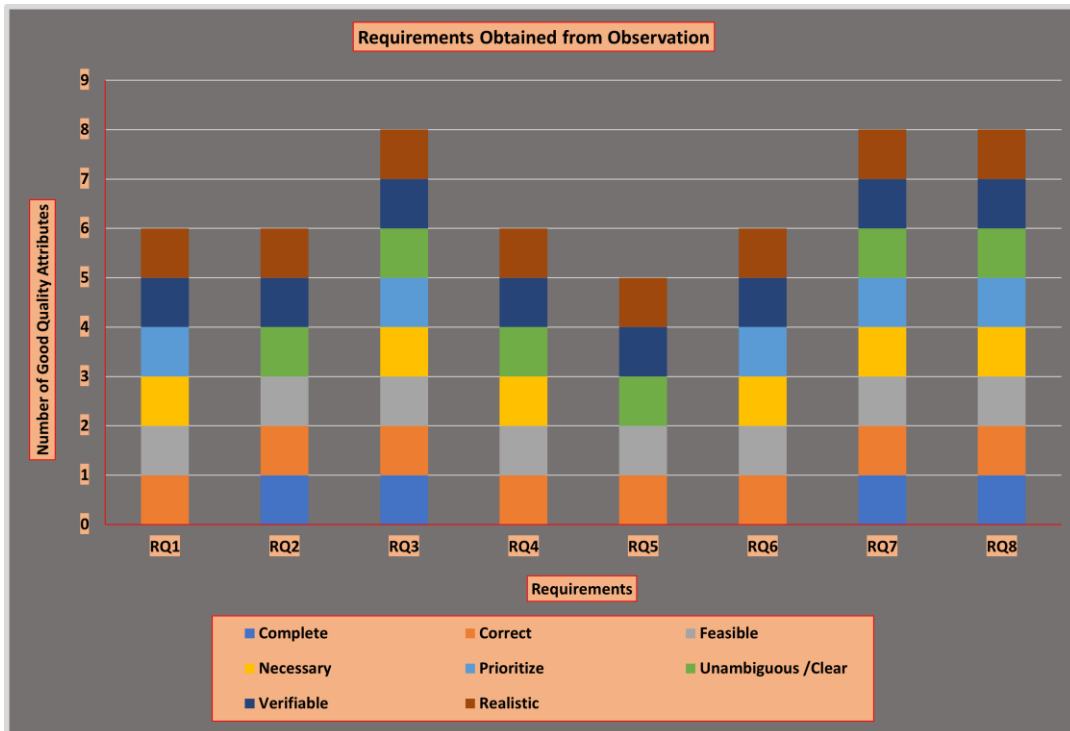


Figure 28: Graph Showing Details about Observational Approach

6.6 Proposed Method (Brainstorming + Interviews)

Table 16: Requirements Description Obtained by Proposed Approach

ID	DESCRIPTION
RQ1	First, user should registration with valid phone number for creating his/her account.
RQ2	Without getting login user should not be able to use the app and for login user must needs valid account details (a valid number and password).
RQ3	User should add new contacts and app <u>must</u> detect contacts saved in the phone directory automatically.
RQ4	If user deletes any contact then it must be removed.
RQ5	User can search any contact from the app contact list by name or number.
RQ6	Application never go down and always stay operational 24/7.

RQ7	User should send and receive messages privately.
RQ8	Application may shows the time when user sends and receive any message (txt, image, vid, voices etc).

Table 17: Quality Attributes with Requirements Gathered by Proposed Approach

Attributes/ Req ID	R1	R2	R3	R4	R5	R6	R7	R8
Complete	1	1	1	1	1	1	0	1
Correct	1	1	1	1	1	1	1	1
Feasible	1	1	1	1	1	1	1	1
Necessary	1	1	1	1	1	1	1	0
Prioritize	1	1	1	1	0	1	1	0
Unambiguous /Clear	1	1	1	0	1	1	0	1
Verifiable	1	1	1	1	1	1	1	1
Realistic	1	1	1	1	1	0	1	1
Total	8	8	8	7	7	7	6	6
Average = Sum of All Totals / Total Requirements								7.125

This approach is a hybrid of brainstorming and interviews as explained in methodology. We merged the two top averaged approaches in this case to check whether they produce better results as compared to all other approaches or not. So, in response to our analysis this proposed methodology produces the highest average than all other approaches. **RQ1, RQ2** and **RQ3** support all eight characteristics while **RQ4, RQ5** and **RQ6** support seven characteristics and the remaining **RQ7, RQ8** supports six characteristics each of good quality requirements with an average score of **7.125**.

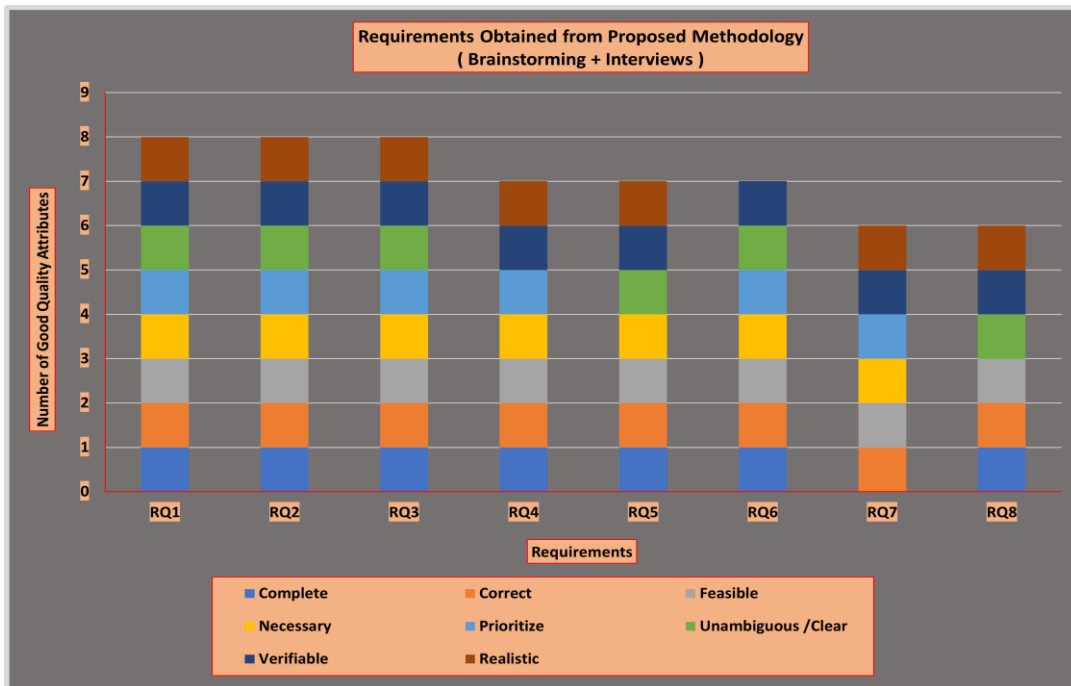


Figure 29: Graph Showing Details about Proposed Approach

Six results of different approaches are compiled in the figure below. This line chart is basically the graphical representation of all eight requirements after crosschecking with all quality characteristics obtained by six different approaches as mentioned in the figure below. Requirements are along x axis and quality characteristics are along y axis. Dots represents the number of fulfilled characteristics.

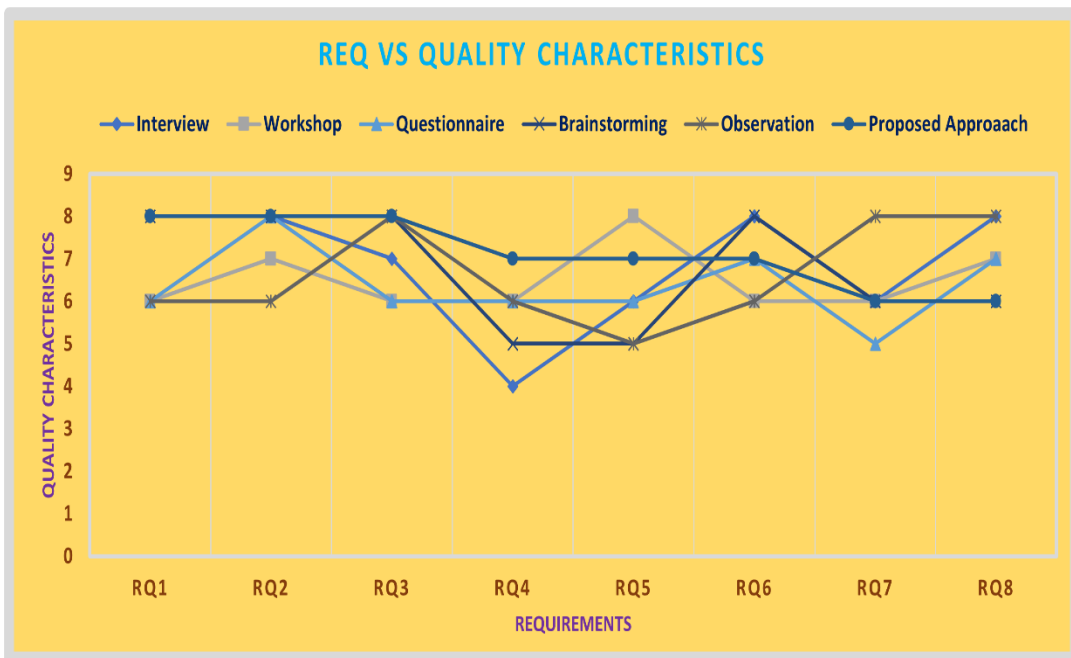


Figure 30: Requirements Vs Quality Characteristics

CHAPTER 7: CONCLUSION AND FUTURE EXTENSION

According to CHAOS details, major issue of failure of computer field projects can be encountered in the phase of requirements [40]. Process of requirement gathering and also selecting the appropriate approach for requirement gathering process in requirement engineering relies on different aspects like domain of problem, duration of software project, expertise of team and project type etc. In this research, we have collected requirements for a chat application by six different approaches and from randomly selected individuals, after that we checked the requirements with good quality characteristics of requirements. We have proposed a hybrid methodology by combining the two approaches (brainstorming and interviews) and then check the requirements obtained with this methodology with good characteristics. Lastly, we compared the average values of proposed methodology with all other approaches to identify that which approach produce better quality requirements.

Every project has some user requirements. For ensuring project success, requirement engineer, or analyst requires to select proper and suitable approach for the elicitation of the project requirements. None of the elicitation approaches are completely appropriate for every project or situation. Every approach has its own pros and cons. Furthermore, selection of requirement gathering approaches depends on several aspects like project cost and time duration, project type and domain etc. Brainstorming is not useful for big and complex projects. Elicitation process is mostly performed poorly and this leads to major issues in system, which causes project failure [39]. Figure below shows the complete analysis of our research study.

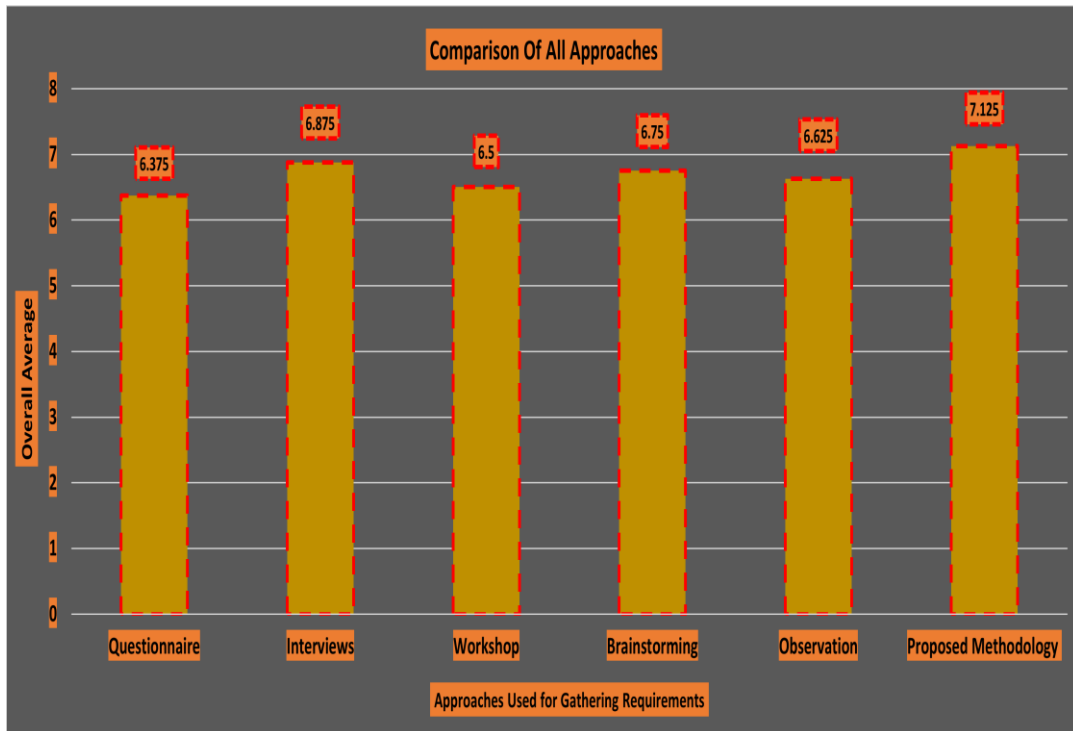


Figure 31: Graph Showing Detailed Comparison of all Approaches.

As, we have gathered requirements for chat application, so these applications always have a space for improvement, and currently we only gathered requirements for text communication only by using different approaches. Graph below shows the average score of all approaches including our proposed methodology, which consist of brainstorming and interview. As the average score of proposed methodology is highest among all that is 7.125, so it produces quality requirements as compared to other approaches. As a combination of different approaches complement each other and resulting in collecting a complete and good quality requirement for software projects.

REFERENCES

- [1] Ul Haq and W. Haider Butt, "The State of Practices in Requirement Elicitation: An Improved Methodology for Pak Software Industry," 2022 17th International Conference on Emerging Technologies (ICET), Swabi, Pakistan, 2022, pp. 76-82, doi: 10.1109/ICET56601.2022.10004655.
- [2] Nuseibeh B, Easterbrook S (2019) Requirements engineering: a roadmap. In: *Procs. of the conference on the future of software Eng. (ICSE'00)* ACM, pp 35–46.
- [3] Kotonya, G., Sommerville, I.: *Requirements Engineering. Processes and Techniques*. John Wiley & Sons, Chichester (1997).
- [4] Wiegers K, Beatty J (2013) *Software requirements*, 3rd edn. Microsoft Press, Redmond, Washington.
- [5] Stallbaum S, Ly A (2016) Up to 80% of your products are losing Money. *PDMA Visions Mag* 40(3). <https://community.pdma.org/knowledgehub/book/portfolio/80-percent-of-products-are-losing-money>. Accessed 31 Dec 2020.
- [6] Procaccino JD, Verner JM, Overmyer SP, Darter ME (2002) Case study: factors for early prediction of software development success. *Inf Software Technol* 44(1):53–62.
- [7] Inam-Ul-Haq, W. Abbas and W. H. Butt, "Systematic Literature Review on Requirement Management Tools," 2022 International Conference on Emerging Trends in Smart Technologies (ICETST), Karachi, Pakistan, 2022, pp. 1-6, doi: 10.1109/ICETST55735.2022.9922932.
- [8] Van Lamsweerde A (2009) *Requirements engineering: from system goals to UML models to software specifications*. Wiley, New Delhi.
- [9] C. Schwaber, and P. Sterpe, "The Root of the Problem: Poor Requirements," Forrester Research, Inc., Sept 1, 2006.
- [10] Jill Barson Gilbert. (2010) [Online]. Available: <http://ezinearticles.com/?Good-Requirements-Lead-toBetterSoftware&id=4758177>.
- [11] A. Davis, O. Dieste, A. Hickey, N. Juristo and A. M. Moreno, "Effectiveness of Requirements Elicitation Techniques: Empirical Results Derived from a Systematic Review," 14th IEEE International Requirements Engineering Conference (RE'06), 2006, pp. 179-188, doi: 10.1109/RE.2006.17.
- [12] Jones C (1996) *Applied software measurement: Assuring productivity and quality*. McGraw-Hill: New York.

- [13] Nuseibeh B, Easterbrook S, Russo A (2000) Leveraging inconsistency in software development. *Compute IEEE* 33(4):24–29.
- [14] Carrizo D, Dieste O, Juristo N (2014) Systematizing requirements elicitation technique selection. *Inf Softw Technol* 56(6):644–669.
- [15] Pacheco CL, Garcia IA, Reyes M (2018) Requirement’s elicitation techniques: a systematic literature review based on the maturity of the techniques. *IET Softw* 12(4):365–378.
- [16] Dieste O, Juristo N (2017) Systematic review and aggregation of empirical studies on elicitation techniques. *IEEE Transactions Softw Eng* 37(2):283–304.
- [17] Ambreen T, Ikram N, Usman M, Niazi M (2018) Empirical research in requirements engineering: trends and opportunities. *Requir Eng* 23(1):63–95.
- [18] Groen EC, Seyf N, Ali R, Dalpiaz F, Dörr J, Guzman E, Hosseini M, Marco J, Oriol M, Perini A, Stade MJC (2017) The crowd in requirements engineering: the landscape and challenges. *IEEE Softw* 34(2):44–52.
- [19] Maalej W, Nayebi M, Johann T, Ruhe G (2016) Toward data driven requirements engineering. *IEEE Softw* 33(1):48– 54.
- [20] Maalej W, Nayebi M, Ruhe G (2019) Data-driven requirements engineering: an update. In: *Software engineering in practice track at international conference on software engineering (SEIP-ICSE)*, pp 289–290.
- [21] Zahid, A. H., Liaqat, A., Farooq, M. S., & Naseer, S. (2020). Requirement Elicitation issues and Challenges in Pakistan Software Industry.
- [22] Elahi G, Yu E, Li T, Liu L (2020) Security requirements engineering in the wild: a survey of common practices. In: *IEEE 35th annual computer software and applications conference (COMPSAC)*, pp 314–319.
- [23] Raatikainen M, Männistö T, Tommila T, Valkonen J (2018) Challenges of requirements engineering—a case study in nuclear energy domain. In: *IEEE 19th international requirements engineering conference (RE)*, pp 253–258.
- [24] Bjarnason E, Wnuk K, Regnell B (2015) Requirements are slipping through the gaps - A case study on causes & effects of communication gaps in large-scale software development. In: *IEEE 19th international requirements engineering conference (RE)*, Trento, Italy, pp 37–46.
- [25] Pacheco, C., García, I. and Reyes, M. (2018), Requirements elicitation techniques: a systematic literature review based on the maturity of the techniques. *IET Softw.*, 12: 365-378.

- [26] Berntsson-Svensson R, Gorschek T, Regnell B, Torkar R, Shahrokni A, Feldt R (2012) Quality requirements in industrial practice: an extended interview study at eleven companies. *IEEE Transactions Softw Eng* 38(4):923–935.
- [27] Hiisilä H, Kauppinen M, Kujala S (2015) Challenges of the customer organization's requirements engineering process in the outsourced environment—a case study. In: 21st international working conference on requirements engineering: foundation for software quality (REFSQ), Essen, Germany, pp 214–229.
- [28] Kassab M (2015) The changing landscape of requirements engineering practices over the past decade. In: IEEE 5th international workshop on empirical requirements engineering (EmpiRE), pp 1–8.
- [29] Malviya S, Vierhauser M, Cleland-Huang J, Ghaisas S (2017) What questions do requirements engineers ask? In: IEEE 25th international requirements engineering conference (RE), pp 100–109.
- [30] Liebel G, Tichy M, Knauss E, Ljungkrantz O, Stieglbauer G (2018) Organisation and communication problems in automotive requirements engineering. *Requir Eng* 23(1):145–167.
- [31] Alsaqaf W, Daneva M, Wieringa R (2019) Quality requirements challenges in the context of large-scale distributed agile: an empirical study. *Inf Softw Technol* 110:39–55.
- [32] Denys G. and Inna H., "Requirement Elicitation Techniques for Software Projects in Ukrainian IT: An Exploratory Study," 2020 15th Conference on Computer Science and Information Systems (FedCSIS), 2020, pp. 673-681.
- [33] Wagner S, Mendez D, Kalinowski M, Felderer M, Mafra P, Vetrò A, Conte T, Christiansson MT, Greer D, Lassenius C, Männistö TS, Nayebi M, Oivo M, Penzenstadler B, Pfahl D, Prikladnicki R, Ruhe G, Schekelmann A, Sen S, Spinola R, de la Vara JL, Tuzcu A, Wieringa R, Winkler D (2019) Status quo in requirements engineering: a theory and a global family of surveys. *Trans Software Eng Methodol* 28(2):1–48.
- [34] Liu L, Li T, Peng F (2010) Requirements engineering fails: a survey report from China. In: 18th IEEE international requirements engineering conference (RE), pp 317–322.
- [35] Todoran I, Seyf N, Glinz M (2013) How cloud providers elicit consumer requirements: an exploratory study of nineteen companies. In: 21st IEEE

international requirements engineering conference (RE), Rio de Janeiro, Brazil, pp 105– 114.

[36] Hadar I, Sofer P, Kenzi K (2014) The role of domain knowledge in requirements elicitation via interviews: an exploratory study. *Requirements Eng* 19(2):143–159.

[37] Sethia NK, Pillai AS (2014) The effects of requirements elicitation issues on software project performance: an empirical analysis. In: *requirements engineering foundation for software quality (REFSQ)*, pp 285–300.

[38] Manzoor MI, Shaheen M, Khalid H, Anum A, Hussain N, Faheem MR (2018) Requirement elicitation methods for cloud providers in IT industry. In: *Int. Journal Mod Education Comput Sci* 10:40–47.

[39] Gunda, S.G. 2013. *Requirements engineering: Elicitation Techniques*. University West, Department of Technology, Trollhattan, Sweden.

[40] The CHAOS Report. Available at <http://www.standishgroup.com/>, accessed 10 December 2021.