Risk Based Testing Framework for Prioritizing Testing of High Risk Components

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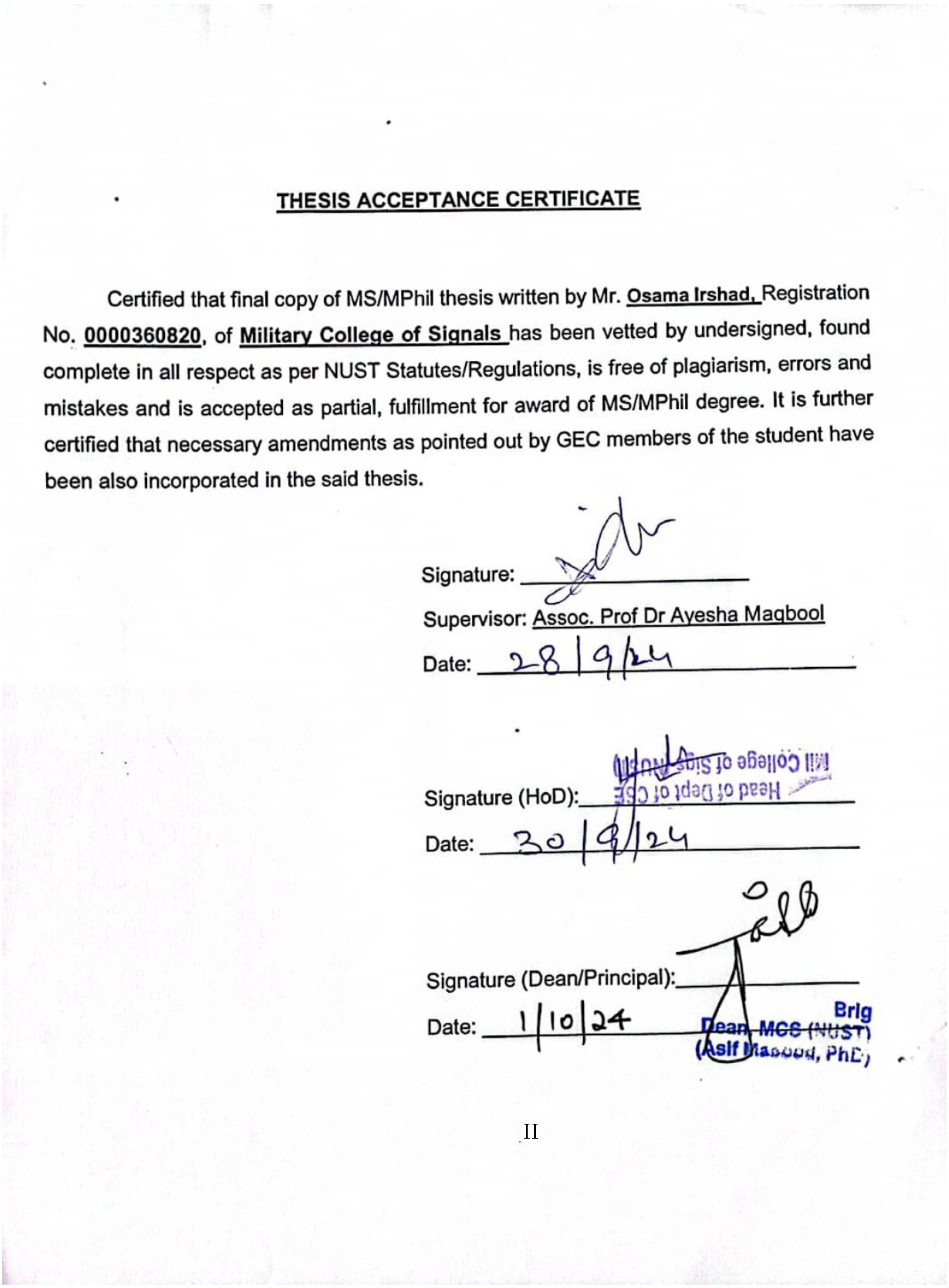

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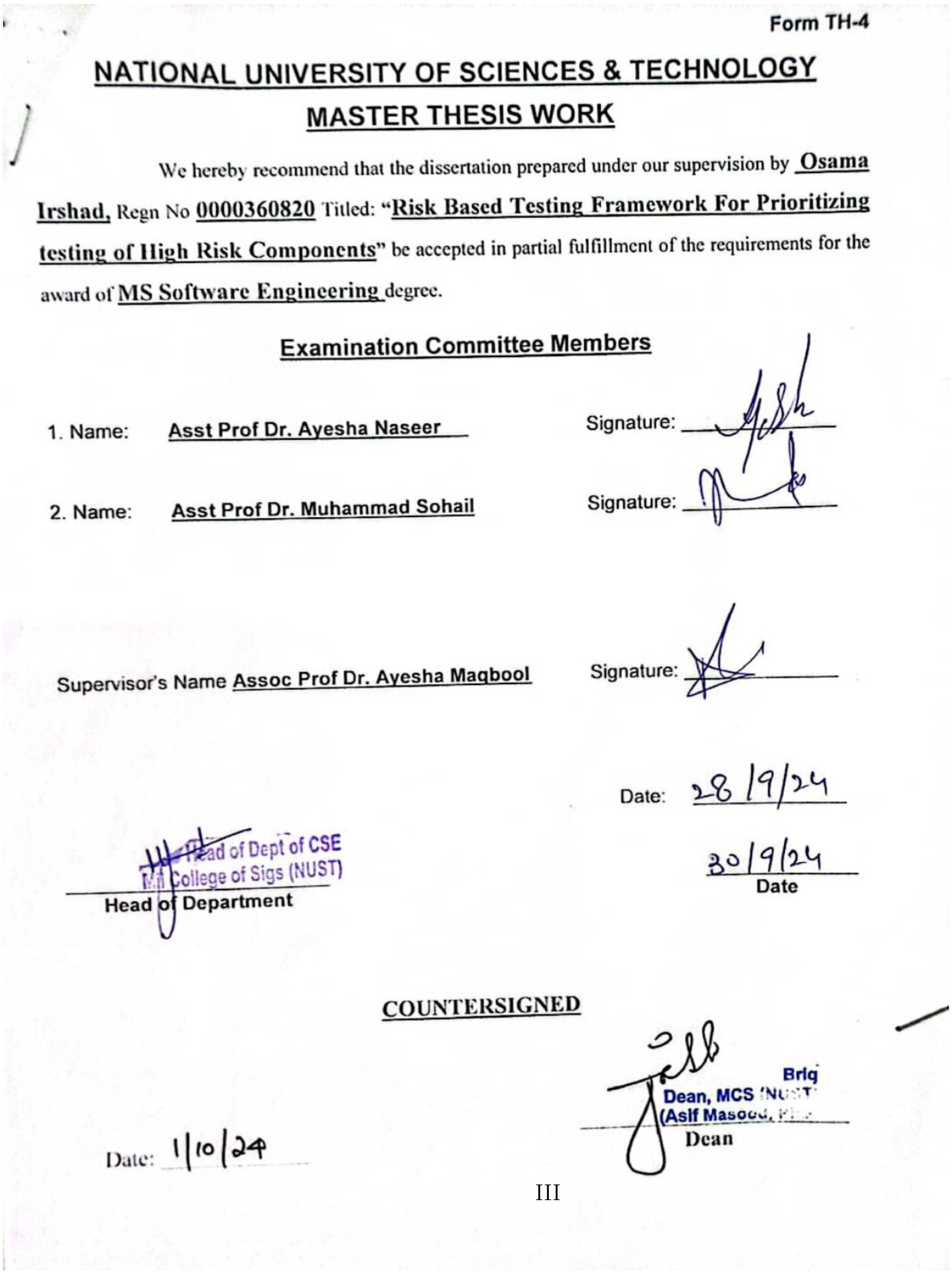

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MASTER THESIS WORK

We hereby recommend that the dissertation prepared under our supervision by **Osama Irshad,** Regn No **0000360820** Titled: "**Risk Based Testing Framework For Prioritizing testing of High Risk Components**" be accepted in partial fulfillment of the requirements for the award of **MS Software Engineering** degree.

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This is to certify that the research work presented in this thesis, entitled "**Risk Based Testing Framework for Prioritizing Testing of High Risk Components**." was conducted by Mr. **Osama Irshad** under the supervision of **Assoc Prof Dr. Ayesha Maqbool.**

No part of this thesis has been submitted anywhere else for any other degree. This thesis is submitted to the **Department of Computer Software Engineering** in partial fulfillment of the requirements for the degree of Master of Science in Field of Computer **Software Engineering Department of Military College of Signals, National University of Sciences and Technology, Islamabad**.

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At any time if my statement is found to be incorrect even after I graduate, the university has the right to withdraw my MS degree.

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DEDICATION

"In the name of Allah, the Creator and Sustainer of all existence, to whom belongs all honor and authority. It is by the Almighty's will alone that achievements are attained and obstacles overcome. From the beginning of my journey at this esteemed institution to its conclusion, I attribute all successes to the blessings and guidance of the Almighty. This thesis is dedicated to my much-loved Parents, siblings and my friends, who all have been my never-ending source of love, inspiration, and strength. Their untiring belief in my skills, immeasurable sacrifices, and relentless support has been the base on which I have established my academic quests. Without their guidance, affection and support this thesis and research work would not have been made possible.".

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Sincerely, I wish to convey my appreciation to my thesis advisors first Associate Professor Dr. Touseef Ahmed Rana and then Associate Professor Dr. Ayesha Maqbool for the valuable support and guidance during the course of my research. Their unwavering dedication to this field, vast knowledge, and expertise have been a constant source of inspiration throughout my thesis journey. Their sincere concern for my development and dedication to excellence have had a profound effect on my educational and personal progression. It has been a great privilege to have worked under their guidance, and I am sincerely appreciative of their consistent encouragement and faith in my capabilities.
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Abstract

In software development, testing plays a critical role in ensuring the reliability and quality of applications. However, conducting extensive and comprehensive testing across all areas and components of a software application can be difficult due to time and resource constraints. To address this issue, a Risk-based testing framework is proposed in this thesis to prioritize testing efforts on the high-risk areas and components of an application. Risk-based testing is a prevalent method for maximizing testing efforts by prioritizing tests according to their potential impact on the system and likelihood of failure. This framework integrates with Raygun software, which collects data on application errors and exceptions, enabling the identification of potential defects and vulnerabilities. By utilizing a risk matrix to analyze the severity and likelihood of identified risks, the framework efficiently prioritizes testing activities, ensuring that critical components and features are properly evaluated. The effectiveness of the proposed framework is validated through real-world evaluation, highlighting the framework's ability to identify and mitigate potential risks and vulnerabilities. Ultimately, this research contributes to the field of software engineering by offering a systematic approach to risk-based testing, enhancing the quality and safety of software applications while optimizing testing resources.

Keywords: Summary; software under test, risk-based testing, software testing lifecycle, regression testing, SDLC, AUT.

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LIST OF SYMBOLS, ABBREVIATIONS AND ACRONYMS

RBT	Risk Based Testing
SDLC	Software Development Lifecycle
STLC	Software Testing Lifecycle
TCP	Test Case Prioritization
RA	Risk Assessment
RM	Risk Matrix
SQA	Software Quality Assurance
ST	Software Testing
AUT	Application under test
SUT	Software under test
RTS	Regression Test Selection
TCS	Test Case Scheduling

Chapter 1

Introduction

"Software testing is the process of evaluating a software system to determine the presence of any faults". Software verification and validation is a systematic process employed to ascertain the conformity of a software service or application with user needs and planned specifications. The assessment of software functioning is crucial in the development of high-quality software [1]. "The fundamental objective of software testing is to detect and expose software defects or bugs in Software under test". Software testing incorporates the process of executing the code in different situations and carefully analyzing its behavior. This examination validates that the program functions as expected and adheres to the specified requirements. The challenge of determining when to initiate and conclude testing emerges. Commencing testing early in the software development process is recommended. This practice not only enables the identification and rectification of errors prior to the final stages, but also reduces the necessity for frequent bug detection throughout the initial phases. This methodology effectively reduces both time and resource consumption. The objective is to achieve optimal value by producing a product of superior quality, while operating within the constraints of time and financial resources [2]. Software testing generally verifies the inconsistencies throughout the SDLC. According to a poll, software errors have been found to have a 0.6 percent impact on the gross domestic product of the United States economy. Moreover, it is worth noting that nearly 80% of the financial resources dedicated to software development projects are dedicated to the crucial task of identifying and resolving errors [3]. Software testing's primary goal is to ensure that a software system is functioning as intended and to identify and eliminate any potential risks or faults that could lead to poor performance or failure. However, testing an entire system is typically impractical and time-consuming, thus testing efforts must be prioritized based on the perceived risks associated with each component or feature. How to effectively prioritize testing efforts for high-risk components of a software system is an essential and relevant issue in software testing that will be addressed. Risk-based testing is a prevalent method for maximizing testing efforts by prioritizing tests according to their

potential impact on the system and likelihood of failure. In the context of high-risk components, there is a need for additional research on the development of frameworks and methodologies for risk-based testing.
Risk-based testing can optimize and improve the effectiveness of the testing procedure by:

- **Optimize Resource allocation**: The primary objective of Risk-based testing is to effectively deploy testing resources in an efficient way by focusing on components with elevated levels of risk, it guarantees early identification and resolution of critical issues during the development process.
- **Improved Test Coverage**: Risk-based testing allows the completion of thorough test coverage in components characterized with high levels of risk, while simultaneously minimizing the extent of testing conducted in components with low levels of risk. By conducting rigorous testing, important functionality is ensured to be comprehensively tested, hence improving the total extent of test coverage.
- **Improved Decision Making**: Risk-based testing offers stakeholder significant insights into the potential risks connected with software, hence enhancing decision-making processes. This data allow individuals to make well-informed choices on the planning for release and the implementation of strategies to mitigate potential risks.

The process presented in fig 1.1 below involves a structured approach of Risk-based testing, beginning with risk identification, in which project requirements are analyzed for potential risks. Following by risk analysis and mitigation strategies to prioritize requirements based on the risk assessment. The prioritized requirements are then incorporated into the test plan to ensure that testing activities correspond to the identified risks. Test execution and result analysis emphasize testing priorities and risk mitigation. This approach helps in managing project risks and maintaining testing schedules.
The motivation for implementing Risk-based testing is based on the requirement for optimized and proficient testing methodologies inside the complicated domain of modern software development. Conventional testing methodologies, which strive to evaluate all components of a system with equal emphasis, frequently encounter limitations in terms of resource allocation and the identification of defects The implementation of RBT enables organizations to optimize their utilization of testing resources by prioritizing high-risk components, the testing efforts for AUT are strategically focused towards areas that require the most consideration, hence optimizing the allocation of resources.

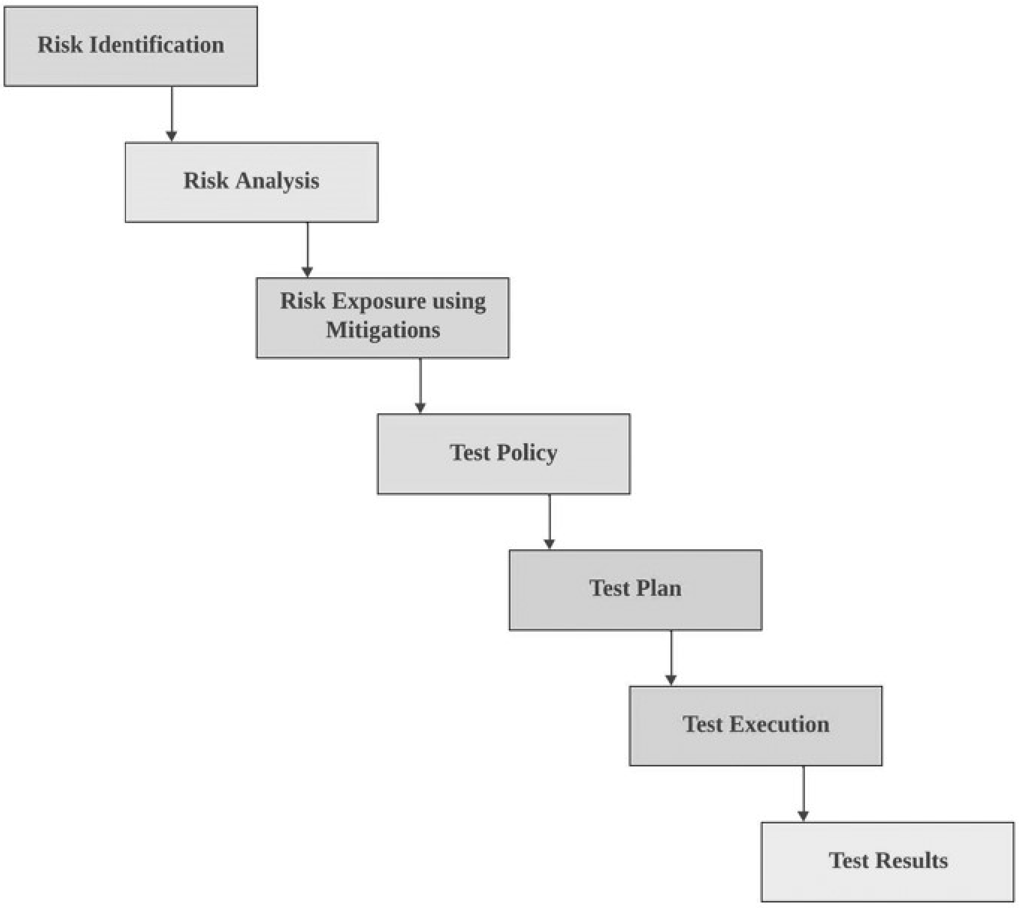

Figure 1.1: Risk Based Testing Phases (h2kinfosys) [27]

1.1 Motivation

Regression testing is an essential and crucial procedure that verifies the software's quality after any modification. However, executing the entire regression test suite for AUT is time-consuming, costly, and tedious, which frequently results in budget and schedule constraints. TCP is utilized to enhance regression testing by rescheduling test cases in a manner that improves defect detection [5]. A variety of risk-based testing approaches are available and it is essential to determine their core concepts and methodologies in order to compare their strengths and limitations. RBT is a widely utilized approach that aims to enhance the efficiency of testing efforts by assigning priority to tests according to their potential influence on the system and the probability of failure [1][2][3]. However, further investigation is necessary regarding the development of frameworks and procedures associated with risk-based testing, particularly within the context of high-risk components. This study seeks to establish a comprehensive framework that enables the prioritization of testing efforts on components with higher risk levels, employing principles derived from risk-based testing. This research has the potential to offer valuable practical understanding and guidance for software developers and testers who have the responsibility of ensuring the reliability and quality of software systems. The thesis aims to propose a comprehensive framework for risk-based testing, which offers an organized approach for the identification and prioritization of high-risk components inside a software system. This framework enables the efficient allocation of testing resources in accordance with the identified risks.

1.2 Problem Statement

Within the domain of software development, the consistent problem arises of delivering software programs that are both robust and reliable, while complying strictly with time and resources. The testing phase is an essential element in the software development process as it plays a vital role in discovering errors, vulnerabilities, and assuring the overall quality of the product. However, this phase often encounters various pressures, which highlights the necessity for the implementation of effective testing procedures. Although it is ideal to do thorough testing, the extensive analysis of each software component becomes unfeasible due to the time and resource burdens involved. In order to address this difficulty, it is imperative to use a methodical approach that strategically distributes testing efforts to the components of a software application with higher risks. A proposed solution to this issue is the implementation of a Risk-based testing framework, which enables the prioritization of testing efforts according to the probability and possible effects of errors or vulnerabilities. The primary objective of this framework is to improve software quality assurance and optimize the allocation of limited testing resources by focusing testing efforts on the most relevant areas of the AUT. Current methodologies for RBT frequently lack a unified strategy that can effectively and thoroughly discover, evaluate, and prioritize risks across various components or functionalities of software systems. Moreover, the incorporation of real-time application data for the purpose of Risk Assessment and prioritizing has not been thoroughly investigated. This research aims to fill these existing gaps by introducing and evaluating a novel risk-based testing approach. The framework utilizes the functionalities of the Raygun software an error-tracking and monitoring tool in order to collect real-time data on application faults and exceptions. The utilization of this information, in conjunction with an organized risk matrix, will facilitate the correlation and classification of detected risks in terms of their severity and likelihood of occurrence. By prioritizing testing efforts on areas with higher risk, the proposed framework intends to provide a systematic and efficient approach to software quality assurance.

1.3 Research Objectives

The main objectives of this research work are:

- To identify and categorize different types of potential risks that might lead to software failures.
- To propose a Risk-based testing framework that incorporates the use of Raygun and a risk matrix for prioritizing testing efforts as well as to identify high-risk areas of the application under test.
- To evaluate the proposed Risk-based testing framework with a detailed validation questionnaire in order to measure the efficiency and effectiveness of the framework on testing process, and on the overall quality of the software under test.
- To analyze and explore the outcomes of the framework and to identify strategies for mitigating the challenges.

1.4 Relevance to National Needs

The use of Risk based testing can identify and mitigate potential risks and vulnerabilities in safety and security of critical software systems, which can prevent system failures, data breaches, and other security incidents that can have serious national implications. Risk based can contribute in the development of high-quality and reliable software systems that can support various national initiatives and programs. For instance, RBT can be applied to software systems used in government agencies that are responsible for managing public resources, such as taxes, social security, and healthcare. By developing a framework for risk-based testing the industry can improve the quality and reliability of software products, which can boost their reputation and competitiveness in the global market.

1.5 Areas of Application

The framework can assist in the following areas:

- During software development and in maintenance where the failure can have severe consequences.
- Development of safety and security critical systems.
- Software testing processes

- This can also be used to prioritize testing of critical financial system components to ensure their availability and security.

1.6 Advantages

Followings are the advantages of this research work:

- The framework developed as a result of this study will aid in prioritizing the testing of high-risk components, ensuring that testing resources are utilized effectively.
- The study will enable the testing teams to prioritize testing efforts on high-risk components and allocate testing resources accordingly, resulting in a reduction in testing time and expenses.
- This strategy will considerably enhance the software's overall quality, making it more reliable, secure, and resilient.
- This study will aid in establishing credibility with stakeholders, boosting their confidence in the software and decreasing the risk of costly failures.

1.7 Thesis Organization

The research work has been organized and distributed in the following chapters:

- **Chapter 1**: This chapter provides insights on introduction, objectives of research, relevance to national needs followed by areas of application, advantages and justification of the topic.
- **Chapter 2** : Review and analysis of previous published works that how Risk Based Testing contributes in overall software process by optimizing resources. An overview of previous published articles summarizing different Risk Based testing approaches and methodologies.
- **Chapter 3**: Discuss the overall research methodology including, Overview of Proposed framework followed by the application and implementation of proposed model.
- **Chapter 4**: Discuss the case study performed in order to validate the propose framework.
- **Chapter 5**: Discuss the detailed validation performed by domain experts.
- **Chapter 6**: This Chapters presents the results and objective achieved by the proposed framework.
- **Chapter 7**: Concludes the research with results validation and provides direction for future work.

Chapter 2

Literature Review

2.1 Introduction

Chapter 2 offers a thorough analysis of the extensive previously published research in this particular field. This chapter provides an in-depth analysis of the various methodologies, techniques, and approaches that have been examined by scholars in the domain of software quality assurance. This highlights the development of Risk-based testing, outlining its development and illustrating its use in numerous circumstances, ranging from safety-critical systems to object-oriented software. Through a critical evaluation of the findings and insights obtained from these studies, this literature review not only provides a retrospective analysis of the field but also highlights existing trends, challenges, and emerging areas of research in the domain of Risk-based testing. This chapter serves as a fundamental basis for understanding the previous work done on Risk-based testing and acts as an outline for the remaining chapters in this research.

2.2 Related Work

The literature review is an essential element of scholarly research, as it implies a comprehensive examination and evaluation of relevant academic literature related to a particular study topic or inquiry. The fundamental objective of this literature is to conduct a thorough and comprehensive analysis of the existing body of knowledge within a particular field of study. The primary objective of a literature review is to examine and integrate existing research papers in a critical manner, with the intention of identifying significant patterns, trends, and discoveries that enhance the comprehension of a certain subject.
Azeem Uddin et al., in [1] "Importance of Software Testing in the Process of Software Development" highlight the essential significance of software testing in ensuring the

quality and reliability of software systems. Software testing is generally a process of evaluating and validating software in order to ascertain its compliance with user requirements and its proper functioning. The paper discusses the historical context of software crises, including incidents of significant failures that have been attributed to inadequate testing. The mentioned failures, such as the Northeast Blackout in 2003 and the Arian 5-Space Rocket disaster in 1996, serve to highlight the serious implications that occur due to improper testing. Their paper highlights the significance of applying appropriate software testing techniques, tools, and expertise in software testing in order to prevent severe failures. This analysis reveals multiple reasons that contribute to these failures, encompassing the involvement of inexperienced developers, evolving consumer requirements, and a rapid increase in software costs. However, it argues that the most significant factor contributing to these failures is the absence of extensive testing.

The author in [2] emphasizes that it is an undeniable fact that errors and faults are an inherent part of the software development process. The importance of testing to identify and fix these issues is widely acknowledged by the majority of organizations. The testing phase frequently comprises of a significant proportion, roughly 40%, of the total cost associated with software development. This cost highlights the significance attributed to the process of testing during the development phase. As the demand for software of high quality and optimal efficiency persists, organizations face increasing pressure to improve their software testing methodologies. The focus on improvements highlights the ever-changing role of software testing and its essential significance for delivering reliable and effective software products and services.

F. K. Mohd et al., highlight the significance of testing in the software development lifecycle in [3], they emphasize the importance of initiating testing at an early stage to seamlessly integrate it with the process of determining requirements. The authors state that the main objective of testing is to verify if there are any discrepancies in any phase of the software development lifecycle. Testing plays an integral part in maintaining the integrity and ensuring the quality of the software development process.

Michael Felderer in [4] specifies the significance of RBT. According to him (RBT) is a recognized testing technique that puts significant emphasis on the evaluation and management of potential risks inherent in a software product. This approach serves as the primary factor in directing decision-making throughout the different phases of the testing process. These activities include the many stages of testing, particularly test planning, design, implementation, execution, and assessment. RBT approach is a pragmatic and extensively acknowledged strategy that seeks to address the issue of limited testing resources by strategically prioritizing scenarios that have the potential to trigger critical situations within a software system. Risk estimation is a fundamental component of the Risk-based Testing (RBT) process, as it plays a crucial role in determining the importance of risk values assigned to tests. This evaluation directly impacts the overall effectiveness and quality of the risk-based testing process. In this particular

context, risks are defined as the probability of undesirable events taking place and the potential consequences that these events may have on predetermined objectives.
Regression testing is an essential and crucial procedure that verifies and validates software's quality after any modification. However, executing the entire regression test suite is time-consuming, costly, and tedious, which frequently results in budget and schedule constraints [5]. As a result TCP is utilized to enhance regression testing by rescheduling test cases in a manner that improves defect detection. The authors acknowledge that conventional approaches for TCP frequently fail to consider the dynamic and contextual aspects of software risks. In order to address this discrepancy the authors used a systematic approach for prioritizing test cases based on risk factors. The analysis is initiated by identifying potential risks that may be linked with each system method. This includes carrying out an extensive review of the software's architecture, functioning, and interactions in order to identify possible vulnerabilities. A prioritization approach has been used that considers both the severity of the risks and the criticality of the associated system methods. Test cases that are associated with risks of high severity and critical procedures are given greater priorities for execution [5].
Omdev Dahiya et al., in [6] outlines the basics steps involved in RBT. According to their analysis software testing has undergone significant development, encompassing a range of dimensions and objectives that extend beyond the mere identification of defects subsequent to the coding phase.

- **Risk Identification**
  The process of identifying risks is an essential element in risk management. Identifying potential risks as early as possible in the project development cycle can prevent damage or delays from accomplishing business objectives. Stakeholders' active participation can assist in the identification of potential risks, particularly those that may have an impact on the quality of the product.

- **Risk Assessment**
  This involves evaluating potential risks and their associated impacts in order to make proactive decisions and develop appropriate strategies to mitigate or manage those risks. The purpose of this phase is to assess the severity of risks and the likelihood of their occurrence, allowing the development of plans to effectively manage or reduce these risks.

- **Risk Mitigation**
  Risk mitigation refers to the implementation of measures to minimize potential risk. The process includes monitoring and tracking of identified risks, evaluating their effectiveness, and modifying testing efforts according to the degree of risk. The testing techniques applied may need to be more particular for higher-level

risks, whereas lower-level risks can be effectively addressed using less extensive methods.

- **Risk management**
  This involves the evaluation and measurement of potential risks in order to develop and execute efficient risk management strategies. The use of efficient risk management practices contributes to an organization's comprehensive understanding of its internal structure and operational processes.

Currently, the scope of testing has expanded to include the evaluation of multiple attributes, such as portability, dependability, maintainability, efficiency, and compatibility. Within the framework of the SDLC, a significant proportion of resources and efforts are allocated to the critical process of software testing. Nevertheless, despite the diligent endeavors of testing teams, the effectiveness of testing frequently fails to meet anticipated outcomes [7]. Insufficient testing practices have resulted in financial setbacks and societal challenges. Although the idea of conducting exhaustive testing may appear to be a viable approach, it is frequently deemed impossible due to limitations in terms of time and resources. The main objective is to identify and expose a maximum number of defects. In order to accomplish this objective, it is necessary to select from a range of testing methodologies, as it is impractical to utilize all available options simultaneously [8].
The process of choosing effective approaches is highly desirable, although it poses a significant challenge due to a lack of information regarding the costs, efficiency, and comparative efficiency of those techniques. Obtaining this information can be challenging due to several aspects such as the choice of programming language, kind of software, planned actions, and the specific testing settings involved [9]. Numerous scholarly assessments endorse the utilization of varied testing methodologies; yet, this approach may prove to be resource-intensive and inefficient due to the potential duplication of efforts. Hence, it is imperative to conduct a comparative analysis and assessment of testing methodologies in terms of their efficiency [26].
RBT is recognized as a highly effective methodology. The prioritization of test cases based on risks ensures that testing is directed towards the most critical aspects. Each risk is linked to specific test activities, and these actions are carried out in a prioritized manner. This methodology involves monitoring of identified risks, wherein technical and business professionals collaborate to assess the magnitude of risks associated with application features and align them with corresponding test cases. The prioritization of test cases is determined by their level of risk, with tests that pose a higher risk being given priority. Tests with low levels of risk may be excluded due to limitations in time and financial resources. RBT provides a distinct approach wherein test cases are prioritized based on their potential impact on the business and consumers, as opposed to aiming to identify all defects, irrespective of their relevance. This methodology aims to achieve an optimal balance between comprehensive testing protocols and limitations

imposed by available resources [6].
RBT is a fundamental and crucial approach that plays a critical role in assuring the quality and reliability of software. The process involves a systematic evaluation of possible risks linked to a software system and the subsequent allocation of testing efforts in accordance with these risks. This methodology has attracted considerable interest and has been thoroughly investigated in scholarly publications. Numerous scholars have put forth novel approaches and conceptual frameworks intended to improve the effectiveness of risk-based testing.
Jahan et al., [5] in their work "Risk-Based Test Case Prioritization by Correlating System Methods and Their Associated Risks" presented a semi-automated approach for test case prioritization, utilizing software modification information and the relationships between invoked methods. Van Veenendaal [11] in "Practical Risk-Based Testing" – "The PRISMA Approach" proposed a thorough methodology for enhancing the process of risk-based testing by means of product risk management. Various previous published works have explored the topic of risk estimation. Felderer et al., [10] in "Experiences from an initial study on risk probability estimation based on expert opinion" made valuable contributions in improving the understanding of risk assessment within the context of testing. Haisjackl et al., [11] in "Integrating manual and automatic risk assessment for risk-based testing," proposed a methodology that integrates manual and automated risk assessment techniques to optimize the testing procedure. The sources mentioned collectively emphasize the importance of risk-based testing in the field of software quality assurance. They also provide insightful information on the ongoing efforts to improve and develop testing techniques through the application of risk assessment. Risk-based testing is an essential component of software testing since it enables the allocation of testing resources to components of the software that are more prone to errors and vulnerabilities.
The authors in [12] provides an introduction to the fundamental concepts of risk analysis in the context of software testing. Additionally, the paper integrates practical metrics for the evaluation of risk. The inclusion of a case study focused on a financial application serves as a demonstration of how these risk analysis techniques can be effectively employed within a practical context. Their article establishes the fundamental basis for comprehending the crucial connection between risk assessment and software testing, highlighting its significance in ensuring the quality and reliability of software.
F. Redmill in [7, 22] offers a thorough investigation into risk-based testing and its related implications. The scope of his research extends beyond the limits of methodology and explores the wider implications associated with the use of risk-based testing inside software development projects. By providing valuable perspectives on potential benefits, it emphasizes the importance of prioritizing risks during the testing phase. The author in [22] provides a comprehensive analysis of risk-based testing, incorporating both theoretical frameworks and actual implementations. The mentioned resource serves as a link connecting theoretical concepts with practical applications, making

it a highly significant resource for both scholars and professionals in the field. The inclusion of both theoretical foundations and practical factors facilitates a thorough comprehension and effective use of risk-based testing procedures.

2.3 Types of Software Risk

Software's increased complexity and integration into critical systems bring many concerns. In the proposed Risk-based testing framework that prioritizes testing of high-risk components, understanding these risks is critical. The framework evaluates and addresses SUT vulnerabilities, problems, and uncertainties. This framework will help organizations to efficiently allocate testing resources by identifying, evaluating, and prioritizing software risks, ensuring that the most critical components are thoroughly tested, and improving software quality, reliability, and security. This research discusses software risks and their importance in risk-based testing.

2.3.1 Technical Risks

Technical Risks arise due to uncertainties or difficulties in implementing new or unverified technologies during the software development process. These can include compatibility, integration, performance, and security issues. Failure to manage technical risks may lead to system failures, security vulnerabilities, or unanticipated performance issues [27].

2.3.1.1 Performance Risks

These issues occur when software does not match the specified performance criteria. These are risks related to speed, efficiency, and scalability.

2.3.1.2 Security Risks

These are related to the vulnerabilities and risks associated with the security of software systems. They include data breaches, unauthorized access, and cyber security concerns.

2.3.1.3 Integration Risks

These are associated with the process of integrating software with other systems or components. These include compatibility concerns and dangers associated with application programming interfaces (APIs).

2.3.2 Project Risks

Risks associated with a software development project include variables that may impact the project's management and execution. These risks may involve project planning, resource allocation, project scope, and project administration. Failure to effectively manage project risks can lead to project delays, cost overruns, and a failure to meet project objectives. Effective project risk management requires the proactive identification, evaluation, and mitigation of risks [28].

2.3.2.1 Schedule Risks

Schedule risks are one of the most prominent challenges in software project management. When project timelines are inaccurately estimated, resulting in potential delays and cause estimation risks. Changes to the project's scope can result in scope creep, which can lengthen the duration of the project. To mitigate schedule risks, organizations frequently employ project management methodologies, experienced project managers, and scheduling tools to effectively manage and monitor project timelines.

2.3.2.2 Personnel Risks

Schedule Human factors within the project team create personnel-related risks. These risks include the departure of important team members, which can result in knowledge gaps. When team members lack the necessary expertise to effectively complete project tasks, there are skill gaps. Ineffective communication can result in misunderstandings and delays. Creating a supportive team environment, providing continuous training, and ensuring clear and effective team communication are required to mitigate personnel risks.

2.3.2.3 Requirement Risks

Misunderstandings, ambiguity, or alterations to the project's requirements create requirements-related risks. When new requirements are introduced without appropriate evaluation, scope creep occurs. Effective requirements risk management requires rigorous requirement collection and documentation, ongoing requirement verification and validation, and a formal change control procedure to manage scope modifications.

2.3.3 Quality Risks

The potential problems with the software's functionality, dependability, and maintainability are referred to as quality risks. Inadequate testing, inadequate quality assurance processes, or a lack of resources can result in these risks. If quality risks are not addressed, post-release defects and customer dissatisfaction may result. [27].

2.3.3.1 Functional Risks

Functional risks relate to issues with the intended functionality of the software. These include lacking features that users expect, incorrect calculations, and functionality gaps that reduce the software's effectiveness. To mitigate these risks, exhaustive testing, user acceptance testing, and strict adherence to explicit and comprehensive functional specifications are required.

2.3.3.2 Reliability Risks

Reliability risks include the consistency and predictability of the software's performance. Reliability risks involve system failures, data corruption, and a failure to recover effectively from errors or unexpected events. Mitigation strategies include rigorous testing, fault-tolerance mechanisms, and error-handling procedures.

2.3.3.3 Maintainability Risks

Maintainability risks relate to the software's ability to be easily maintained and updated. These are usually due to complex, and convoluted code, a lack of documentation, and excessive component coupling, making modifications difficult. Maintainability risks can result in higher maintenance costs and a delayed response to changing user requirements. Clean and well-documented code, adherence to coding standards, and modular architecture design are essential for mitigating these risks.

Table 2.1 offers an overview of scholarly articles organised into three main concepts: Risk assessment and integration, Risk-based testing methodologies, and Risk-based testing fundamentals. The first concept covers the fundamental ideas and importance of Risk-based Testing in software quality assurance. The next concept covers different Risk-based testing techniques and methodologies, like regression testing and automated test case generation and the last articles emphasise that how risk assessment is included into the software testing process and how it helps to maximise testing efforts and enhance product quality.

Table 2.1. Scholarly articles reviewed in this study

No	Concept	Description
1	Risk-based testing Fundamentals[5], [14], [19], [20]	Fundamental concepts and methodologies of RBT. These explain the theoretical foundations and practical applications of RBT, as well as its significance and potential advantages in software quality assurance.
2	Risk-based testing Methodologies [17], [18], [21], [7], [22], [23], [24], [25]	Focuses on identifying various strategies and methodologies for RBT. Involves an extensive range of approaches and techniques used in RBT, such as regression testing based on specification, automated test case generation, and case studies.
3	Risk Assessment and Integration [10], [11], [12], [13], [15], [16]	Describe the seamless integration of risk assessment into the software testing process. These explore numerous methodologies and techniques for evaluating and effectively managing risk,emphasizing the significance of risk analysis in optimizing testing efforts, improving product quality.

2.4 Summary

The scholarly articles reviewed in this literature review make substantial contributions in the area of risk-based testing. The authors present novel strategies and methodologies aimed at enhancing the efficiency of testing endeavors through the prioritization of test cases according to their associated risks. Certain scholarly articles included in the related work emphasize on improving the accuracy of risk estimation by using expert opinion and organized frameworks, however, others investigate the integration of manual and automated risk assessment to enhance testing procedures. At the end of related work a number of scholarly articles presented in tabular form in Table 2.1 offer valuable insights into the implementation of risk-based testing methodologies, including heuristic strategies and regression test selection based on specifications.

Chapter 3

Proposed Methodology

3.1 Introduction

This chapter presents an in-depth analysis of the conceptual framework for the Risk-Based Testing, which serves as a fundamental element of this research. The objective of this chapter is to present a concise yet comprehensive understanding of the framework being proposed, its components, and their interactions, establishing the foundation for the succeeding stages of the research. The importance of a practical and flexible testing framework has become essential as software systems increase in complexity. The research methodology employed in this study provides a systematic approach for developing and validating the essential framework. The conceptual model presented includes various phases and essential elements as well as the interaction of these components, facilitating streamlined testing procedures, providing valuable insights into areas of potential risks, and leveraging the real-time data capabilities of Raygun. In this chapter, a comprehensive analysis is presented of these entities, their respective functions, and the dynamics of communication among them, encompassing their integration with Raygun. The objective is to provide a comprehensive understanding of the structure and functioning of the framework, enhanced by the real-time error-tracking capabilities offered by Raygun.

3.2 Overview of Proposed Framework

The development of an effective Framework for risk-based testing involves several important phases. It all begins with the important phase of risk identification, which identifies any potential risks to the project. This phase includes a comprehensive risk assessment involving a variety of stakeholders, such as the development and quality assurance teams, business analysts, and project managers. After the risks have been

identified, it is essential to evaluate their severity.
In addition to their potential impact on the project, risks are evaluated based on their likelihood of occurrence. This evaluation serves as a requirement for prioritizing these risks and focusing testing efforts on the most critical components and features. With an adequate understanding of the risk identified, the next phase is to determine the optimal testing approach for each high-risk component and feature. This often requires an optimized combination of testing methods, such as manual testing for complex, high-impact components and automated and exploratory testing for others. The testing objectives, test cases, and methods to be employed for each high-risk component are subsequently outlined in a comprehensive test plan. This plan also includes essential resources such as test data and the setup of a suitable testing environment. After executing the tests according to the determined plan, it is essential to closely monitor the results. However, the process does not conclude here; this forms a cycle of continuous improvement. The risks are regularly re-evaluated, and the testing approach is modified when needed to accommodate changes in the project environment. Based on the results of testing, components, and features may be added or removed from the high-risk list.

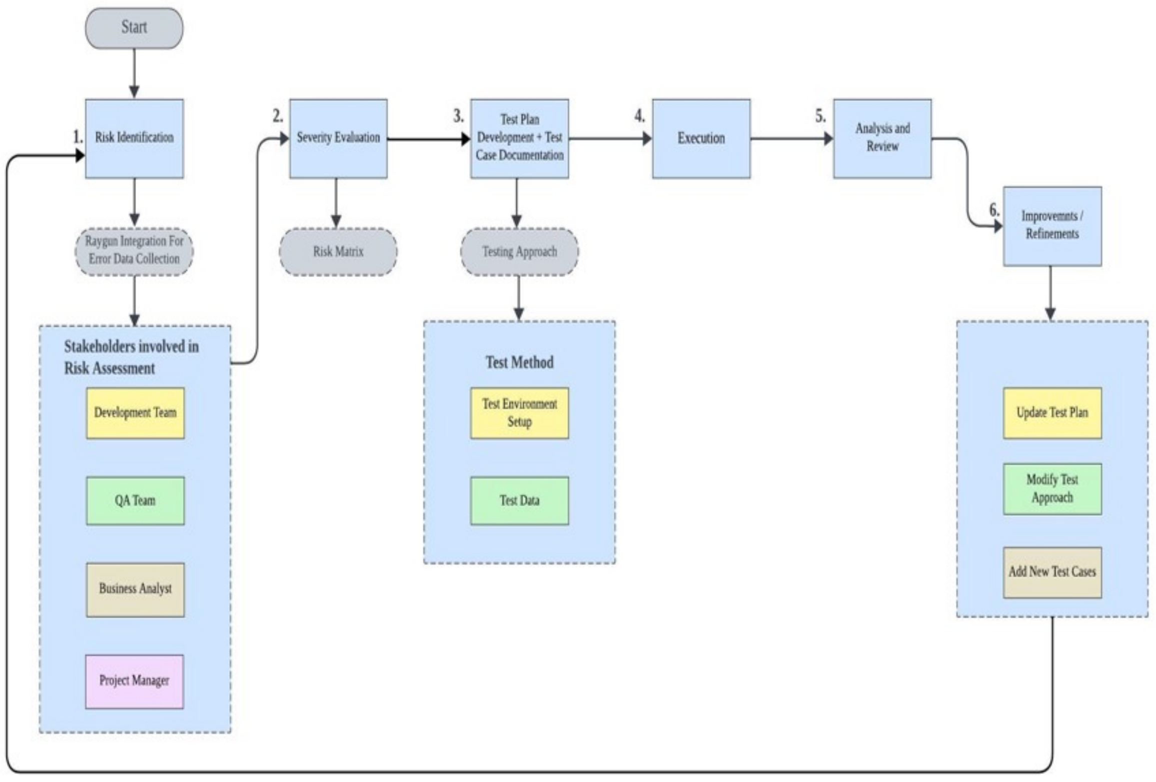

Figure 3.1: Proposed framework for Risk-Based Testing

3.3 Proposed Framework Description

The proposed framework provides a structured road map that directs testing efforts towards the most critical components of a project, ensuring that resources are allocated effectively. This framework can be particularly vital for experts desiring to strike a balance between comprehensive testing and efficient resource utilization. Systematically identifying and prioritizing risks is the framework's primary objective. This ensures that software professionals can focus their attention on high-risk components and features, where potential issues could considerably impact the project's overall quality. This targeted testing not only improves the likelihood of early detection of critical defects but also enables the efficient utilization of resources. By focusing their efforts precisely where it matters most, experts can maximize their testing resources. This optimization leads to accelerated testing processes and cost savings. Essentially, the Risk-based testing framework equips professionals to make informed decisions, allocate resources carefully, and ensure the robustness and quality of software systems efficiently.

Following is the detailed depiction of each phase:

3.3.1 Phase 1

The primary objective of the initial phase of the Risk-based testing framework is to identify potential software project risks. This incorporates various categories of risks, such as security risks, performance risks, and functional risks. To accomplish this, a detailed risk assessment process is conducted, with the participation of key stakeholders from the development and quality assurance teams, business analysts, and project managers. This phase ensures an exhaustive and accurate identification of risks by incorporating multiple perspectives, laying the groundwork for effective risk-based testing.
The integration of Raygun for error data collection in the initial phase of the Risk-based testing framework is an essential step towards improving the overall efficiency as well as effectiveness of the testing process. Raygun robust error tracking and real-time monitoring capabilities provide the framework with an extensive range of benefits. By integrating Raygun, the RBT framework acquires the ability to capture real-time error data, offering valuable insights into the software's performance and reliability. This data enables proactive identification of defects, allowing for faster response times and decreasing the likelihood of critical issues slipping through testing. As a result, testing becomes more focused on the components and features that are most likely to contain vulnerabilities or bugs, ensuring that high-risk areas are exhaustively tested.
In addition, Raygun collection of error data provides an exhaustive view of how the software behaves in various scenarios. Not only does this data assist in identifying defects, but it also aids in determining the root causes of problems. It provides a distinct

path for the testing team to follow when addressing and resolving issues, resulting in more efficient problem resolution and preventing future occurrences of similar defects. This integration of Raygun streamlines the communication and collaboration between development and quality assurance teams. Testers can provide developers with comprehensive error reports, including stack traces and user information, thereby making the testing process more efficient. This collaborative approach facilitates the detection and correction of errors, thereby optimizing the testing procedure.

3.3.2 Phase 2

After the risks have been identified, the next phase involves evaluating the identified risks in terms of their potential impact on the project and the likelihood of their occurrence. This evaluation assists with prioritizing the identified risks according to their severity. The severity assessment serves as a guide for determining the testing approach for each component and feature with a high-risk level. Risks with greater severity receive greater attention, ensuring that the most vital components of the project are exhaustively tested, thereby mitigating the likelihood that severe defects will negatively impact the final product.

Table 3.1. Risk Assessment Matrix

Risk Level	**Description**	**Likelihood (L)**	**Severity (S)**	**Risk priority (LxS)**
Low	Risks with a minimal impact on the project	Unlikely	Negligible	Low
Medium	Risks with a moderate impact that can be managed	Possible	Serious	Medium
High	Risks with a significant impact that need attention	Likely	Moderate	High
Critical	Risks with a severe impact requiring immediate action	Very Likely	Critical	Critical

The Risk Matrix is an integral part of the proposed Risk-based testing framework, playing a significant role in prioritizing the testing of high-risk components and features. It functions as an interactive tool for assessing and categorizing risks based on their likelihood and severity, enabling project teams to make informed decisions regarding where to allocate testing resources. Each risk has been assigned a likelihood and severity rating in this matrix. The Likelihood (L) scale indicates the likelihood that a risk will occur, whereas the Severity (S) scale measures the potential impact that risk could have on the project. By multiplying these ratings (L x S), the matrix determines a Risk Priority that assists teams in identifying and focusing on the most important risks. The Risk Matrix provides a systematic approach to risk assessment, allowing project managers and stakeholders to more efficiently allocate resources. The matrix's color coding identifies high-priority risks for immediate attention, ensuring that the most critical components and features are exhaustively tested. This not only improves the project's quality but also contributes to effective resource management, resulting in a more robust and dependable software application. This matrix is used during the risk identification and assessment phase of the proposed framework. Stakeholders can assign each risk a likelihood and severity rating, and the risk priority can be calculated. The framework can then focus testing efforts for SUT on high and critical risk areas to ensure they are thoroughly tested and mitigated.

- **Risk Level**
  Risks are classified according to their potential impact.

- **Description**
  The description briefly explains the level of risk.

- **Likelihood (L)**
  Likelihood (L) determines the probability that a given risk will occur; it is commonly assigned as a rating of low, medium, high, or very high.

- **Severity (S)**
  Severity (S) measures the potential implications of the risk and is classified as either negligible, moderate, serious, or very critical.

- **Risk Priority (L x S)**
  Risk Priority (L x S) allows the prioritization of risks and is calculated as the product of likelihood and severity. Higher priorities for risks require more immediate attention.

3.3.3 Phase 3

This phase focuses on the development of a comprehensive test plan. The testing objectives, specific test cases, and methodologies to be utilized for every high-risk component and feature are outlined in this plan. Furthermore, it contains provisions for essential resources such as test data and the setup of the testing environment, thus ensuring a structured and planned testing process. This phase ensures that all risks are rigorously addressed by adding an additional level of precision to the testing process through the documentation of the test cases. In the third phase, the testing approach for each high-risk feature and component is also determined according to their severity. Due to the fact that not all testing methods are applicable in all circumstances, this phase may include a combination of exploratory testing, automated testing, and manual testing, customized to the particular requirements of each component. Critical security risks, for instance, might require exhaustive manual testing, whereas performance risks can be effectively evaluated via automation. This phase ensures an appropriate allocation of resources and makes certain that the testing approach is in accordance with the risk profiles of each component of the project, thereby optimizing efficiency and scope.

3.3.4 Phase 4

During the execution phase of the Risk-based testing framework, the testing teams follow the comprehensive test plan that has been carefully developed. This phase implies the proactive execution of the RBT approach, placing particular emphasis on the high-risk components as well as features specified in the plan. The testing team executes test cases rigorously, following the suggested approaches and strategies that are specifically developed to identify potential vulnerabilities in these critical components. By employing the structured testing approach, the most vulnerable components of the software are carefully evaluated, which is consistent with the primary objective of improving the quality of the project. Meanwhile, thorough observation constitutes an essential element of the execution phase. This process comprises an evaluation of testing outcomes in real-time, which enables early identification of any potential problems that might appear in the high-risk components. Early identification of issues is essential as it allows for the quick rectification of potential defects and maintains the testing procedure's flexibility and responsiveness. Hence, the execution phase is critical in which the theoretical framework transforms into a practical, systematically reinforcing the application against potential vulnerabilities while improving its overall reliability.

3.3.5 Phase 5

This phase of the Risk-based testing framework signifies an important phase in the testing lifecycle. The continuous flow of this process is distinguished by the regular reevaluation of risks, which highlights the importance of being flexible in light of the evolving project requirements. In this context, the testing approach is not static but rather adaptable, capable of being modified in response to emerging insights acquired from testing results and changes in the dynamics of the project. This observation demonstrates a proactive approach by recognizing that the risk profile of a project is susceptible to modification. Consequently, in order to effectively adapt to these changes, the testing approach should be flexible. The key component of this stage resides in continuous monitoring and adaptation. Regularly reevaluating the risks enables the testing team to remain informed of any modifications that may occur in the risk context of the project. The ability to adapt ensures that the testing efforts remain aligned with the current risk profile, thereby optimizing the allocation of resources and concentration on testing. Implementing this proactive strategy not only improves the framework's ability to withstand challenges but also enhances its significance over the course of the project's life cycle. Fundamentally, this phase signifies a continuous commitment to continuous improvement, ensuring that the RBT Framework maintains its strength and adaptability as a framework for maintaining software quality.

3.3.6 Phase 6

In the final phase, the Risk-based testing framework exhibits a constant commitment to continuous improvement. During this phase, the framework is refined in accordance with the insights obtained from the testing outcomes and the valuable input provided by stakeholders. Facilitating planned adjustments, functions as an essential feedback cycle, allowing the testing team to refine the framework through iteration. In this particular context, continuous improvement might involve making modifications to the test plan, integrating additional test cases to enhance coverage, or implementing implicit modifications to the test plan as a whole. Due to this phase's iterative nature, the RBT Framework provides a dynamic and adaptable resource. The ability to incorporate observations obtained from testing efforts and interactions with stakeholders is essential for maintaining its continued applicability. Through ongoing improvement, the framework aligns itself with the dynamic project environment, thus ensuring its continued importance in RBT approaches. Being committed to improvement is not simply a final requirement; rather, it is a deeply rooted concept that develops a sense of excellence and flexibility in the testing procedure. Therefore, the framework undergoes development to become a reliable and effective method for identifying, assigning priority to, and mitigating risks at every stage of the software development life cycle.

To summarize, the Risk-based testing framework comprises six phases that have been carefully designed to form a robust strategy for organizing testing efforts in relation to high-risk features and components. The implementation of this comprehensive approach signifies a fundamental change in the field of software testing, as it abandons traditional, resource-intensive techniques in favor of a more focused and effective testing process. The strength of the framework resides in its ability to systematically identify, evaluate, and rectify risks at every stage of the software development lifecycle, thus ensuring that critical components receive the necessary attention they require. Through its emphasis on high-risk components, this framework effectively improves the overall quality of the software product. By directing testing efforts toward the most critical areas, facilitates the timely identification and resolution of potential problems.

At the same time, the framework implements a degree of resource optimization that was previously unavailable in conventional testing methodologies. With precise resource allocation, the software's most critical components are subjected to exhaustive testing. In essence, this framework serves as confirmation of the improvement of testing methodologies, providing a structured and flexible approach that addresses the complex requirements inherent in modern software development.

3.4 Justification of Proposed Model

In the dynamic field of software development, ensuring the quality of deliverables is important. Traditional testing methodologies, although fundamental, encounter difficulties while seeking to account for the constantly evolving and complicated aspects of modern software projects. Risk-based testing framework is introduced, which is intended to give priority to the testing of components that pose the highest level of risk. The reason for implementing this framework lies in its ability to improve the precision of software product testing, optimize the allocation of resources, allow timely identification of critical defects, align to agile methodologies, and, importantly, elevate the quality of software products as a whole. The following extensive justification outlines the underlying reasoning for proposing this framework and its ability to fundamentally transform software testing practices.

3.4.1 Improving testing precision

The concept of introducing a Risk-based testing framework emerges from a pressing requirement in the field of software development. Traditional testing approaches frequently allocate limited resources across every component, resulting in inefficiencies and failure to detect critical areas. Through prioritizing and allocation of testing resources to high-risk components, the framework ensures more focused and accurate testing. Ensuring such precision is important in order to identify potential issues at an early stage, thus reducing the probability that critical defects will go unnoticed. Therefore, the framework serves as an effective approach to enhance the effectiveness and accuracy of the overall testing process.

3.4.2 Resource Optimization

An important reason for the proposed framework is its ability to maximize the utilization of available resources. Conventional testing methodologies, characterized by their broad scope, can result in the allocation of significant resources towards components that are comparatively less important. On the other hand, the RBT Framework ensures an effective allocation of resources, with an emphasis on components that contain the highest potential for impact. While doing so, not only is testing conducted more efficiently, but resources are also maintained, which can be allocated to other important aspects of software development. In modern development contexts that include resource limitations and swiftness, the ability to optimize resources is of the utmost importance, making the framework valuable.

3.4.3 Early Identification of critical defects

The early detection of defects, particularly those that have significant implications, is a critical challenge in software development that is effectively addressed by the proposed framework. The framework's emphasis on evaluating high-risk components ensures that it specifically targets components where defects are more probable to result in significant consequences. Early identification of critical errors is imperative for avoiding subsequent complications that may increase the project's costs and jeopardize the ultimate quality of the product. By implementing a proactive approach, the framework mitigates the consequences of potential defects and strengthens the software's ability to overcome vulnerabilities.

3.4.4 Aligning with Agile and Iterative development

The RBT Framework is ideal for agile and iterative development methodologies, which emphasize continuous delivery and rapid change. The flexibility of the system enables instantaneous modifications to testing priorities in response to changing project requirements. Conventional testing approaches, characterized by rigid and comprehensive test plans, frequently encounter difficulties in adapting to the ever-evolving features of agile projects. The proposed framework not only adapts to but flourishes in a context where flexibility and efficiency are of the utmost importance.

3.4.5 Improved software quality

The fundamental basis for the justification is, in simple terms, the framework's impact on improving the quality of software. Through a systematic emphasis on high-risk components, the framework effectively decreases the likelihood of critical defects persistent in the ultimate product. As a result, a software product is developed that is of superior quality and fulfills or surpasses the expectations of users. As organizations strive to provide superior software solutions, the RBT Framework becomes essential in an era where user satisfaction and experience are of paramount significance.

3.5 Summary

By prioritizing high-risk components, the proposed Risk-based testing Framework represents an evolution in software testing methodologies. Through a thorough description of the six essential phases of the framework ranging from risk identification to continuous improvements this chapter has effectively highlighted a systematic and constantly evolving strategy towards testing. The integration of Raygun for the collection of real-time error data introduces an important aspect, facilitating proactive defect management. The phases of test plan development and execution ensure a comprehensive evaluation of critical components, thereby developing an effective testing environment. The inclusion of a comprehensive visual representation of the framework, which represents the six phases and the Risk Matrix, serves to enhance the clarity of the chapter and facilitates comprehension of the interaction between testing strategies and risk assessment. The diagrammatic sequence presented functions as a visual road map, providing a convenient reference point for the real-world implementation of the framework. This chapter serves as more than a technical reference; it also provides organizations seeking to improve software quality with a strategic road map. Through the prioritization of high-risk components, this framework effectively optimizes resource utilization while improving software against critical defects. The chapter's comprehensive review of each phase, along with practical implementation, establishes the RBT Framework as an innovative approach to modern software development. The subsequent chapters will explore deeper into and validate the effects of this framework on software quality, resource efficiency, and the overall success of the research.

Chapter 4

Case Study

4.1 Introduction

To evaluate the proposed framework's efficiency in practical circumstances, it is being implemented on a project currently under development within a Software and Tech consultancy company. The primary objective is to evaluate the framework's performance in a real-world context as well as its application in the organization's development processes. By integrating the framework into the ongoing project, the organization aims to determine its impact on testing processes, particularly in terms of prioritizing high-risk components. Through this implementation, the organization seeks to acquire significant information regarding the framework's efficiency, usability, and overall effectiveness in improving the testing phase of software development projects. The objective of this case study is to evaluate the proposed Risk-based testing framework for prioritizing the testing of high-risk components in the context of the Business Innovative Technologies (BIT) project. The objective of this framework is to provide a systematic and effective testing strategy, with a particular emphasis on high-risk components, in order to improve software quality assurance and optimize the allocation of limited testing resources by directing testing efforts to the most relevant areas of the application under test throughout the development stage. This case study aims to assess the framework's practicality and usefulness in real-world scenarios. The primary objective is to identify how the framework supports and improves the testing phase of the BIT project, hence contributing to the advancement of risk-based testing methods and to acquire valuable information about its practical significance, efficiency and overall impact on testing procedures for high-risk components in the BIT development life-cycle.

4.2 Scope and Criteria

The proposed framework provides a structured road map that directs testing efforts towards the most critical components of a project, ensuring that resources are allocated effectively. This framework can be particularly vital for experts desiring to strike a balance between comprehensive testing and efficient resource utilization. Systematically identifying and prioritizing risks ensures that software professionals can focus their attention on high-risk components, where potential issues could considerably impact the project's overall quality. This targeted testing not only improves the likelihood of early detection of critical defects but also enables the efficient utilization of resources. By focusing their efforts precisely where it matters most, experts can maximize their testing resources. This optimization leads to accelerated testing processes and cost savings. The criteria that are adopted to implement the framework are solely practical and result oriented.

4.3 Level of Assurance

In the context of this case study, the level of assurance regarding the validation of the proposed framework for prioritizing testing of high-risk components is notably high. The practitioners engaged in this validation process are experts within their respective domains and possess a thorough understanding of the proposed framework. These individuals bring extensive experience and expertise in software development, testing methodologies, risk management, and project management. Their involvement ensures a comprehensive evaluation of the framework's applicability and effectiveness within the specific context of the Business Innovative Technologies (BIT) project. With their deep domain knowledge and practical insights, the practitioners are well-equipped to assess how the framework can enhance the testing phase and contribute to the overall success of the BIT project. This high level of expertise among the practitioners instills confidence in the validation process and underscores the credibility and reliability of the findings derived from this case study.

4.4 Overview of the Project

The BIT (Business Innovative Technologies) platform is a company that utilizes the BIT platform to sell or purchase goods and services to other registered businesses. This type of business is associated with a business account managed by the Super-Admin, which enables them to manage their online store by performing various tasks such as listing items, setting prices, managing inventory, processing orders, and tracking sales. Moreover, a BIT BUSINESS-USER can take advantage of the platform's payment processing and shipping features to streamline their operations and offer a hassle-free buying experience to their customers.

4.5 Framework Implementation

4.5.1 Project Objective

The objective of the BIT project is to develop a comprehensive platform that facilitates seamless transactions between registered businesses for buying and selling goods and services. The platform aims to streamline business operations by providing features such as online store management, inventory tracking, order processing, and integrated payment processing and shipping capabilities. The overarching goal is to create a user-friendly and efficient platform that fosters growth and collaboration among businesses.

4.5.2 Identification of the Actors Involved

Different actors involved in BIT are:

- Super-Admin
- Business-User
- Customer
- Inventory Manager
- Order Fulfillment Manager
- Payment Processor
- Shipping Provider
- Marketing Manager
- Technical Support Staff
- Financial Analyst
- Product Manager
- Quality Assurance Tester Analyst
- Compliance Officer
- System Administrator

4.5.3 User Stories

BIT system functional requirements are gathered via Epics and User Stories which specifies the user requirements and the behavior of the system. Some user stories identified are as under:

- As a Business-User, I want to list my products on the platform to attract potential customers.
- As a Customer, I want to search for specific products easily to find what I need.
- As a Super-Admin, I want to approve new business accounts to ensure legitimacy.
- As an Inventory Manager, I want to track inventory levels to prevent stock outs.
- As an Order Fulfillment Manager, I want to process orders efficiently to meet customer expectations.
- As a Payment Processor, I want to securely process transactions to protect sensitive information.
- As a Shipping Provider, I want to receive shipping details to deliver orders promptly.
- As a Marketing Manager, I want to run promotional campaigns to increase sales.
- As a Technical Support Staff, I want to assist users with platform-related issues to ensure a positive experience.
- As a Financial Analyst, I want to generate financial reports to analyze business performance.
- As a Product Manager, I want to gather feedback from users to improve platform features.
- As a Quality Assurance Tester, I want to test platform functionality to identify and report bugs.
- As a Data Analyst, I want to analyze user behavior to improve platform usability.
- As a Compliance Officer, I want to ensure platform compliance with regulatory standards.
- As a System Administrator, I want to maintain platform security to protect user data.

4.5.4 Use Cases

Some use cases identified are as under:

- Register Business Account
- Add Product Listing
- Search for Products
- Approve Business Account
- Track Inventory
- Process Customer Orders
- Process Payment Transaction
- Manage Shipping Details
- Run Promotional Campaign
- Provide Technical Support
- Generate Financial Reports
- Gather User Feedback
- Test Platform Functionality
- Analyze User Behavior
- Ensure Regulatory Compliance
- Maintain Platform Security
- Update Platform Features
- Monitor Sales Performance
- Resolve Customer Issues
- Backup Platform Data

4.5.5 Identification of high risk components and the risks involved

1. **Payment Processing**

   Payment processing involves following risk factors:

   - **Data Security**

Payment processing involves the management of sensitive data such as credit card numbers, bank account information, and personal identifiers. Furthermore, compliance with regulations such as PCI DSS (Payment Card Industry Data Security Standard) is required to avoid data breaches and ensure secure data storage.

   - **Fraud Prevention**

It is critical to use robust fraud detection techniques (such as anomaly detection and machine learning models). Real-time monitoring tools must be in place to identify and report suspicious transactions.

   - **System Reliability**

High availability is critical since downtime immediately affects revenue and consumer trust. Load balancing, redundancy, and failure measures must be used to ensure continuous system operations.

2. **User On-boarding**

   User On-boarding involves following risk factors:

   - **Security**

User onboarding is vulnerable to attacks such as phishing, man-in-the-middle, and social engineering. Implementing multi-factor authentication (MFA) and secure password management techniques can help to mitigate these risks.

   - **Data Integrity**

The integrity and consistency of user data during the onboarding process are significant. Using validation procedures (e.g., CAPTCHA, email verification) helps ensure that the data acquired is authentic and secure.

- **User Experience**

Onboarding processes that are too complicated or time-consuming can cause user drop-offs. A/B testing and user feedback loops should be focused on to improve and expedite the process while ensuring security.

3. **Inventory Management**

   Inventory Management involves following risk factors:

- **Accuracy and Real-time Data**

Inventory management systems must support real-time data synchronisation across several channels (e.g., online shopfronts and physical warehouses). Implementing a robust database management system (e.g., distributed databases, NoSQL databases for scalability) is critical for ensuring precise inventory records.

- **Integration**

The ability of the system to integrate with other corporate operations (such as sales and procurement) is critical. API-driven architectures and microservices can help manage these integrations while ensuring data integrity across the platform.

4. **Order Fulfillment**

   Order Fulfillment involves following risk factors:

- **Accuracy**

Order accuracy is ensured by comprehensive data validation at multiple stages of the fulfilment process. Automated barcode scanning and RFID technology can help reduce human error.

- **Integration with Logistics**

Order fulfilment frequently requires integration with third-party logistics providers. Secure, real-time API integrations are required to provide seamless data exchange, such as order tracking, inventory updates, and shipment status.

- **Scalability**

During peak periods (e.g., holidays, sales events), the system must scale effectively. Cloud-based solutions with autoscaling capabilities can help in managing the additional load while maintaining performance and accuracy.

5. **Shipping Integration**

   Shipping Integration involves following risk factors:

- **Real-time Data**

Carriers must provide real-time information to ensure accurate shipping. Webhooks or push APIs for live tracking, as well as robust error-handling techniques, are required to ensure accurate delivery information.

- **Cost Management**

Dynamic pricing algorithms should be integrated to calculate shipping costs based on weight, dimensions, destination, and shipping speed. Cost prediction models can help in budgeting and avoiding unexpected expenses.

6. **Financial Reporting (Invoices)**

   Financial Reporting (Invoices) involves following risk factors:

- **Compliance**

Financial reporting must conform to various regulatory standards. Automated compliance checks should be used to guarantee that all financial data is correct and correctly documented.

- **Data Integrity**

Ensuring the correctness of financial data involves analysing inputs, and maintaining historical data for audits and reviews.

- **Security**

Given the sensitivity of financial data, encryption (at rest and in transit) is critical. Access to financial data must be limited using role-based access control (RBAC) and permissions matrix.

7. **Business User Management**

Business User Management involves following risk factors:

- **Access Control**

User management requires strong authentication systems, such as single sign-on (SSO) and multi-factor authentication (MFA). Role bases access control (RBAC) should be used to control permissions, ensuring that users only have access to the data and functions required by their role.

- **Activity Logs**

Detailed logging of user actions (e.g., access and modification logs) is critical for tracking changes and identifying potential security incidents. These logs should be kept secure and accessible only to authorised individuals.

8. **Dashboard**

Dashboard involves following risk factors:

- **Data Accuracy**

Dashboards collect data from a variety of sources, therefore ETL (Extract, Transform, Load) processes must be structured to handle data inconsistencies and errors. Real-time data processing techniques can be used to ensure that data is presented on time and accurately.

- **Visualization**

Dashboard UI and functionality must be optimised to meet users' requirements. Dynamic and interactive data visualisations, allow better decision-making.

- **Performance**

Dashboards frequently query large data sets, therefore performance optimisation techniques like indexing, caching, and database partitioning should be used to ensure quick response times and smooth user interaction.

9. **Subscription Packages**

Subscription Packages involves following risk factors:

- **Billing Accuracy**

Subscription systems must handle recurring payments correctly. To prevent billing problems, implement automated billing systems that enable multiple payment gateways and currency conversions.

- **Service Continuity**

Any disruptions in subscription management (for example, failed payments or improper billing cycles) can result in service interruptions. The failures should be handled using failover techniques and retry logic.

- **Customer Retention**

Personalisation algorithms (such as recommendation systems can improve the user experience and retention. Furthermore, prediction algorithms can be utilised to identify high-risk consumers and take preventive measures.

10. **User Management**

    User Management involves following risk factors:

- **Account Security**

User management includes essential security features such as secure password storage, authentication protocols (e.g., OAuth) and session management. To prevent brute force attacks and account takeovers, rate limiting and IP blacklisting are required.

- **Data Privacy**

Compliance with privacy legislation involves careful management of user data, such as encryption, anonymity, and the implementation of data retention policies.

- **Scalability**

User management solutions must be scalable to accommodate a large number of users and concurrent sessions. Horizontal scaling should be used to maintain performance under excessive load.

Table 4.1. High-Risk Components and Summary of Reasons for Classification

Component	**Summary of Reasons for High Risk Classification**
Payment Processing	Involves sensitive financial data, high risk of fraud and errors, critical for maintaining customer trust.
User On-boarding	Essential first interaction with users, complex process, potential security vulnerabilities.
Inventory Management	Requires precise stock level accuracy, significant financial implications, impacts operational efficiency.
Order Fulfillment	Critical for ensuring order accuracy and timely delivery, directly affects customer satisfaction, prone to integration issues.
Shipping Integration	Essential for accurate shipping information, risk of delivery delays, increased costs, and logistical complexity.
Financial Reporting (Invoices)	Necessitates financial accuracy, compliance with regulatory standards, involves handling sensitive financial data.
Business User Management	Manages user permissions, potential security risks, and operational disruptions.
Dashboard	Aggregates complex data for decision-making, requires high data accuracy.
Subscription Packages	Ensures recurring billing accuracy, service continuity, and customer satisfaction.
User Management	Involves account security, authentication and authorization processes, risk of data breaches.
Third Party Integration	Manages dependencies, impacts overall functionality and security, risk of service disruptions.

4.5.6 Risk assessment matrix

Once the high risk components are identified, risk assessment is used for assessing and categorizing risks based on their likelihood and severity. Each risk has been assigned a likelihood and severity rating in this matrix. The Likelihood (L) scale indicates the likelihood that a risk will occur, whereas the Severity (S) scale measures the potential impact that risk could have on the project. By multiplying these ratings (L x S), the matrix determines a Risk Priority that assists teams in identifying and focusing on the most important risks. The Risk Matrix provides a systematic approach to risk assessment, allowing project managers and stakeholders to more efficiently allocate resources.

High-risk components of the BIT project are prioritized according to their likelihood and severity in the risk assessment matrix. Critical severity is assigned to Payment Processing, Financial Reporting (Invoices), and Third Party Integration due to their significant impact on financial transactions, regulatory compliance, and system functionality. Because of its importance to both security and user experience, user on boarding is significant and categorized as serious. Inventory management, order fulfilment, shipping integration, business user management, dashboards, and subscription packages are classified as moderately severe because of their operational significance and possible influence on customer satisfaction. Although user management is essential to security, its impact is rather minimal, giving it a moderate level of severity. Focused testing on components with the greatest possible influence is ensured by this approach.

Table 4.2. Risk assessment matrix

High risk components	**Likelihood (L)**	**Severity (S)**	**Priority (L x S)**
Payment Processing	Possible	Critical	High
User On-boarding	Likely	Serious	High
Inventory Management	Likely	Moderate	Moderate
Order Fulfillment	Unlikely	Serious	Low
Shipping Integration	Possible	Moderate	Moderate
Financial Reporting	Possible	Serious	High
Business User Management	Likely	Moderate	Moderate
Dashboard	Likely	Moderate	Moderate
Subscription Packages	Possible	Critical	High
User Management	Likely	Moderate	Moderate
Third Party Integration	Unlikely	Critical	High

4.5.7 Test plan development

4.5.7.1 Features to be tested (In-Scope)

- Payment Processing
- User On-boarding
- Inventory Management
- Order Fulfillment
- Shipping Integration

- Financial Reporting (Invoices)
- Business User Management
- Dashboard
- Subscription Packages
- User Management
- Third Party Integration

4.5.7.2 Features not to be tested

- Edit Account Information
- Create Multiple Accounts

4.5.7.3 Estimation

- Total hours required for testing high risk modules: 75 hours

4.5.7.4 Staffing

- Manual Tester: 1
- Automation Tester: 1

4.5.7.5 Training

- Selenium web driver, PyCharm
- Duration: 10 hours

4.5.7.6 Test levels

- System Testing
- Acceptance Testing

4.5.7.7 Exit Criteria

- Testing is finished and there are no functional bugs
- All remaining bugs have low severity
- No more than 10% of medium-severity bugs are open

4.5.7.8 Suspension Criteria

- Critical Bugs are open and they are blocking testing
- All remaining test cases are blocked by an open bug

4.5.7.9 Test deliverables

- Test Cases
- Bugs Report
- Test Summary Report

4.5.7.10 Test Environment

- Operating System: Windows 10
- Server: QA Staging Server, Sandboxing
- Browser: Google Chrome

4.5.7.11 Test References

- Requirement Documents
- User Stories
- Figma Design
- System Design

4.5.8 Analysis and review

- Review test results for identified high-risk components
- Analyze defects and areas of improvement
- Evaluate test coverage and effectiveness of testing strategies
- Identify any gaps in test cases or execution

Table 4.3. Metrics used for the validation

Metrics	**Proposed RBT Framework (BIT)**	**Traditional Approach (Shahadah)**
Resource Allocation	2 Tester/QA assigned	2 Tester/QA assigned
Testing Approach	Risk based testing framework	Exhaustive testing, smoke testing and regression testing
Time Per Component	5 hours/ Day	7 hours/ Day
Total hours	75 hours	184 hours
Cost	Calculated based on hourly rates of Tester/QA	Calculated based on hourly rates of Tester/QA
Efficiency	Higher	Lower
Potential Cost Savings	Higher	lower
Overall effectiveness	Higher	lower

4.5.9 Improvements

- Enhance test coverage
  - Identify and include additional test scenarios to cover edge cases and potential vulnerabilities
- Refine test cases
  - Update test cases based on feedback from testing iterations to improve accuracy and effectiveness
- Optimize testing process
  - Streamline testing procedures and methodologies to reduce testing cycle time and improve efficiency
- Test automation
  - Test automation tools and frameworks should be introduced to automate repetitive test scenarios and increase testing coverage
- Improve documentation
  - Documentation standards should be improved for test plans, test cases, and test results to enhance traceability and facilitation future testing efforts.

The table 4.3 compares two testing approaches for software quality assurance: the proposed Risk-Based Testing (RBT) framework (BIT) and the traditional testing approach (Shahadah). Both approaches assign the same number of testers/QA individuals, ensuring an equal assessment in terms of human resources. However, the most important variation is in the testing approaches they utilise. The RBT framework prioritises the testing of high-risk components, resulting in a more targeted and efficient approach. The traditional methodology, on the other hand, employs exhaustive testing, smoke testing, and regression testing, all of which are more extensive and repetitious. The RBT framework has a significant advantage in terms of time management efficiency. According to the table, the RBT framework requires only 5 hours per day for each component, whereas the traditional approach requires 7 hours per day. This difference amounts to 75 hours for the RBT framework against 184 hours for the old technique, demonstrating a significant time-saving benefit. This time efficiency is critical for project management, especially when resources and timelines are strictly constrained. Cost is another important element in which the RBT framework excels. Both approaches compute expenses based on the hourly rates of testers/QA workers, but the RBT framework's concentrated strategy yields more potential cost savings.

4.6 BIT User Flows

4.6.1 Registration and Onboarding

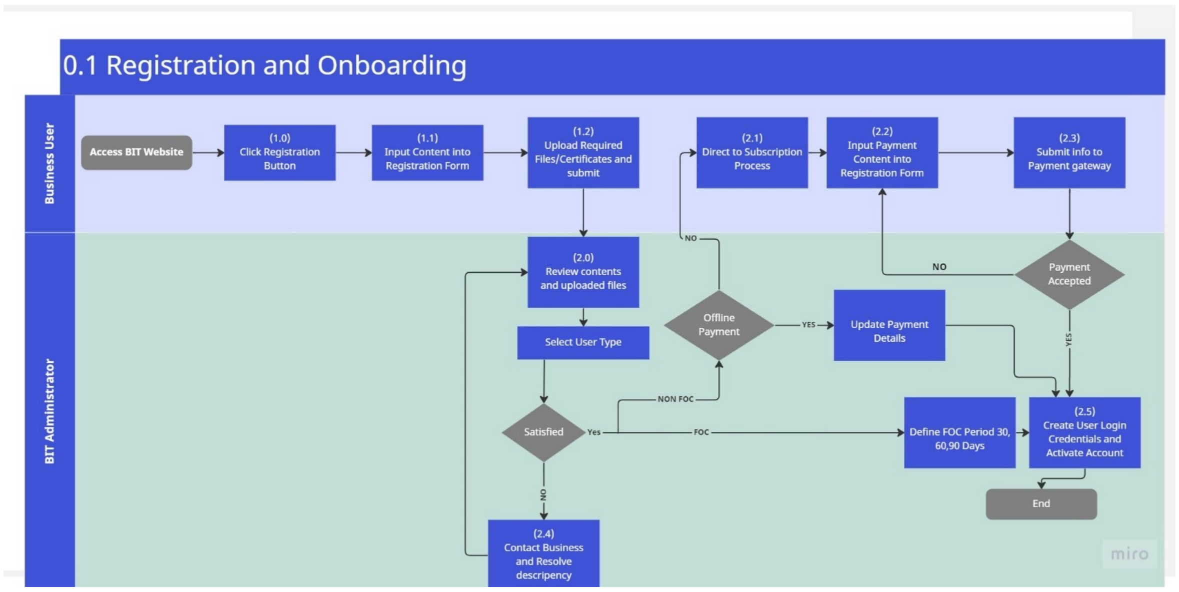
0.1 Registration and Onboarding
Business User
BIT Administrator
Access BIT Website
(1.0) Click Registration Button
(1.1) Input Content into Registration Form
(1.2) Upload Required Files/Certificates and submit
(2.1) Direct to Subscription Process
(2.2) Input Payment Content into Registration Form
(2.3) Submit info to Payment gateway
(2.0) Review contents and uploaded files
Select User Type
Satisfied
Yes
NO
(2.4) Contact Business and Resolve descripency
NON FOC
FOC
Offline Payment
NO
YES
Update Payment Details
Payment Accepted
NO
YES
Define FOC Period 30, 60,90 Days
(2.5) Create User Login Credentials and Activate Account
End
miro

Figure 4.1: Registration and Onboarding

Fig 4.1 shows registration and onboarding of a business user. A BUSINESS-USER of BIT platform is a company that utilizes the platform to sell or purchase goods and services to other registered businesses. This type of business is associated with a business account managed by the Super-Admin, which enables them to manage their online store by performing various tasks such as listing items, setting prices, managing inventory, processing orders, and tracking sales. Moreover, a BIT BUSINESS-USER can take advantage of the platform's payment processing and shipping features to streamline their operations and offer a hassle-free buying experience to their customers.

4.6.2 Product Management

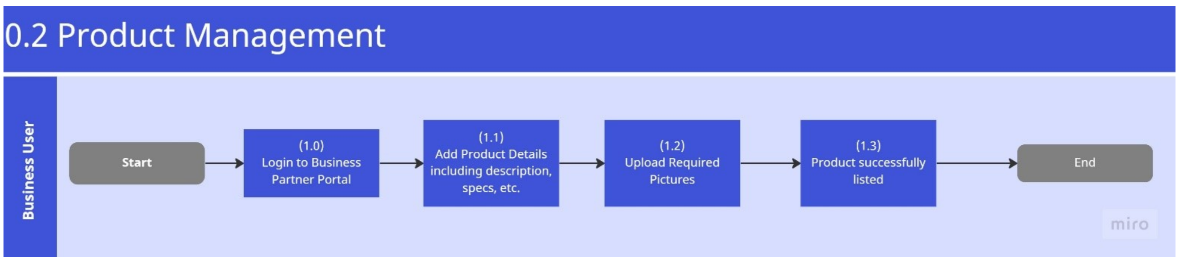
0.2 Product Management
Business User
Start
(1.0) Login to Business Partner Portal
(1.1) Add Product Details including description, specs, etc.
(1.2) Upload Required Pictures
(1.3) Product successfully listed
End
miro

Figure 4.2: Product Management

Fig 4.2 shows that Product management at BIT involves the process of creating and managing products as shown in Fig 2.2. This includes tasks such as adding new products, updating product information and pricing, categorizing products, and managing inventory levels

4.6.3 Order Management

Fig 4.3 shows that a BUSIENSS-USER can proceed to the order checkout using the order management process. The manual payment system will allow customers to complete their purchase transactions by making payments through payment options available on the BIT. The BUSINESS-USER will select the checkout using order management and supplier will update the order status information of the BUSINESS-USER on BIT.

4.6.4 Checkout Process

The BIT portal will allow buyers to add items to their cart from sellers on the marketplace. The portal will provide a checkout page where the buyer can review the order details, such as product name, quantity, unit price and total price.

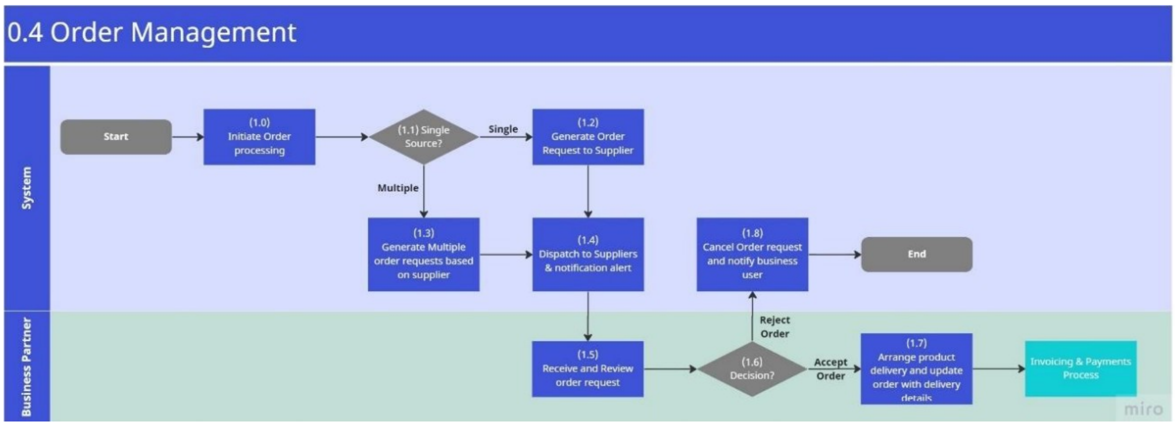
0.4 Order Management
System
Business Partner
Start
(1.0) Initiate Order processing
(1.1) Single Source?
Single
Multiple
(1.2) Generate Order Request to Supplier
(1.3) Generate Multiple order requests based on supplier
(1.4) Dispatch to Suppliers & notification alert
(1.8) Cancel Order request and notify business user
End
Reject Order
(1.5) Receive and Review order request
(1.6) Decision?
Accept Order
(1.7) Arrange product delivery and update order with delivery details
Invoicing & Payments Process
miro

Figure 4.3: Order Management

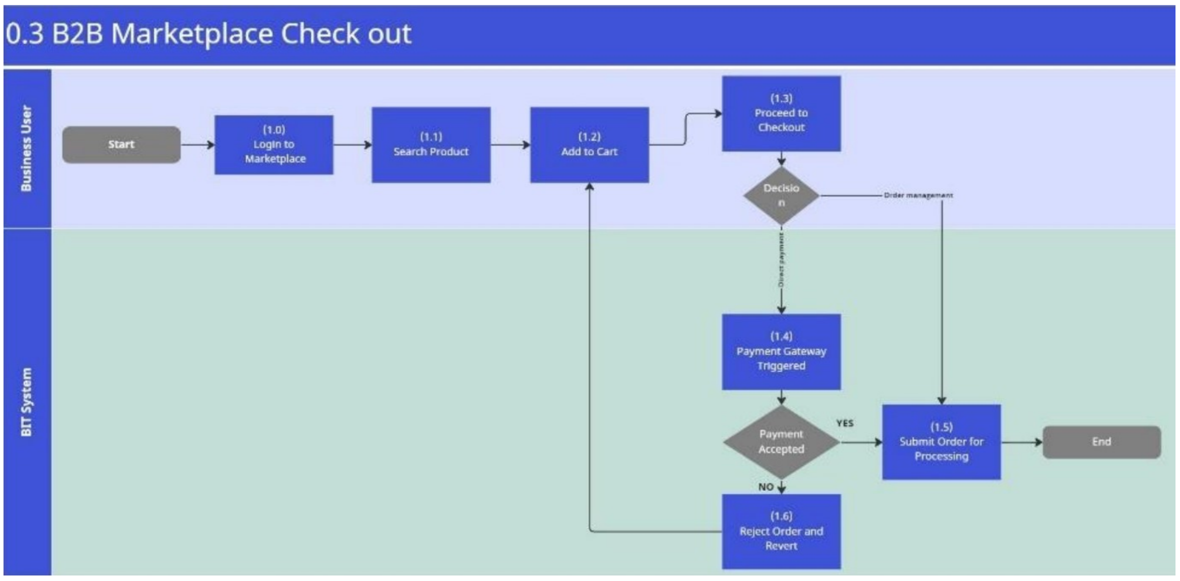
0.3 B2B Marketplace Check out
Business User
BIT System
Start
(1.0) Login to Marketplace
(1.1) Search Product
(1.2) Add to Cart
(1.3) Proceed to Checkout
Decision
Order management
Direct payment
(1.4) Payment Gateway Triggered
Payment Accepted
YES
NO
(1.5) Submit Order for Processing
End
(1.6) Reject Order and Revert

Figure 4.4: Checkout Process

4.7 Summary

By eliminating unnecessary testing efforts and focussing on high-risk componnets, the Risk based testing framework saves resources while maintaining high testing standards. The cost-effectiveness is especially beneficial for projects with tight budgets or those seeking for ways to optimise their financial resources. Overall, the Risk based framework is rated as more efficient and effective than the traditional approach. The RBT framework's focused and systematic process for identifying risks allows for more precise and effective testing. Furthermore, the adoption of real-time error data gathering systems such as Raygun improves the ability to identify and rectify issues quickly, in line with industry trends towards data-driven decision making. This comprehensive and flexible approach makes the RBT framework an effective solution for modern software testing difficulties, focussing on proactive risk management.

Chapter 5

Proposed Framework Validation

5.1 Introduction

This chapter explores the practical validation of the proposed Risk-based testing framework by collecting opinions and evaluations from a wide range of experts in the field. A comprehensive validation process is facilitated by the collaboration of several key stakeholders: project managers, quality assurance experts who possess a keen awareness of software quality, the development team, who have extensive experience in the complexities of the code base, and business analysts, who design the project requirements. This chapter explores more than a mere analysis of theoretical concepts; rather, it provides a comprehensive review of the practical implementation and effectiveness of the Risk-based testing framework. By actively involving these professionals, the objective is to obtain practical suggestions, determine the framework's compatibility with various project environments, and understand the way it complies with current standards. The validation process is an important phase in which the practicality of the proposed framework undergoes evaluation, putting its theoretical ability to the test. This chapter aims to record the valuable perspectives provided by experienced professionals, thereby promoting productive communication that strengthens and improves the RBT Framework. The integration of theory and practice in this collaborative endeavor not only enhances the research's significance but also makes the way for the future implementation of the framework into modern software development practices.

5.2 Methodology

In order to ensure a comprehensive validation of the Risk-based testing Framework, it is significant to employ an organized and structured approach. A methodology is selected that enables to utilize the extensive expertise of professionals in the field.

The primary methodology utilized in this task is a carefully designed questionnaire. The questionnaire appears as a comprehensive resource for collecting perspectives from Project Managers, Quality Assurance experts, Developers, and Business Analysts, the very people responsible for the software development. The questionnaire is intended to elicit detailed perspectives regarding the effectiveness, applicability, and feasibility of the proposed framework. In order to streamline and optimize this procedure, utilizing Google Forms as the operational framework for this survey is considered as effective source. The basic idea of the aforementioned choice is usability and accessibility. Google Forms ensures a streamlined experience for the participants, allowing them to contribute thoughtful responses to the questionnaire without encountering insignificant challenges. The survey comprises a combination of multiple-choice and open-ended inquiries. The utilization of a multiple-choice format in the assessment provides organization and enables a quantitative evaluation of perspectives regarding various facets of the framework. As a result, open-ended inquiries allow valued professionals a beneficial platform to provide nuanced feedback, suggestions, and qualitative insights. By employing this approach, the objective is not simply to provide justification; rather, fostering a collaborative environment where innovative concepts and industry knowledge come together. The primary objective is to not only validate the effectiveness of the proposed framework but also extract practical insights that will drive its improvement and amplify its practical implications. This approach ensures that the perspectives of individuals who regularly confront the complexities of software development projects will be integrated into the development of our framework.

The methodology includes the following key steps:

5.2.1 Questionnaire Design

The design of this questionnaire is a systematically composed synthesis of precision and transparency. The discussion commences with introductory inquiries that setup the context and introduce participants to the fundamental principles of the Risk-based testing framework. Following this foundation, the research seeks an exploration that includes both multiple-choice and open-ended inquiries. The utilization of multiple-choice questions offers a systematic approach to quantitatively assess particular facets of the framework. On the other hand, the open-ended questions give participants the opportunity to express nuanced perspectives, recommendations, and observations, thereby guaranteeing a thorough evaluation.

5.2.2 Selection of Participants

The selected participants are equipped with extensive knowledge and expertise in the field of software development, making them experts in their fields. The intended audience comprises Project Managers, Quality Assurance experts, Developers, and Business Analysts. By involving these experienced professionals, the objective is to encompass a wide range of opinions that accurately represent the practical challenges and demands of software development and testing.

5.2.3 Data Collection

The questionnaire serves as a foundation for acquiring valuable feedback regarding diverse aspects of the proposed Risk-Bases testing framework. The participants will be guided through a sequence of thoroughly planned inquiries, during which they will provide their perspectives on the framework's usability, effectiveness, and feasibility. The data collected via Google Forms will be a significant repository of perspectives, presenting the combined knowledge of professionals in the field.

5.2.4 Data Analysis

A quantitative methodology will be utilized to analyze the responses to the multiple-choice inquiries, allowing the identification of statistically significant observations regarding the choices and perspectives of the participants. In the context of open-ended inquiries, a qualitative approach will be utilized to classify and interpret the detailed narrative responses in a systematic manner. By using this comprehensive analysis, the objective is to not only understand the quantitative preferences but also acquire the nuanced insights and recommendations that come from the expertise of the participants.

5.3 Questionnaire Content

Questionnaire will cover different aspects of the proposed Risk-based testing Framework:

5.3.1 Introduction

The questionnaire begins with a series of introductory questions designed to obtain information regarding the participants' backgrounds. These questions will inquire about their professional responsibilities in the field of software development, their specific area of expertise, and any particular affiliations with domains or industries. By providing this fundamental information, it will be ensure that the rest of the responses will fit within the diverse professional experiences of our expert participants.

5.3.2 Current Testing Practices

Acquiring an understanding of the current context is essential in order to evaluate feedback. The participants will be requested to provide further details regarding the testing practices or methodologies that they presently utilize in their current roles. This observation establishes a foundational level by which will help in evaluation of the integration and possible enhancements that the Risk-based testing framework might introduce to current methodologies.

5.3.3 Evaluation of Framework Phases

The main component of this questionnaire is structured around the evaluation of each phase included in the proposed Risk-based testing framework. The participants will be presented with a set of multiple-choice questions (MCQs) that have been specifically designed to evaluate the efficiency and practicality of each component of the framework. The objective of this part is to collect quantitative data regarding specific aspects of the framework, allowing to determine the choices and perspectives of participants.

5.3.4 Improvement and enhancements

The open-ended section of the questionnaire seeks responses from participants regarding possible improvements that could be made to the proposed framework. This unrestricted forum allows the expression of modest recommendations, innovative ideas, and constructive evaluation. By applying the combined knowledge and skills of the participants, the objective is to highlight original perspectives that might help in the improvement and expansion of the Risk-Based Testing.

5.4 Summary

The validation phase of the Risk-based testing framework is an essential part of ensuring its feasibility and effectiveness in practical scenarios. The principal method for this validation effort is a thoroughly designed questionnaire which includes an ideal combination of introductory, evaluative, and open-ended questions. The primary component of this validation approach is the evaluation of each phase of the proposed framework. The main objective is to quantitatively evaluate the perceived effectiveness and applicability of the framework components through the use of multiple-choice questions (MCQs). By utilizing a structured approach, it becomes possible to gather nuanced data that provides useful information about the preferences and opinions of participants with regard to particular aspects of the framework. Meanwhile, the questionnaire includes an open-ended segment in which individuals are encouraged to express their perspectives regarding possible enhancements and modifications. The inclusion of this qualitative aspect provides an opportunity for participants to express novel concepts and constructive comments, thereby enhancing the validation procedure with a wide range of expert perspectives. At the end of this thesis a case study has also been included with an objective to evaluate the practicality and effectiveness of the framework in practical situations. The main objective is to determine how the framework assist and improves the testing phase in a software project, hence contributing to the enhancement of risk-based testing techniques. With the help of an extensive analysis of the proposed framework's performance, the aim is to obtain valuable information regarding the practical significance, ease of use, and overall impact on the testing procedures related to high-risk components in the development life cycle.

Chapter 6

Results and Analysis

6.1 Introduction

The results and analysis chapter is essential for the evaluation of the proposed Risk-based testing framework. This chapter is focused on analyzing the data acquired from the extensive survey that was communicated among industry experts, with a particular focus on their assessments, observations, and opinions. The primary objective is to extract significant patterns and trends from the gathered responses, thereby highlighting the framework's practicality and effectiveness. Through rigorous analysis of the data, both quantitatively and qualitatively, the objective is to derive conclusions supported by evidence that support the framework's strengths while also uncovering potential areas that require improvement. In addition, the Results and Analysis chapter will serve as a way to demonstrate the framework's adaptability in handling various types of contexts. By means of an extensive analysis of the results, the objective is to provide pragmatic understandings and suggestions for customizing the framework to suit diverse software development contexts. This chapter explores more than just the presentation of findings; rather, it involves a dynamic examination of the potential advancements, applications, and implications that emerge from the collaborative interaction with industry experts.

6.2 Analysis

Reflecting on the effectiveness, compatibility, and practicality of the proposed Risk Based Testing Framework, the extensive questionnaire responses compiled from a diverse group of industry specialists provide valuable insights.

6.2.1 Applicability across diverse software projects

While evaluating the expert feedback, it becomes obvious that the proposed Risk-based testing framework has been widely acknowledged for its effectiveness and compatibility in various software projects. The adaptability of the framework was consistently emphasized by experts from diverse fields, such as Testers, business analysts, developers, project managers, and quality assurance experts. The framework's ability for adaptability was regarded as a significant benefit, as it enabled its smooth integration into projects of diverse scopes and complexities. The participants placed significant emphasis on how the framework's flexible architecture allowed its seamless integration, making it adaptable to address the distinct difficulties presented by diverse software development scenarios.

6.2.2 Insights on Framework Application

The valuable insights regarding the practical implementation of the Risk-based testing framework were derived from the expert feedback. Several participants provided specific instances that how will they effectively integrate the framework into their ongoing projects, thereby demonstrating its practical impact. The framework received significant recognition for its ability to optimize testing processes, specifically regarding the early identification and resolution of high-risk components throughout the development process. The effectiveness of testing processes experienced a significant increase, as reported by experts, resulting in improved software quality.

6.2.3 Framework Strengths

An essential component of the analysis involved compiling the strengths of the proposed framework as analyzed by professionals in the field. Several strengths were agreed upon, such as the systematic approach employed to identify risks, the ability to adapt dynamically, and the smooth integration of Raygun for the collection of real-time error data. For resource optimization, the risk matrix, which prioritizes testing according to the severity and probability of identified components, has been viewed as a valuable measure. An additional significant strength of the framework was its ability to facilitate collaboration among cross-functional teams, thereby developing a collective understanding of project risks and testing priorities.

6.2.4 Industry and Domain

Experts with diverse knowledge and experience related to development across different domains such as Software Development mainly Mobile application development, web application development, game development, banking, healthcare systems etc., have participated and shared there valued reviews and perspectives for the proposed framework.

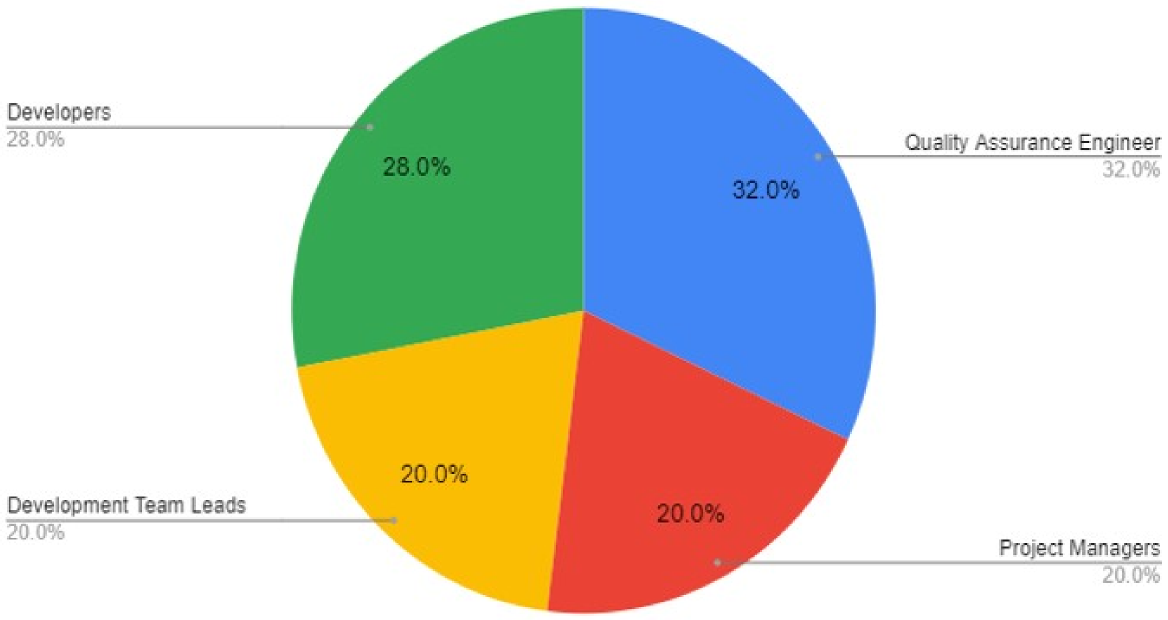

Figure 6.1: Experts involved in validation process

6.2.5 Processes used by Organizations for Risk identification in Risk Based Testing

Fig 6.2 presents the experts from different organizations and domains identified different processes that their organizations generally used in Risk-based testing such as assessing the likelihood of defects, identifying high-risk components coordination, prioritizing test cases randomly, collecting stakeholder feedback as important processes for the identification of risks.

6.2.6 Risk assessment models used by Organizations

Fig 6.3 shows different risk assessment models are being used by experts across different organizations. According to the feedback collected experts are employing models including Pareto Analysis, Risk Matrix, Cost-Benefit Analysis, and Quantitative Risk Analysis.

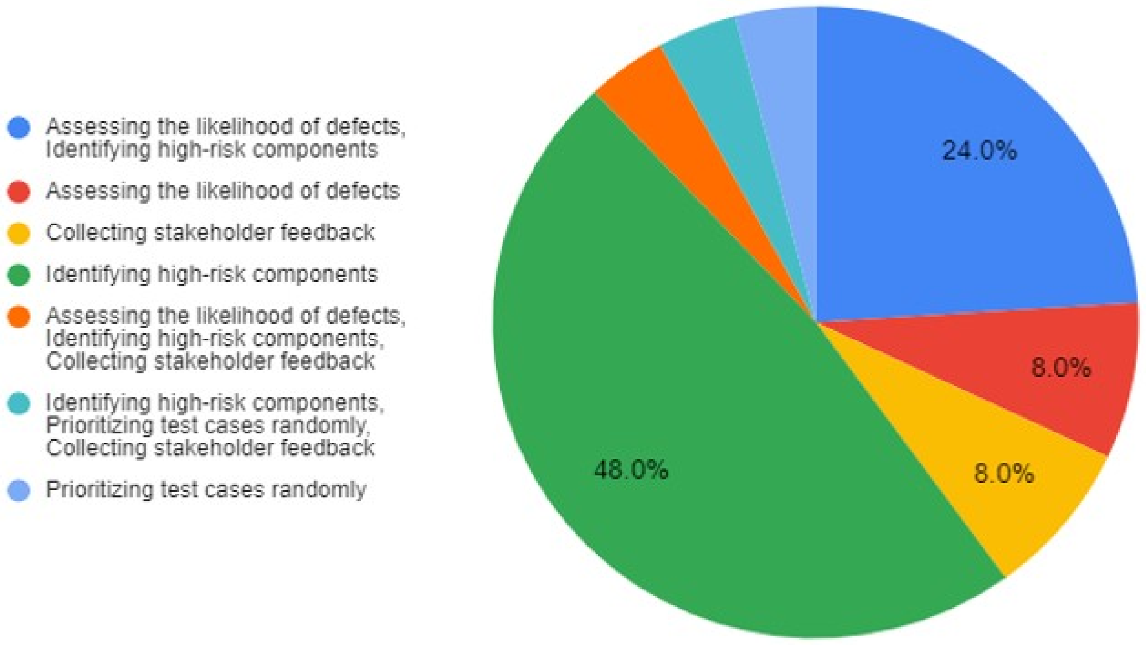

Figure 6.2: Processes used by organizations for Risk Identification

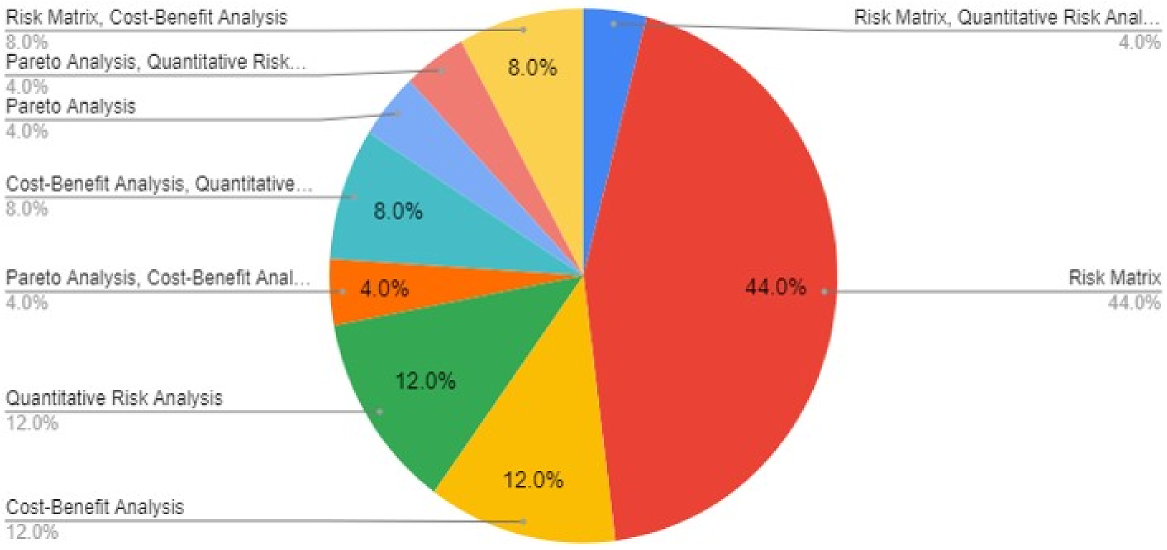

Figure 6.3: Existing risk assessment models used by Organization

6.2.7 Integration of Raygun with RBT Framework

Experts have provided their valued insights regarding the integration of Raygun with the RBT Framework. According to experts Raygun can assist in providing real time monitoring and error tracking which can be useful for the identification of high risk components.

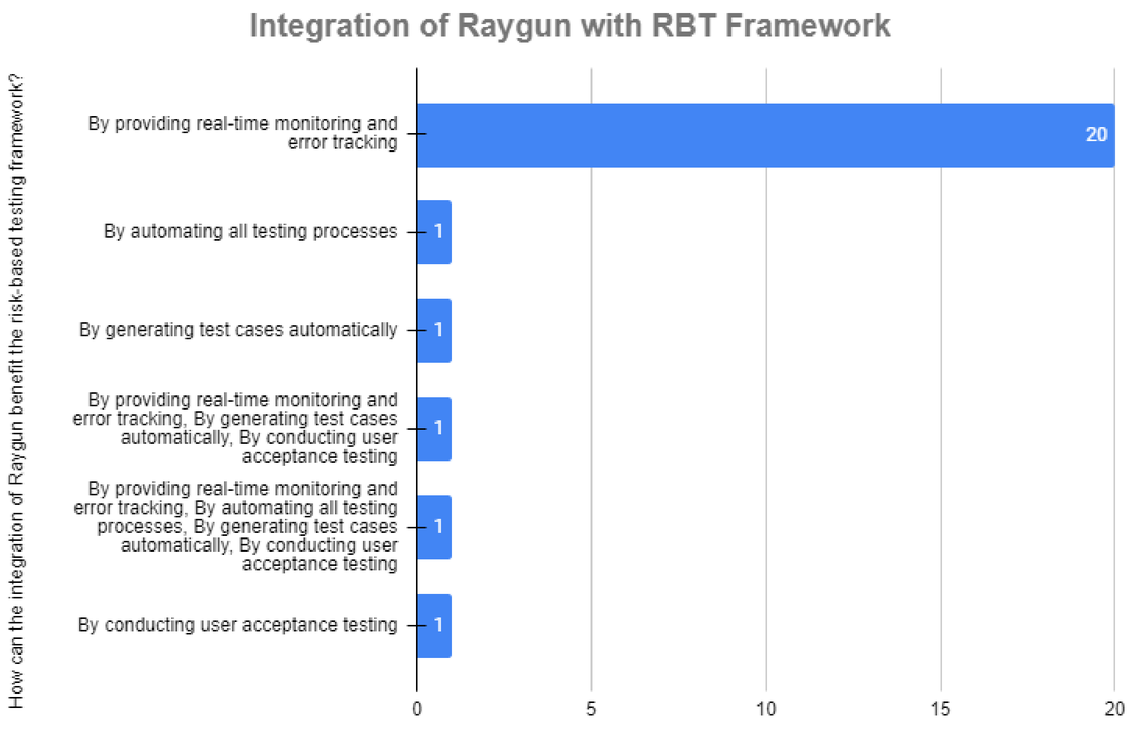

Figure 6.4: Integration of Raygun

6.2.8 Benefits of using Test Case Prioritization in testing

According to the perspectives and insights shared by experts featuring various facets of software development most suggest that Test Case Prioritization can assist in executing high risk test cases exhaustively and to execute high risk test cases first while other suggest that this can also help in executing test cases based on their creation date as expressed in fig 6.5.

6.2.9 Effectiveness of Risk Matrix in prioritizing testing efforts

The Risk Matrix is an essential part of the proposed Framework, playing a substantial role in prioritizing the testing of high-risk components and features. Fig 6.6 shows most

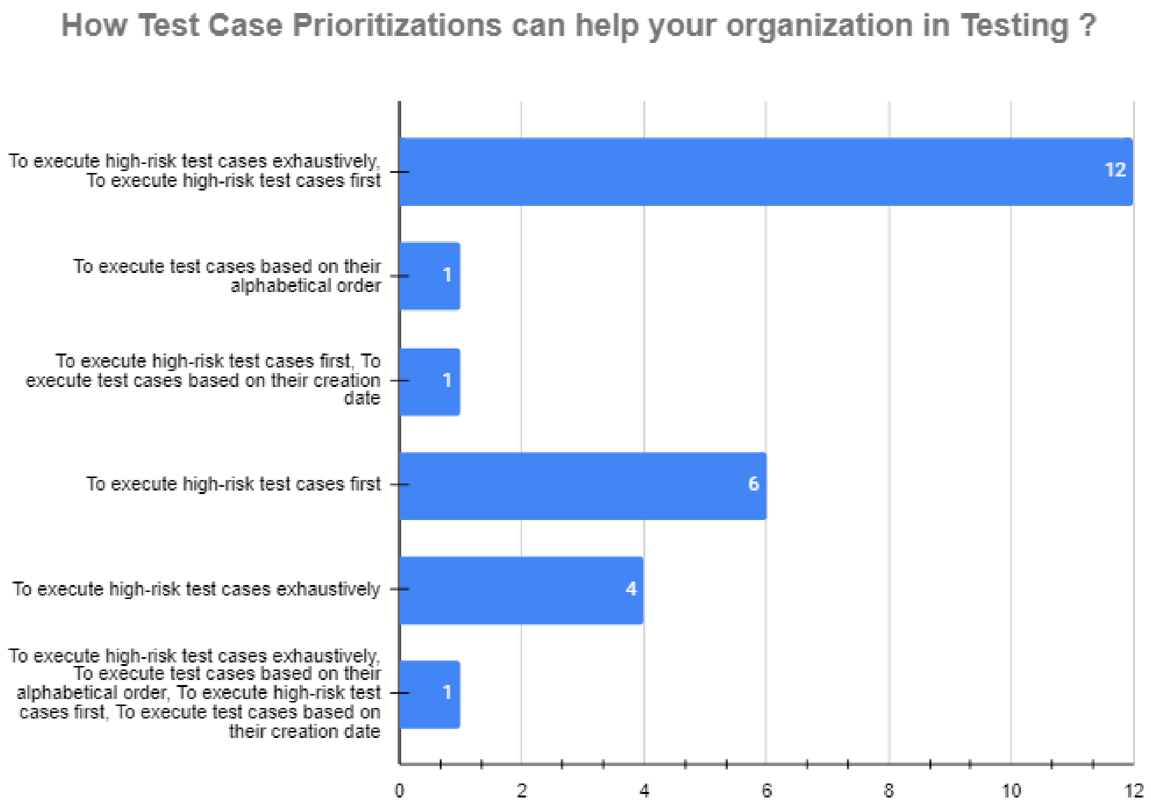

Figure 6.5: Benefits of using Test Case Prioritization

experts suggest that risk matrix can assist in categorizing risk based on their severity and likelihood while other suggest that risk matrix can be beneficial in assigning a random risk score to each component.

6.2.10 Challenges while integrating the Framework with existing development processes

Experts shared valuable insights regarding the potential challenges that can be encountered while integrating the framework with existing processes. Fig 6.7 shows that according to 52% of the total responses, challenges can be; Resistance to change from traditional testing methods while 28%, suggest that Enhanced collaboration between teams can be a potential challenge.

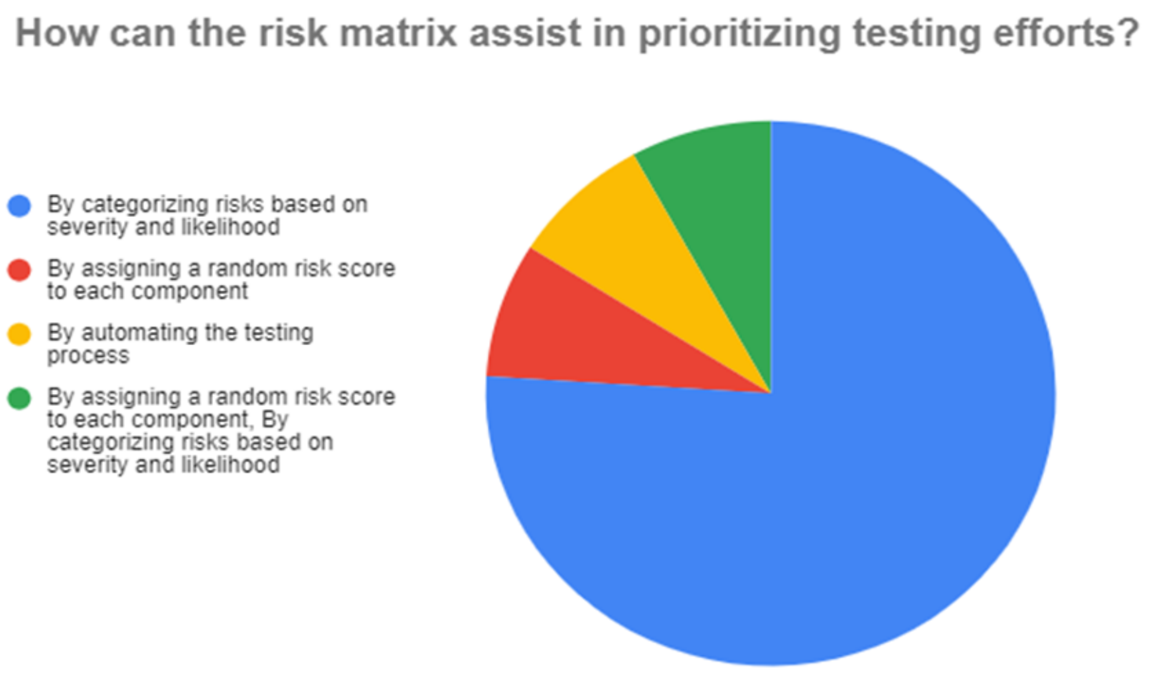

Figure 6.6: Using Risk Matrix for prioritizing testing efforts

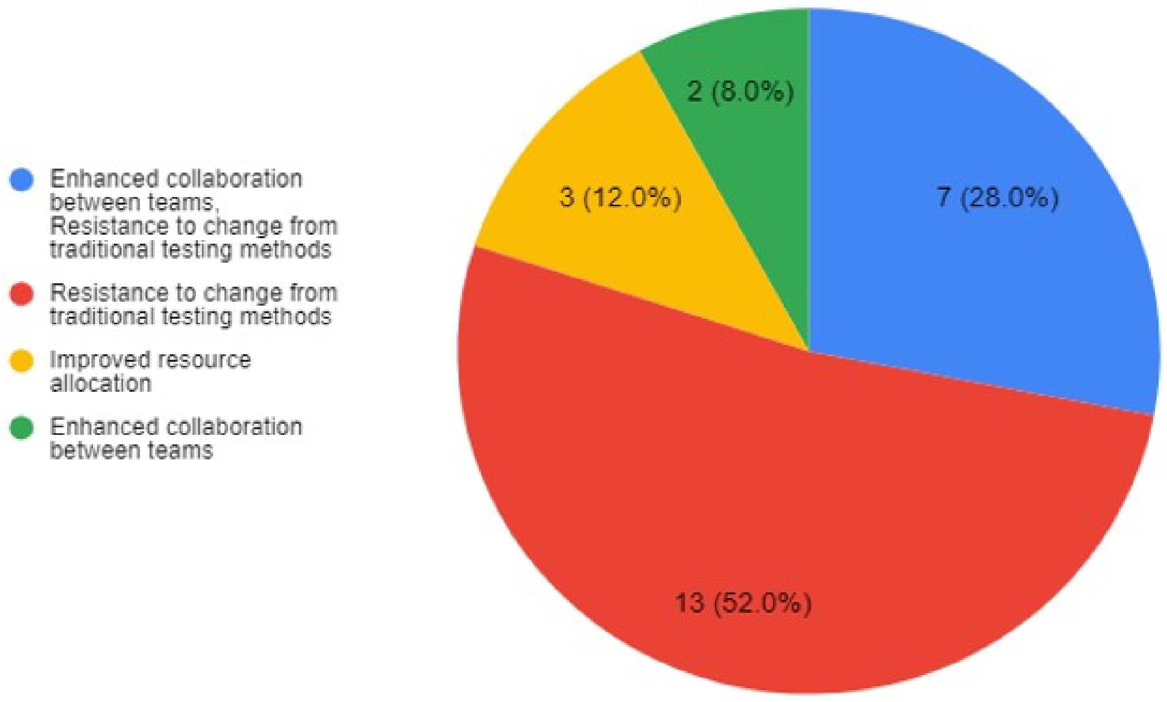

Figure 6.7: Challenges while Integrating the Framework

6.2.11 Challenges faced by experts while prioritizing risk in RBT

Experts expressed different potential challenges which in their perspectives could be encountered while prioritizing the risk in RBT. According to most of the experts the two factors i.e., Lack of stakeholder involvement and insufficient data for Risk assessment could be the important challenges while prioritizing of risks. Some experts suggest that difficulty in identifying high risk components could also be an important challenge.

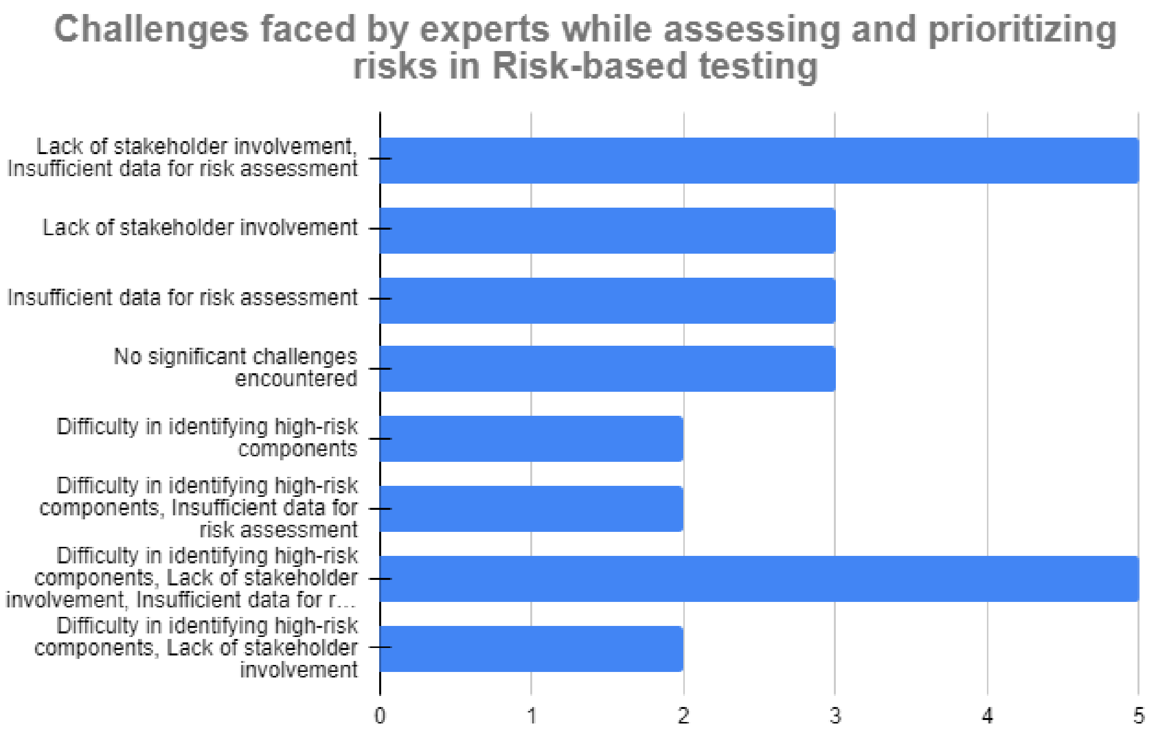

Figure 6.8: Challenges faced by experts while risk prioritization

6.2.12 Framework customization for specific projects

Experts have provided their valuable feedback regarding the customization of the framework for specific projects. Around 76% of the experts suggested that the proposed framework requires moderate effort for customization while 12% suggest that proposed framework can be customized with minimum effort

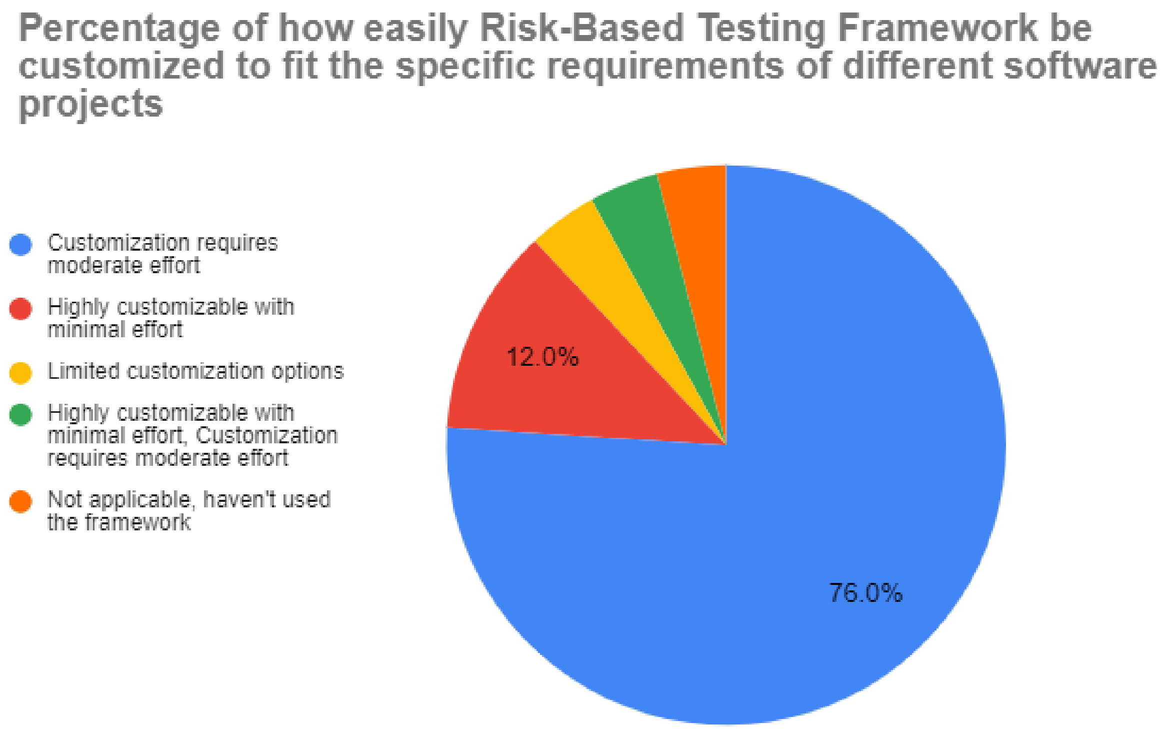

Figure 6.9: Framework customization for specific projects

6.2.13 Effectiveness of Risk Based Testing in prioritizing testing of high-risk components

A substantial percentage of experts shared that the proposed Risk-based testing framework can be effective in terms of improving defect detection and to ensure top notch software quality.

6.2.14 Strengths of the Proposed Framework

Experts have shared different insights regarding the strengths of the proposed framework such as early defect detection, risk prioritization, increasing software quality, optimizing resource allocation and strategic allocation of testing resources etc.

Table 6.1. Key Advantages of proposed framework

Proposed Framework Strengths	**Key Advantages**
Systematic Risk Identification Approach	Early identification of potential issues enables proactive risk management
Dynamic Adaptability	Seamless integration with modern development approaches
Integration of Real-Time Error Data (Raygun)	Instant identification and resolution of issues during testing
Order Fulfillment	Critical for ensuring order accuracy and timely delivery, directly affects customer satisfaction, prone to integration issues.
Risk Matrix for Prioritizing Testing	Resource optimization by focusing testing efforts on critical components
Facilitation of Cross-Functional Collaboration)	Enhanced collaboration, fostering a collective understanding of risks and priorities
Comprehensive Test Planning and Documentation	Explicit guidance for assessing testing objectives, methods, and necessary resources
Effective Communication of Risk Priorities	Enhanced understanding among stakeholders through visual risk matrix representation
Continuous Improvement	Constant refinement based on feedback, ensuring flexibility to changing project needs

6.3 Comparative analysis of the proposed Risk-based testing framework with existing models

While evaluating the proposed Risk-based testing framework for prioritizing testing of high-risk components, it is imperative to consider it in contrast to the existing Risk-based testing frameworks. Table 6.2 shows that although there are already several well-known models available, such as the IEEE 829 standard and Microsoft's Practical Software testing, the suggested framework differentiates due to its comprehensive approach and flexible adaptation. In contrast to many conventional models that primarily concentrate on risk assessment during the later stages of the software development life cycle, the proposed framework effortlessly incorporates risk considerations from the initial phases. The systematic process of risk identification provides the proactive identification of potential issues, enabling more focused testing efforts. Early integration in software development corresponds to the principles of agile and DevOps, highlighting the importance of ongoing testing throughout the entire development process. The risk matrix, an essential element of the proposed framework, presents a visual representation of the prioritizing of testing endeavors, determined by the combination of severity and likelihood. This visual description enhances the ability to rapidly and comprehensively identify the areas where testing endeavors should be focused. The proposed framework is particularly valuable in situations when effective communication of risk priorities is essential among various project stakeholders, as it addresses the common issue of the visual aspect being insufficient or less prominent in conventional models. Moreover, the use of Raygun for real-time error data collection is a distinctive feature. This not only corresponds with the industry's shift towards data-driven decision-making but also enables immediate identification and resolution of any issues during testing. This real-time feature represents a deviation from certain previous models, which might require greater reliance on historical data.

The proposed Risk-based testing framework is significant for its comprehensive and flexible approach, early integration of risk factors, graphical representation using a risk matrix, and integration of real-time error data. It introduces advancements in risk-based testing, which is in line with modern software development approaches. It focuses a strong emphasis on proactive risk management throughout the testing process. To summarize, the proposed Risk-based testing framework stands out due to its ability to adapt, continuously integrate risk, and utilize modern tools. By overcoming the restrictions of conventional models and complying with the principles of current agile approaches, it becomes a strong answer for present-day software testing difficulties. The framework emerges as a strong solution for modern software testing difficulties by overcoming the constraints of previous models and adopting a dynamic, real-time approach to risk management.

Table 6.2 shows that, despite the existence of known models such as the IEEE 829 standard and Microsoft's Practical Software Testing, the proposed framework signifies its comprehensiveness and applicability. Unlike traditional models, which frequently emphasise risk assessment in the latter stages of the software development life cycle, this framework incorporates risk considerations from the initial phase. This proactive risk identification process allows for earlier, more targeted testing efforts. This early integration is consistent with agile and DevOps approaches, which emphasise the value of continuous testing throughout the development process. The risk matrix is an important component of the proposed framework since it clearly depicts the prioritisation of testing efforts depending on the severity and likelihood of potential concerns. This improves the ability to swiftly and efficiently recognise components that require focused testing. The framework is especially beneficial in situations where effective communication of risk priorities among project stakeholders is crucial, as it addresses the typical problem of insufficient visual emphasis in traditional models. Furthermore, the use of Raygun for real-time error data gathering distinguishes this framework apart by aligning with the industry's shift towards data-driven decision-making. Unlike older models, which may rely significantly on historical data, this feature allows for the instant detection and resolution of issues during testing.

Table 6.2. Comparative analysis of proposed framework with conventional models

Concept	**Proposed Framework**	**Conventional Models**
Risk Integration	Early integration with in the SDLC	IEEE 829 standard, Microsoft practical software testing like conventional models uses this primarily during later stages of SDLC
Risk Identification Process	Provides Proactive identification from the initial phases	Traditional models lacks proactive risk identification
Risk-Matrix Utilization	Risk matrix is utilized in prioritizing testing efforts	Traditional models lacks visual representation for risk prioritization
Communication of Risk Priorities	Improves communication by utilizing a visual representation of a risk matrix	Visual representation is not sufficient for effective communication
Real-Time Error Data Integration	Integration of Raygun for real-time error data collection	Dependent primarily on Historical data which plays a more significant role
Adaptability Modern Approaches	In accordance with the principles of agile and DevOps	May lacks seamless integration with modern software development
Focus on Proactive Risk Management	Focuses significantly on proactive risk mitigation	Conventional model relies more on reactive risk management strategies

The proposed Risk-Based Testing (RBT) methodology stands out for its comprehensive and adaptable approach, early incorporation of risk elements, visual representation via a risk matrix, and real-time error data integration.

6.4 Summary

This chapter highlights the validation of results of the proposed framework effectiveness in prioritizing testing of high risk components and to ensure high quality software products. The primary objective was to extract significant patterns and trends from the gathered responses, thereby highlighting the framework's practicality and effectiveness. The flexibility of the framework was constantly highlighted by experts from various fields, such as Testers, business analysts, developers, project managers, and quality assurance experts. The framework's ability for adaptability was observed as an important benefit. Moreover the experts placed significant stress on how the framework's flexible architecture enabled its seamless integration, making it adjustable to address the diverse complications presented by various software development scenarios.

Chapter 7

Conclusion and Future Work

7.1 Conclusion and objective achieved

In conclusion, through this research a proactive Risk-based testing framework has been proposed for testing of high risk components customized for the unique encounters in software testing and quality assurance. By integrating insights from industry experts across domains such as Web application development, mobile application development, game development, AI, healthcare, banking, and finance, the framework's effectiveness has been acknowledged. The primary intentions of this research have been achieved with decisive success. The integration of Raygun, risk matrix for severity analysis and the validation from diverse experts and professionals further enhance the framework's position as a valuable tool for effective testing and for ensuring high software quality. The validation and confirmation by experienced professionals emphasize framework's pragmatic strengths and relevance. By incorporating stake holder's feedback regarding the components which can have high priority of risks the framework offers an organized yet flexible solution that upheld the potential to significantly augment testing processes. The integration of Raygun for the collection of real-time error data presents a significant aspect, enabling proactive defect management. The phases of test plan development and execution confirm a comprehensive evaluation of critical components, thereby developing an effective testing environment. The diagrammatic sequence offered functions as a visual roadmap, providing an appropriate reference point for the real-world implementation of the framework. The proposed framework also provides organizations seeking to increase software quality with a strategic road map. Through the prioritization of high-risk components, this framework efficiently optimizes resource utilization while improving software against critical defects.

7.2 Limitations

While the proposed Risk-based testing framework offers early defect detection and the prioritization of high risk components, it is imperative to acknowledge probable limitations associated with the framework. The effectiveness may differ and depends on size and scale of project in development as well as the degree of complexity. While evaluating the expert feedback, it became obvious that the proposed Risk-based testing framework has been widely acknowledged for its effectiveness and compatibility in various software projects. However further research could enhance framework's applicability for projects of different scales as well the integration of test automation processes.

7.3 Future Work

According to evaluation gathered from the expert feedback, it has been concluded that the proposed Risk-based testing framework could be effective, adaptable and compatible for various software projects. The framework with Raygun and risk matrix integration provides organizations seeking to increase software quality. Through the prioritization of high-risk components, this framework efficiently optimizes resource utilization while improving software against critical defects. However further research could enhance framework's applicability for projects of different scales as well as the inclusion of test automation processes. The proposed framework could also integrate different software development processes other than agile as shared by some experts. Test automation techniques could also be incorporated with the framework which will reduce the resource utilization. Machine learning algorithms can further enhance frameworks proactive abilities allowing real-time defect detection, automated test cases and reports generation. This integration would allow testing and quality assurance teams to respond vigorously to challenging encounters of complex projects. Furthermore, current association with industry experts, researchers, and technology experts could produce constant perspectives for improving and escalating the framework's capabilities.

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Appendix A

Annexure

A.1 Proposed framework validation

The Annexure section of this research paper presents an extensive questionnaire aimed to validate the proposed Risk-Based Testing Framework. The questionnaire involved 25 software development experts. These participants, with extensive expertise in software development, quality assurance, and project management, contributed valuable insights and input to the framework. Notably, five of these experts have used and implemented the proposed framework in their projects. Their observations, experiences and evaluations were critical in determining the framework's effectiveness, applicability, and potential areas for improvement. The collective input provided by these professionals has significantly enhanced the validity and usefulness of the proposed Risk-Based Testing Framework.

A.1.1 Introductory questions

1. What is your current Industry / Domain?
2. What is your current role in software development?
3. How many years of Experience do you have in Software Development?
4. Does your Organization use Agile Development?

A.1.2 Existing Risk Based Testing Techniques

1. In the context of risk-based testing, which of the following best describes the process of identifying risks in your organization?
   (a) Assessing the likelihood of defects
   (b) Identifying high-risk components
   (c) Prioritizing test cases randomly
   (d) Collecting stakeholder feedback
2. In your Organization which risk assessment model is commonly used in risk-based testing for evaluating the impact of identified risks?
   (a) Pareto Analysis
   (b) Risk Matrix
   (c) Cost-Benefit Analysis
   (d) Quantitative Risk Analysis
3. How satisfied are you with your organization's testing procedures?
   (a) 1 - Not Satisfied
   (b) 5 – Highly Satisfied
4. How effective do you think Risk Based Testing can be in prioritizing testing of high-risk components
   (a) Not Effective
   (b) Highly Effective
5. How can the integration of Raygun benefit the Risk-based testing framework?
   (a) By providing real-time monitoring and error tracking
   (b) By automating all testing processes
   (c) By generating test cases automatically
   (d) By conducting user acceptance testing
6. How do you think Test Case Prioritization can help your organization in Testing?
   (a) To execute high-risk test cases exhaustively
   (b) To execute test cases based on their alphabetical order
   (c) To execute high-risk test cases first

   (d) To execute test cases based on their creation date

7. How can risk-based testing optimize resource allocation?
   (a) By allocating maximum resources to low-risk components
   (b) By allocating equal resources to all components
   (c) By allocating maximum resources to high-risk components
   (d) By not considering resource allocation

8. In the context of risk-based testing, what can be the main objective of defect resolution in your opinion?
   (a) To identify the total number of defects
   (b) To prioritize defect resolution based on risk
   (c) To prioritize defect resolution based on risk
   (d) To identify the total number of defects

9. How can collecting feedback from stakeholders important in risk-based testing?
   (a) It is not relevant to risk-based testing.
   (b) To determine which components are high-risk
   (c) To generate automated test reports
   (d) To assign blame for testing failures

10. How can the risk matrix assist in prioritizing testing efforts?
   (a) By assigning a random risk score to each component
   (b) By categorizing risks based on severity and likelihood
   (c) By automating the testing process
   (d) By generating test cases

11. What can be the potential challenges when integrating the Risk-based testing framework with existing development processes?
   (a) Enhanced collaboration between teams
   (b) Resistance to change from traditional testing methods
   (c) Improved resource allocation
   (d) Quantitative No challenges are expected

12. Have you implemented a Risk-based testing framework in your organization?

(a) 1 - Yes

(b) 5 - No

13. What are the key benefits you have observed from using a risk-based testing approach in your projects?

    (a) Not Improved defect detection

    (b) Faster testing cycles

    (c) Reduced resource allocation

    (d) No significant benefits observed

    (e) Not used

A.1.3 Comprehensive Risk Mitigation Plan

14. What challenges have you faced when assessing and prioritizing risks in risk-based testing?

    (a) 1 - Difficulty in identifying high-risk components

    (b) 2 – Lack of stakeholder involvement

    (c) 3 - Insufficient data for risk assessment

    (d) 4 - No significant challenges encountered

15. In your experience, how easily can the proposed Risk-based testing framework be customized to fit the specific needs and requirements of different software projects?

    (a) Highly customizable with minimal effort

    (b) Customization requires moderate effort

    (c) Limited customization options

    (d) Not applicable, haven't used the framework

16. Do you think that the Proposed Risk-based testing framework exhibit scalability, allowing it to handle both small-scale and large-scale software projects effectively?

    (a) Highly scalable, suitable for any project size

    (b) Moderately scalable, better suited for specific project sizes

    (c) Limited scalability, primarily for small-scale projects

    (d) Not sure about the framework's scalability

17. What integration challenges can be encountered when implementing the proposed framework with existing testing and development tools or processes?

    (a) No integration challenges encountered

    (b) Minor integration challenges, easily resolved

    (c) Significant integration challenges requiring additional effort

    (d) Haven't implemented the framework yet

18. Does the framework include mechanisms for collecting feedback from testing teams and stakeholders to continually refine risk assessments and test case prioritization?

    (a) Robust feedback mechanisms in place

(b) Basic feedback collection, but room for improvement
(c) Limited or no feedback mechanisms
(d) Not applicable, haven't used the framework

19. In your opinion, what are the main strengths of the proposed Risk Based Testing Framework?
20. What additional improvements or refinement would you suggest regarding proposed framework?