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Performance and Quality Evaluation of the External Alarm System Based on ISO/IEC 25010 Standards

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ABSTRACT

This study evaluates the performance and quality of an external alarm system using the ISO/IEC 25010 software product quality model. The evaluation focuses on eight quality characteristics, namely functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability, to provide a comprehensive assessment of the system. A quantitative approach was employed, and data were analyzed using a measurement model to test construct validity and reliability. The results of the validation test show that all indicators have outer loading values above 0.70 and Average Variance Extracted (AVE) values exceeding 0.50, confirming satisfactory convergent validity. Reliability testing also indicates strong internal consistency, with Cronbach's Alpha and Composite Reliability values for all constructs exceeding the recommended threshold of 0.70. These findings demonstrate that the proposed measurement model is valid and reliable for evaluating external alarm systems. Overall, the study confirms that ISO/IEC 25010 provides a robust and effective framework for assessing software quality and performance in safety-critical alarm systems.

1. Introduction

External alarm systems play a vital role in ensuring safety and operational awareness in various environments, such as healthcare facilities, industrial plants, smart buildings, and public infrastructure. These systems are designed to provide early warnings when abnormal or dangerous conditions occur, allowing users to respond quickly and effectively [1]-[3]. As technology advances, external alarm systems are increasingly integrated with software-based platforms, sensors, and communication networks. This shift has made software quality a critical factor in determining the overall effectiveness and reliability of alarm systems, especially in situations where delayed or inaccurate alerts may lead to serious consequences.

Despite their importance, many external alarm systems are still evaluated primarily based on functional operation or hardware performance, with limited attention given to comprehensive software quality aspects. In practice, issues such as slow response time, system downtime, poor usability, and

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security vulnerabilities are frequently reported. These problems can reduce user trust, increase false alarms, or even cause alarm failures during critical moments. Such limitations highlight the need for a more structured and holistic evaluation approach that goes beyond basic functionality and considers multiple quality dimensions. Software quality standards provide a systematic way to assess and improve system performance [4]-[6]. Among these, the ISO/IEC 25010 standard is widely recognized for defining comprehensive software product quality characteristics, including functional suitability, performance efficiency, reliability, usability, security, compatibility, maintainability, and portability [7]-[9] The standard has been successfully applied in various domains; however, its implementation in evaluating external alarm systems remains relatively limited. This gap suggests that the potential of ISO/IEC 25010 to improve alarm system quality has not been fully explored.

In safety critical systems such as external alarms, performance efficiency and reliability are particularly crucial. Alarm notifications must be delivered accurately and within strict time constraints, while the system must remain stable under continuous operation and unexpected conditions. At the same time, usability and security cannot be overlooked, as users must quickly understand alarm signals and the system must be protected from unauthorized access or manipulation. Based on these considerations, this research aims to evaluate the performance and quality of an external alarm system using the ISO/IEC 25010 standard as the evaluation framework. The study seeks to validate relevant quality characteristics and analyze their contribution to overall alarm system performance. By adopting a standardized and empirical approach, this research is expected to provide practical insights for developers, system administrators, and decision-makers in designing and improving reliable, efficient, and user centered external alarm systems for safety critical applications.

2. Literature Study

The rapid growth of safety critical and monitoring systems has increased the importance of external alarm systems in various domains, including healthcare, industrial automation, transportation, and public safety [10]-[12]. External alarm systems are designed to provide timely warnings to users or operators in response to abnormal or hazardous conditions. Prior studies emphasize that the effectiveness of such systems depends not only on functional correctness but also on their overall software quality, particularly in environments where delays or failures may lead to serious consequences. As a result, systematic evaluation of alarm system performance and quality has become a crucial research focus to ensure reliability, usability, and operational efficiency.

Several researchers have highlighted the limitations of traditional system evaluation methods that focus solely on functional testing or hardware performance metrics. These approaches often overlook non-functional quality characteristics such as response time, reliability, maintainability, and user interaction. In the context of external alarm systems, performance issues such as latency, false alarms, and system unavailability can significantly reduce user trust and system effectiveness. Consequently, contemporary studies advocate for standardized software quality models that provide a comprehensive framework for evaluating both performance and quality attributes in an integrated manner.

The ISO/IEC 25010 standard has emerged as a widely accepted reference model for software product quality evaluation. It defines eight main quality characteristics functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability along with detailed sub-characteristics. Previous research has successfully applied ISO/IEC 25010 in evaluating information systems, healthcare applications, embedded systems, and safety-critical software. In relation to alarm and warning systems, existing literature has primarily focused on technical performance indicators, such as signal accuracy, response time, and system availability. However, fewer studies have explicitly mapped these indicators to the ISO/IEC 25010 quality characteristics. Some recent works have begun bridging this gap by evaluating alarm systems using performance efficiency, reliability, and usability dimensions of the standard [13]-[15]. Their findings indicate that performance efficiency, especially time behavior and resource utilization, plays a dominant role in ensuring that alarms are delivered promptly and accurately, while usability influences user response and decision-making during critical situations.

Despite these advances, there remains a research gap in comprehensive quality evaluation of external alarm systems using the full ISO/IEC 25010 framework. Many studies address individual quality aspects in isolation, rather than providing an integrated assessment that reflects real-world operational conditions. Therefore, a performance and quality evaluation based on ISO/IEC 25010 standards is necessary to provide a holistic understanding of external alarm system effectiveness [16],[17]. Such an approach not only supports objective quality measurement but also contributes to the development of more reliable, efficient, and user centered alarm systems for safety-critical applications.

3. Method

Figure 1 below provides a visual representation of the ISO/IEC 25010 model and the relationships between each of its characteristics.

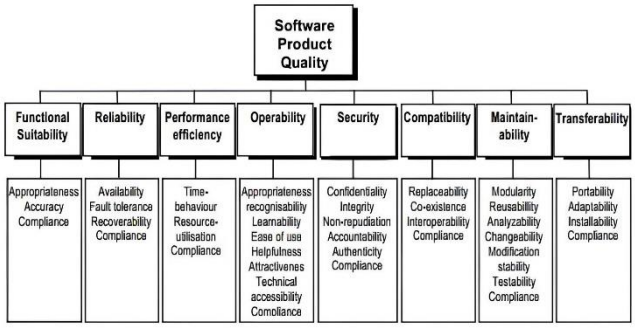

Figure 1 – ISO/IEC 25010 Model

The ISO/IEC 25010 model provides a comprehensive framework for evaluating software product quality by defining eight main quality characteristics and their associated sub-

characteristics. In this research, the model is used as a structured reference to assess the performance and overall quality of the external alarm system. The adoption of ISO/IEC 25010 ensures that the evaluation process is systematic, measurable, and aligned with internationally recognized software quality standards, which is particularly important for safety-critical systems such as external alarms.

a. *Functional Suitability*

Functional Suitability refers to the degree to which the external alarm system provides functions that meet stated and implied requirements. This includes functional appropriateness, accuracy, and compliance. In the context of this research, functional suitability evaluates whether the alarm system correctly detects triggering events, generates accurate alerts, and complies with predefined operational specifications. A high level of functional suitability ensures that the system performs its intended warning functions without errors that could lead to missed or false alarms.

b. *Performance Efficiency*

Performance Efficiency is a core focus of this study, as external alarm systems must operate under strict time constraints. This characteristic includes time behavior, resource utilization, and capacity compliance. Performance efficiency assessment examines how quickly the system responds to triggering events, how efficiently it uses system resources, and whether it maintains stable performance under varying workloads. For alarm systems, low latency and consistent response times are essential to ensure timely notification in critical situations.

c. *Reliability*

Reliability measures the ability of the external alarm system to maintain its performance under normal and abnormal conditions. Sub characteristics such as availability, fault tolerance, and recoverability are particularly relevant. In this research, reliability evaluation focuses on the system's uptime, its ability to continue functioning during partial failures, and its capability to recover quickly after faults. Reliable alarm systems are crucial in preventing system downtime that could compromise safety and operational continuity.

d. *Usability (Operability)*

Usability (Operability) assesses how easily users can understand, learn, and operate the external alarm system. This includes appropriateness recognizability, ease of use, learnability, and accessibility. In emergency or high-pressure environments, users must be able to interpret alarm signals quickly and accurately. Therefore, this research evaluates whether the alarm interfaces, notifications, and indicators are intuitive and support rapid user response.

e. *Security*

Security evaluates the system's ability to protect information and prevent unauthorized access or manipulation. This includes confidentiality, integrity, authentication, and accountability. For external alarm systems, security assessment ensures that alarm signals cannot be tampered with, suppressed, or falsely triggered by unauthorized parties, thereby maintaining trust in the system's outputs and safeguarding operational data.

f. *Compatibility*

Compatibility focuses on the system's ability to operate alongside other systems within the same environment. This includes interoperability and co-existence. In this research, compatibility assessment examines whether the external alarm system can integrate with monitoring platforms, sensors, or control systems without causing conflicts or performance degradation.

g. *Maintainability*

Maintainability refers to the ease with which the external alarm system can be modified, analyzed, tested, and corrected. Sub-characteristics such as modularity, reusability, analyzability, and testability are considered. Evaluating maintainability helps determine how efficiently the system can be updated or repaired, which is essential for long-term operation and continuous quality improvement.

h. *Portability (Transferability)*

Finally, Portability (Transferability) evaluates the system's ability to be transferred and adapted to different environments, platforms, or hardware configurations. This includes adaptability, installability, and compliance. In this research, portability assessment ensures that the external alarm system can be deployed across different operational settings with minimal modification.

4. Result and Discussion

Figure 2 shows model structure in SmartPLS:

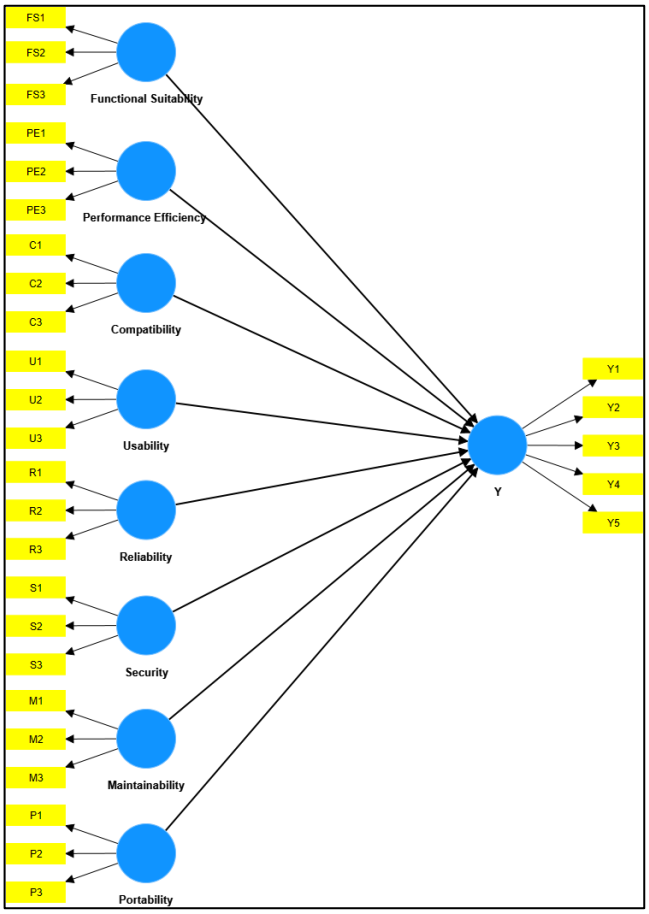

Figure 2 – Model Structure in SmartPLS

The results of the validity and reliability tests conducted through outer model analysis using SmartPLS indicate that all indicators used in this study meet the instrument's eligibility criteria (Table 1). In terms of validity, all indicators have outer loading values above 0.70 and AVE values above 0.50, indicating that each indicator adequately reflects its latent construct. Meanwhile, in terms of reliability, all variables showed Cronbach's Alpha and Composite Reliability values above 0.70, thus the instrument is declared to have excellent internal consistency.

Table 1 – The validity and reliability tests

Variable	Code	Outer Loading (>0,70)	AVE (>0,50)	*Cronbach's Alpha* (>0,70)	*Composite Reliability* (>0,70)
Functional Suitability	FS1	0.918	0.732	0.812	0.827
	FS2	0.730			
	FS3	0.906			
Performance Efficiency	PE1	0.794	0.664	0.751	0.765
	PE2	0.833			
	PE3	0.818			
Compatibility	C1	0.797	0.741	0.824	0.839
	C2	0.849			
	C3	0.931			
Usability	U1	0.906	0.807	0.880	0.883
	U2	0.875			
	U3	0.914			
Reliability	R1	0.936	0.737	0.817	0.856
	R2	0.715			
	R3	0.907			
Security	S1	0.956	0.793	0.868	0.892
	S2	0.913			
	S3	0.795			
Maintainability	M1	0.934	0.787	0.865	0.881
	M2	0.875			
	M3	0.851			
Portability	P1	0.733	0.678	0.759	0.760
	P2	0.865			
	P3	0.865			
Alarm System Performance	Y1	0.895	0.626	0.848	0.856
	Y2	0.744			
	Y3	0.732			
	Y4	0.730			
	Y5	0.839			

The measurement model evaluation was conducted to assess the validity and reliability of the constructs derived from the ISO/IEC 25010 quality characteristics and the alarm system performance variable. The assessment criteria included outer loading, Average Variance Extracted (AVE), Cronbach's Alpha, and Composite Reliability (CR). These indicators were used to confirm convergent validity and internal consistency reliability of the measurement model.

Convergent validity is demonstrated through the outer loading and AVE values. As shown in the table, all indicators exhibit outer loading values greater than the recommended threshold of 0.70, indicating that each item strongly represents its corresponding construct. For instance, the Functional Suitability indicators (FS1–FS3) show high loadings ranging from 0.730 to 0.918, while Performance Efficiency indicators (PE1–PE3) range from 0.794 to 0.833. Furthermore, all constructs achieve AVE values above 0.50, with Usability (0.807) and Security (0.793) showing particularly strong variance extraction. These results confirm that the constructs adequately explain the variance of their indicators.

In terms of internal consistency reliability, Cronbach's Alpha values for all variables exceed the minimum acceptable threshold of 0.70, indicating consistent measurement across items. Functional Suitability (0.812), Compatibility (0.824), and Reliability (0.817) demonstrate strong reliability, while Usability (0.880) and Security (0.868) exhibit very high internal consistency. Composite Reliability values also exceed 0.70 for all constructs, reinforcing the robustness of the measurement model. The consistency between Cronbach's Alpha and Composite Reliability values suggests that the indicators reliably measure their respective latent variables.

Each ISO/IEC 25010 quality characteristic contributes meaningfully to the evaluation of the external alarm system. High indicator loadings in Reliability (R1 = 0.936) and Security (S1 = 0.956) indicate that system availability, fault tolerance, and protection mechanisms are critical quality dimensions for alarm system effectiveness. Similarly, strong loadings in Usability (U1 = 0.906, U3 = 0.914) emphasize the importance of ease of use and user comprehension in ensuring timely and accurate responses to alarm notifications.

The Alarm System Performance construct also demonstrates satisfactory validity and reliability, with indicator loadings ranging from 0.730 to 0.895 and an AVE value of 0.626. Cronbach's Alpha (0.848) and Composite Reliability (0.856) further confirm that the performance construct is measured consistently. These findings indicate that the performance indicators effectively capture key aspects of system responsiveness, accuracy, and operational effectiveness.

Overall, the results confirm that the measurement model meets the required validity and reliability criteria, supporting the use of ISO/IEC 25010 characteristics as reliable constructs for evaluating external alarm system performance. The strong psychometric properties of the model provide a solid foundation for subsequent structural model analysis, enabling further investigation into the relationships between software quality characteristics and alarm system performance.

5. Conclusion

Based on the measurement model evaluation, it can be concluded that the external alarm system quality assessment using the ISO/IEC 25010 framework demonstrates strong validity and reliability. All constructs meet the recommended thresholds for outer loading, AVE, Cronbach's Alpha, and Composite Reliability, indicating that the indicators consistently and

accurately represent their respective quality characteristics. These results confirm that functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability are appropriate and robust dimensions for evaluating external alarm system performance. Consequently, the validated measurement model provides a solid empirical foundation for further structural analysis and supports the applicability of ISO/IEC 25010 as a comprehensive standard for performance and quality evaluation of safety-critical alarm systems.

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