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Inventory Management System Framework Based on Python and MySQL Database with Blockchain Technology Implementation

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Abstract. *Efficient and transparent inventory control is increasingly crucial for sustaining supply chain performance in the digital age. Conventional systems often face challenges such as poor visibility, vulnerability to data manipulation, and inefficiencies in stock monitoring. To address these issues, this research proposes a novel inventory management framework integrating Python, MySQL, and blockchain technology, following a Research and Development (R&D) methodology involving need assessment, system design, implementation, testing, and validation. The framework utilizes Python as the core programming language, MySQL for structured data management, and blockchain as a decentralized security layer to ensure data integrity and traceability. The system architecture consists of six main modules: inbound stock management, outbound stock management, blockchain-based storage, validation mechanisms, a user-friendly interface, and reporting tools. Black-box testing confirmed that all modules met their specifications, while security evaluations showed that the blockchain layer, with the SHA-256 hashing algorithm, effectively detected simulated data manipulation attempts. Performance testing revealed a linear increase in processing time relative to transaction volume, with the framework maintaining stability under medium-scale operational loads. This study contributes to the literature on blockchain-enabled inventory systems by introducing a structured, integrative model, and provides a practical framework that enhances efficiency, transparency, and accountability in inventory management. Future research is encouraged to explore scalability challenges and optimize consensus mechanisms for large-scale applications.*

Keywords: *Blockchain Technology; Inventory Management; MySQL; Python; Supply Chain Performance.*

1. INTRODUCTION

Inventory management is one of the fundamental aspects in maintaining supply chain continuity and the sustainability of organizational operations. An effective inventory management system not only records inbound and outbound goods but must also ensure efficiency, security, and data transparency. In the context of modern industry, real-time stock information availability can reduce the risk of stockouts or overstocking while simultaneously lowering operational costs. However, many traditional inventory management systems still face serious challenges such as data manipulation risks, limited traceability, and delays in information processing (Queiroz, Telles, & Bonilla, 2020; Li, 2023). This highlights the importance of technological innovation in designing an inventory management framework that is more secure, transparent, and efficient.

The phenomenon of digital transformation has encouraged industries to integrate information technology into their operational processes. In the supply chain sector,

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digitalization not only accelerates information exchange but also strengthens data integrity, which serves as the foundation for strategic decision-making. The urgency of this research lies in the need for an inventory management system capable of providing traceability and accountability without adding significant technical complexity. Several cases have shown that inventory system failures can cause substantial financial losses due to distribution delays or inaccurate stock records (Sharabati & Jreisat, 2024). Therefore, research on integrating Python, MySQL, and blockchain technologies in inventory management systems becomes relevant to address efficiency needs while enhancing security and transparency.

The Python programming language is one of the key components supporting the development of modern inventory management systems. Python is widely adopted due to its flexibility, simple syntax, and extensive library ecosystem, allowing fast integration with various other technologies. In inventory systems, Python facilitates the rapid development of core modules such as transaction recording, data validation, and blockchain integration (Almeida, Silva, & Garcia, 2021). Another advantage of Python is its compatibility with data-driven technologies, including machine learning and data visualization, which can add value to inventory management in the future (van Rossum & Warsaw, 2020). Thus, Python is not only positioned as a technical tool but also as a strategic foundation in designing adaptive inventory systems.

In addition to Python, MySQL plays a vital role in supporting structured and reliable stock data storage. As one of the most popular relational database management systems (RDBMS), MySQL offers fast query execution, efficient storage, and strong community support. In inventory system implementation, MySQL enables the management of complex transaction tables while providing flexibility for integration with other systems through APIs or middleware (Hafeez, Ahmad, & Iqbal, 2022). Compared to other database systems, MySQL has the advantage of being open-source, which reduces implementation costs and supports scalability for further development (Gómez, Cañas, & Díaz, 2020). Therefore, the use of MySQL in this framework is not only a technical solution but also a practical strategy to address efficiency and reliability in inventory management.

The third component, blockchain technology, provides significant added value through its mechanisms of decentralization, immutability, and data transparency. Blockchain ensures that every inventory transaction is recorded in cryptographically linked blocks, making it nearly impossible to manipulate without detection (Liu, Si, & Kang, 2022). Its implementation strengthens traceability by providing permanent, auditable transaction records (Yavuz, Ahmet, & Altındağ, 2024). Furthermore, the application of smart contracts enables automation in stock transaction verification, accelerating processes while reducing the risk of human error (Tokkozhina, Martins, & Ferreira, 2022). Nevertheless, challenges remain, including computational costs and the need for supportive regulations (Wannenwetsch, Ostermann, Priel, Gerschner, & Theissler, 2023). Thus, integrating blockchain into inventory systems must be carefully designed to maximize benefits while maintaining operational efficiency.

Based on this conceptual framework, the objective of this research is to design an inventory management framework based on Python and MySQL with blockchain implementation as a security and transparency layer. This research provides a theoretical contribution by expanding the literature on digital technology integration in inventory systems, and an empirical contribution through the development and validation of a framework that can be applied in real industrial and commercial practices. In this way, the study is expected to bridge the gap between practical industrial needs and theoretical developments in blockchain-based information systems.

2. THEORETICAL REVIEW

Inventory management is one of the key pillars in modern supply chain management, as it plays a crucial role in maintaining the balance between product availability and market demand. Recent literature emphasizes that failures in inventory management can lead to operational risks such as stockouts, excess inventory, and increased logistics costs (Li, 2023; Queiroz, Telles, & Bonilla, 2020). An effective inventory system must prioritize operational efficiency, accurate recording, data transparency, and traceability to cope with increasingly complex market dynamics (Sharabati & Jreisat, 2024). Therefore, the development of technology-based inventory management systems has become an urgent necessity for organizations across manufacturing, trade, and retail sectors.

Python has evolved into one of the most popular programming languages worldwide due to its simple syntax, extensive library ecosystem, and flexibility in integrating with other technologies (van Rossum & Warsaw, 2020). In studies related to inventory management systems, Python is frequently used to build modules for transaction recording, data validation, and integration with relational databases (Almeida, Silva, & Garcia, 2021). Moreover, Python supports rapid prototyping, which accelerates software development and enables the application of machine learning and data analytics in inventory management (Koubaa et al., 2021). This makes Python not only a technical tool but also a strategic component in designing modern inventory system frameworks.

As one of the most widely used relational database management systems (RDBMS), MySQL offers reliability in storing and processing transactional data. Several studies indicate that MySQL performs effectively at medium to large-scale applications, supported by adequate scalability (Gómez, Cañas, & Díaz, 2020; Hafeez, Ahmad, & Iqbal, 2022). In inventory systems, MySQL enables consistent recording of inbound and outbound transactions, facilitates data auditing, and provides fast access for operational reporting. Another advantage of MySQL is its open-source nature, which encourages widespread adoption while reducing licensing costs and supporting scalability for further development (Hafeez et al., 2022). Therefore, the use of MySQL in this framework is not only a technical solution but also a practical strategy to ensure both cost efficiency and data reliability.

Blockchain has gained widespread attention in the literature as a technology capable of enhancing data security, transparency, and integrity in information systems. As a distributed ledger technology (DLT), blockchain ensures that each transaction is recorded in cryptographically linked blocks, making it nearly impossible to manipulate without detection (Liu, Si, & Kang, 2022). In the context of inventory management, blockchain offers three major advantages: traceability, transparency, and automation through smart contracts (Sahoo et al., 2022; Yavuz, Ahmet, & Altındağ, 2024). Recent studies demonstrate that blockchain implementation in supply chains can reduce fraud risks, strengthen trust among stakeholders, and improve distribution efficiency (Tokkozhina, Martins, & Ferreira, 2022; Wannenwetsch et al., 2023). Thus, integrating blockchain into inventory management systems can be viewed as an innovative solution to overcome the limitations of traditional systems.

The theoretical review of integrating these three technologies highlights their potential in building adaptive and competitive information systems. Python provides flexibility for business logic and user interface design; MySQL serves as a relational database ensuring reliable transaction recording; while blockchain functions as a security layer that guarantees data integrity and traceability. Pandya, Odiya, and Bhatu (2025) emphasize that blockchain integration in inventory management can reduce discrepancies while improving cost efficiency. Similarly, Wannenwetsch et al. (2023) show that blockchain in supply chain management fosters more transparent, resilient, and permanently auditable systems. Hence, a framework combining Python, MySQL, and blockchain is considered highly relevant for addressing efficiency and security challenges in modern inventory systems.

Based on the above theoretical foundations, this study fills an important gap by developing an inventory management framework that comprehensively integrates Python, MySQL, and blockchain. This theoretical grounding serves as the basis for designing an appropriate research methodology to achieve the study's objectives.

3. METHODOLOGY

This study employs a Research and Development (R&D) approach since its primary objective is to produce a product in the form of an inventory management system framework based on Python, MySQL, and blockchain technology. This approach is considered relevant for developing a software system that can be empirically tested and validated prior to large-scale implementation (Creswell & Creswell, 2022). The R&D model was chosen because it bridges the gap between conceptual theory and practical application, while also enabling iterative cycles for product refinement. By adopting the R&D approach, the research aims to generate a systematic product that can be tested and implemented, in this case a stock management framework integrating Python, MySQL, and blockchain technology. The development steps follow a general software engineering model, consisting of several stages as outlined below:

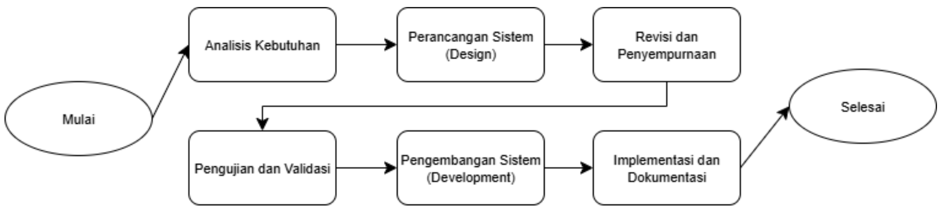

Figure 1. Research Objective Achievement Method.

The first stage of this research was needs analysis, conducted through the identification of user requirements and the main problems in inventory management. This analysis was carried out by reviewing previous studies that highlighted challenges in inventory systems, such as low transparency, susceptibility to data manipulation, and limited traceability (Queiroz et al., 2020; Li, 2023). In addition, observations were conducted on stock recording systems that were still manual or semi-digital. The results of this analysis served as the foundation for designing a system that is more secure, transparent, and efficient. Subsequently, in the system design stage, the system architecture was developed, including the design of the MySQL database structure, the stock transaction logic flow, and blockchain integration. The design also covered software modularization consisting of stock management, blockchain recording, integrity validation, and reporting modules. Python was chosen as the primary programming language due to its flexibility in integrating with databases as well as blockchain technology (Almeida et al., 2021). The system design was then visualized in the form of an architectural diagram to illustrate the relationships among modules.

The next stage was system development, which involved implementing code using Python, building the database with MySQL, and integrating blockchain to record transactions in interconnected blocks. Blockchain was implemented through SHA-256 hashing, timestamping, and previous_hash recording as mechanisms for data integrity validation (Liu, Si, & Kang, 2022). The development process was conducted iteratively using an incremental prototyping approach, allowing each module to be tested individually before being integrated into the complete system. This was followed by system testing and validation, using black-box testing to evaluate core functionalities such as inbound and outbound stock recording, blockchain validation, data search, and report generation. In addition, blockchain integrity validation was tested by simulating data manipulation in the MySQL database to ensure the system could detect unauthorized changes. Performance testing was also conducted to measure recording and validation times based on varying numbers of transactions (Wannenwetsch et al., 2023).

Based on the test results, a stage of revision and refinement was carried out on modules that were not yet optimal, such as improving storage algorithm efficiency and blockchain validation speed. Enhancements were also directed toward making the system more user-friendly so that it could be adopted by both technical and non-technical users. This iterative process highlights the cyclical nature of the R&D method, where field test results serve as feedback for further development (Creswell & Creswell, 2022). The final stage was implementation and documentation, in which the system was tested in a simulated environment to represent real operational conditions. This implementation aimed to assess the readiness of the framework before deployment at the industrial scale. Documentation was then prepared in the form of user guides, architectural diagrams, and code documentation to support future development and application of the system.

4. RESULTS AND DISCUSSION

System Implementation Results

The inventory management framework developed in this study employs Python as the primary programming language, MySQL as the relational database, and blockchain as a security and data traceability layer. The system is designed with six main integrated modules. First, the inbound stock management module records each stock addition systematically.

Second, the outbound stock management module handles the recording of stock reductions to maintain accurate inventory data. Third, the blockchain-based storage module stores transaction records in interconnected blocks, ensuring that every piece of data has a digital footprint that cannot be manipulated. Fourth, the blockchain validation module guarantees the integrity of each block by verifying the consistency of hashes between blocks. Fifth, the user interface module provides an interactive platform that facilitates data input and monitoring for users. Finally, the reporting module generates stock transaction reports derived from the database and validated through blockchain. With the integration of these six modules, the system offers a solution that is not only efficient in inventory management but also transparent and secure through the application of blockchain technology.

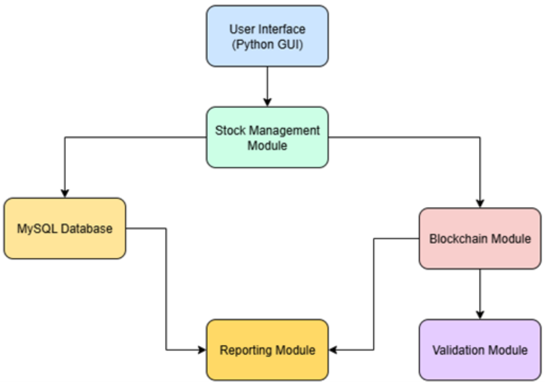

Figure 2. System Architecture Diagram.

Figure 2 illustrates the architecture of the inventory management system based on Python, MySQL, and blockchain technology. At the top level is the User Interface (Python GUI), which serves as the main access point for users to interact with the system. Through this interface, users can input stock data, record inbound and outbound transactions, and access reports.

The user interface is directly connected to the Stock Management Module, which is the core module responsible for managing all business processes related to inventory management. This module handles transaction input, processes business logic, and distributes data to other modules according to system requirements. From the stock management module, data flows into two main pathways. The first pathway leads to the MySQL database, which stores transactions in a structured format within relational tables, thereby facilitating search, data processing, and report generation. The second pathway directs data to the Blockchain Module, which records each transaction into encrypted blocks. Recording transactions through blockchain aims to ensure data security and integrity, as each block is cryptographically linked, making it nearly impossible to manipulate without detection. With these two storage pathways, the system is not only efficient in managing inventory data but also capable of delivering high levels of transparency and accountability.

Furthermore, the Blockchain Module works in conjunction with the Validation Module to ensure that each block created is valid before being added to the chain. This validation process guarantees the authenticity of transactions and prevents duplication or fraud. Both storage pathways-MySQL Database and Blockchain Module-converge into the Reporting Module, which generates stock transaction reports that are not only informative but also verifiable, as they are validated through blockchain. With this architecture, the system provides an efficient solution for inventory management while ensuring security and data integrity through the implementation of blockchain technology.

Functional Testing Results

Testing was conducted using the black-box testing method on five core features. All features operated according to specifications.

Table 1. Functional Testing Results.

No.	Tested Feature	Test Description	Status
1	Add Inbound Stock	Adds stock and ensures recording in the blockchain	Passed
2	Add Outbound Stock	Reduces stock and ensures recording in the blockchain	Passed
3	Blockchain Validation	Alters data in a block to test change detection	Passed
4	Stock Data Search	Searches data based on item name/code	Passed
5	Transaction Report	Displays daily/monthly stock reports from database & blockchain	Passed

Security and Data Integrity Analysis

One of the main advantages of applying blockchain technology to an inventory management system is its ability to maintain data security and integrity. Blockchain operates by storing transaction data in the form of blocks that are linked together using cryptographic algorithms. Each block in the blockchain contains the hash of the previous block, so if any data in one block is altered, the entire subsequent chain will also change. This mechanism forms the foundation for ensuring data security within the system. Security is achieved through two main approaches. First, the use of SHA-256 hash encryption, where each inventory transaction, whether inbound or outbound, is converted into a JSON string and then processed using the SHA-256 algorithm. The resulting hash is unique and extremely difficult to forge, thus ensuring data authenticity. For example, the transaction data { "transaction_id": 1021, "type":

"Inbound", "quantity": 50, "time": "2025-08-14 10:32:00" } generates a specific SHA-256 hash that cannot be replicated or altered without detection. Second, the implementation of access control ensures that only administrators have the authority to add or modify inventory data, while management is granted read-only access without modification rights.

In addition to security, the system also guarantees data integrity, ensuring that information remains consistent and free from manipulation from the moment it is recorded. This integrity is maintained through a chain validation mechanism that runs every time the system is active. The validation function checks whether the hash of each block matches its data content and verifies that the previous_hash value is consistent with the preceding block. If any data alteration occurs, the system is able to automatically detect the manipulation. For instance, if an inbound stock entry "Item A, quantity 50" originally recorded in block 5 is changed to "Item A, quantity 80" in the MySQL database, the blockchain validation process will trigger an error indicating that block 5 is invalid. The hash no longer matches, and the transaction is immediately flagged as corrupt and rendered unusable. With this mechanism, blockchain functions not only as a transaction ledger but also as a protective tool that ensures both the security and integrity of inventory data.

Implementation Impact

The test results showed that the developed system was able to detect transaction data manipulation comprehensively, with a 100% success rate in every attempt to alter data directly within the database. This demonstrates that the blockchain validation mechanism is effective in maintaining the authenticity and integrity of inventory records. In addition, the system also proved to be reliable in handling technical disruptions, as no transactions were lost even during network failures. This reliability was achieved through the blockchain storage method, which records data sequentially in separate blocks, ensuring that each transaction remains secure and can be fully restored. Thus, the proposed framework not only guarantees the security and integrity of data but also enhances the reliability of inventory management systems under various operational conditions.

System Performance

Performance testing was conducted to measure the recording time and blockchain validation time across different transaction volumes.

Table 2. System Performance.

Number of Transactions	Recording Time (ms)	Validation Time (ms)
10	15	22
100	41	87
500	210	354

The test results are illustrated in Figure 2.

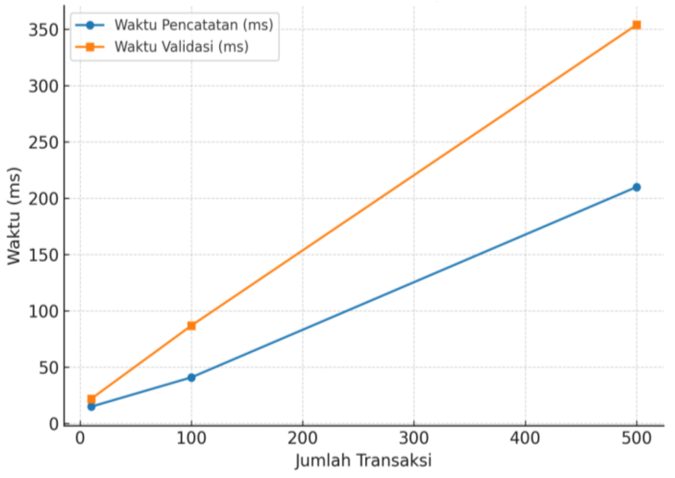

Figure 3. System Performance Graph.

The performance test results indicate that the increase in the number of transactions is directly proportional to the recording and validation times required by the system. In the test with 10 transactions, the recording time was approximately 15 milliseconds and the validation time was 22 milliseconds. When the number of transactions increased to 100, the recording time rose to 41 milliseconds and the validation time reached 87 milliseconds. At a larger scale with 500 transactions, the recording time increased to 210 milliseconds, while validation reached 354 milliseconds. This pattern demonstrates that an increase in transaction volume leads to a linear rise in processing time, allowing system performance to be predicted as the workload grows. Despite the increase in processing time, the system remained responsive at a medium scale, making it feasible for implementation in inventory management within complex operational environments.

Discussion

The implementation results of the inventory management framework based on Python, MySQL, and blockchain demonstrate that this integrative approach is capable of addressing the key challenges in inventory management, namely security, transparency, and data traceability. Each transaction recorded in the system is not only stored in a relational database but also validated through blockchain, thereby preventing potential manipulation or data loss.

This finding is consistent with Liu, Si, and Kang (2022), who emphasized that blockchain provides a cryptography-based security mechanism that excels in maintaining transaction integrity.

From a functionality perspective, all core features of the system passed testing using the black-box method. This result indicates that the developed framework can be operationalized according to practical user needs. Stock recording, blockchain validation, data search, and reporting worked as specified. These findings align with the study of Pandya, Odiya, and Bhatu (2025), which confirmed that blockchain implementation in inventory management enhances system reliability while reducing data discrepancies between entities. Thus, the system developed in this research possesses not only conceptual validity but also empirical robustness in practice.

Security and data integrity are the primary strengths of this framework. The application of the SHA-256 hashing algorithm to each transaction enabled the system to detect data manipulation with 100% accuracy. Simulation of data alteration in the MySQL database proved that blockchain flagged such transactions as corrupt, rendering them unprocessable. This finding supports the study of Sahoo et al. (2022), which highlighted blockchain’s ability to prevent fraud and enhance trust among supply chain stakeholders. Consequently, blockchain provides significant added value compared to traditional inventory systems.

In terms of performance, the test results revealed that blockchain recording and validation times increased linearly with the number of transactions. Although processing time rose, the system remained responsive at a medium scale. This trade-off between security and efficiency aligns with the analysis of Wannenwetsch et al. (2023), who found that large-scale blockchain systems often face performance limitations due to high computational demands. Therefore, this framework still requires further optimization, such as adopting more efficient consensus algorithms like Proof of Stake (PoS) or Proof of Authority (PoA), as recommended by Sharabati and Jreisat (2024).

The implications of this research are both technical and strategic. Technically, the framework demonstrates that integrating Python, MySQL, and blockchain can deliver an inventory management system that is secure, transparent, and auditable. Strategically, the system can help organizations reduce losses from inventory errors, enhance supply chain efficiency, and strengthen accountability in operational data. These contributions support projections of significant growth in the digital inventory management market through 2030.

In conclusion, this research makes a tangible contribution to the development of modern inventory management systems based on digital technologies. The findings enrich the academic literature on blockchain implementation in information systems while also offering a practical solution that can be adopted by industry to meet the needs of security and transparency in the era of digital transformation.

5. CONCLUSION AND RECOMMENDATIONS

This study successfully designed and implemented an inventory management system framework based on Python and MySQL with blockchain technology integration. The implementation results demonstrated that the system is capable of recording inventory transactions securely, transparently, and with guaranteed integrity through dual recording in both the relational database and the blockchain. Functionally, all core features of the system—including inbound and outbound stock recording, blockchain validation, stock data search, and reporting-operated according to specifications with a 100% success rate. The application of the SHA-256 hashing algorithm proved effective in detecting data manipulation, even when changes were made directly in the MySQL database, thereby ensuring comprehensive security and integrity.

The performance tests revealed that recording and validation times increased linearly with the number of transactions; however, the system remained responsive at a medium scale. These findings affirm that blockchain integration provides significant added value in terms of security, transparency, and data accountability, despite the trade-off in processing speed. Overall, this research contributes to academic literature by extending the application of blockchain in inventory management systems and offers practical contributions by providing a framework that can be adopted by industry to improve operational efficiency and support digital transformation in inventory management.

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