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Textile Industry Revolution: Affordable IoT-Integrated SIMS for Efficient Warehousing

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Abstract

This paper explores the transformative impact of implementing a specialized Smart Inventory Management System (SIMS) empowered by the Internet of Things (IoT) in the textile industry. SIMS brings about a significant paradigm shift by optimizing spatial utilization and redefining traditional inventory processes, making advanced warehouse management accessible and affordable for businesses of all sizes. Our SIMS implementation features a cost-effective integration of an alert system, resulting in substantial savings. This proactive system ensures quick responses to inventory needs, minimizing downtime in production by expediting material retrieval. The affordability achieved through this integration makes SIMS an attractive option for textile manufacturers seeking to enhance warehouse management efficiency. Tailored for the textile sector, SIMS excels in controlling inventory, streamlining order processing, and managing deliveries. The dynamic environment enabled by IoT technology allows businesses to maximize warehouse space usage without incurring excessive costs. This comprehensive and affordable solution represents a significant step towards democratizing access to advanced inventory management tools, empowering textile businesses to thrive in the digital age. In summary, our SIMS implementation in the textile industry not only achieves substantial cost reduction but also fosters a more inclusive and efficient future for warehouse management.

1 1. Keywords

Smart Inventory Management System (SIMS), Textile industry, Internet of Things (IoT), Warehouse management, Proactive Alerts

2 2. Introduction

In the realm of industrial operations, the optimization of expenses and efficient time management are paramount objectives. However, the challenge persists due to the inefficiencies arising from the scattered distribution of necessary items across various locations within factories, resulting in substantial time and labor costs (Yerpude, 2018). To address this issue, the implementation of a Smart Inventory Management System (SIMS) emerges as a promising solution, offering streamlined operations and enhanced productivity (Bose et al., 2022). This innovative system efficiently stores and organizes product data, facilitating swift location of desired items within the inventory, thereby minimizing search time and labor costs (Chen et al., 2019). Although the concept of SIMS may appear simplistic at first glance, its long-term benefits are profound, offering a straightforward and cost-effective return on investment (Skuvault, 2019). The novelty of the SIMS lies in its user-friendly interface, optimized operation, ergonomic design, minimal maintenance, and cost-effectiveness. Leveraging SIMS yields substantial time and cost savings, simplifies product location, and provides real-time inventory visibility. Additionally, the system enables inventory optimization and enhances organizational security through customizable user authentication (Skuvault, 2019). Efficient inventory management is particularly crucial in industries such as food processing and distribution, given the substantial volume of stored products that can escalate costs and reduce warehouse efficiency (Lianga, 2013). Traditional inventory management models often struggle to cope with the complexities of global enterprises, resulting in inefficiencies and operational bottlenecks (Srivastava, Kumar Choubey, and Kumar, 2020). However, emerging technologies like Wireless Sensor Networks (WSN) are revolutionizing inventory management by providing real-time monitoring and data-driven decision-making capabilities (Zhang, Alharbe, and Atkins, 2017). These systems, based on lot-sizing techniques and IoT devices, optimize inventory levels and streamline replenishment processes (TAMER and KOKLU, 2021). Moreover, specialized inventory management systems tailored for specific industries, such as construction and hospitality, further enhance efficiency and resource utilization (Jing and Tang, 2013; Paul, Chatterjee, and Guha, 2019). In summary, the integration of Smart Inventory Management Systems offers a transformative approach to inventory management, promising significant improvements in efficiency, cost-effectiveness, and operational agility across various industrial sectors. By leveraging cutting-edge technologies and innovative design principles, these systems are poised to revolutionize traditional inventory management practices and drive sustainable growth in modern enterprises.

3 3 Design Architect

The figure 1 depicts the schematic representation of the design architecture for a cost-effective Smart Inventory Management System, showcasing the interconnected components and data flow mechanisms essential for efficient inventory control and optimization.

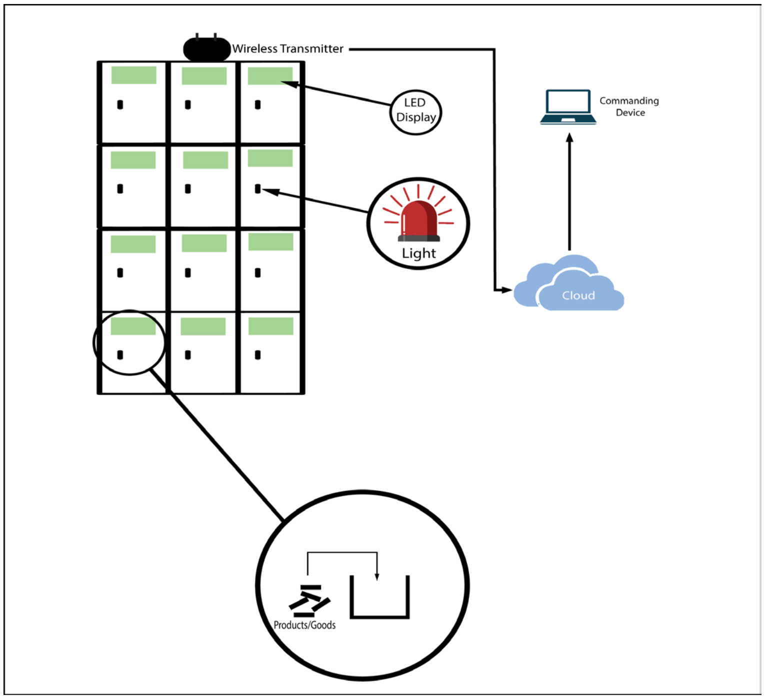


Figure 1: Design Architect for low-cost Smart Management Inventory System

4 4 Data collection & Customer survey

Figure 2 illustrates the utilization of Pareto charts to pinpoint areas requiring immediate attention in process enhancement endeavors. Specifically, Pareto charts present the ordered frequency counts of values associated with different levels of a categorical or nominal variable, thereby aiding in the identification of critical weaknesses necessitating prompt resolution to yield substantial overall improvements. In the context of Smart Inventory Management Systems (SIMS), the depicted chart underscores several key focal points for augmenting customer satisfaction. Firstly, ensuring robust commercial support emerges as a primary consideration, followed by the incorporation of essential features such as displays and alarm systems. Additionally, tailoring the design of SIMS predominantly for indoor environments is highlighted as crucial. By prioritizing these aspects, a notable enhancement of up to 76% in customer satisfaction can be realized.

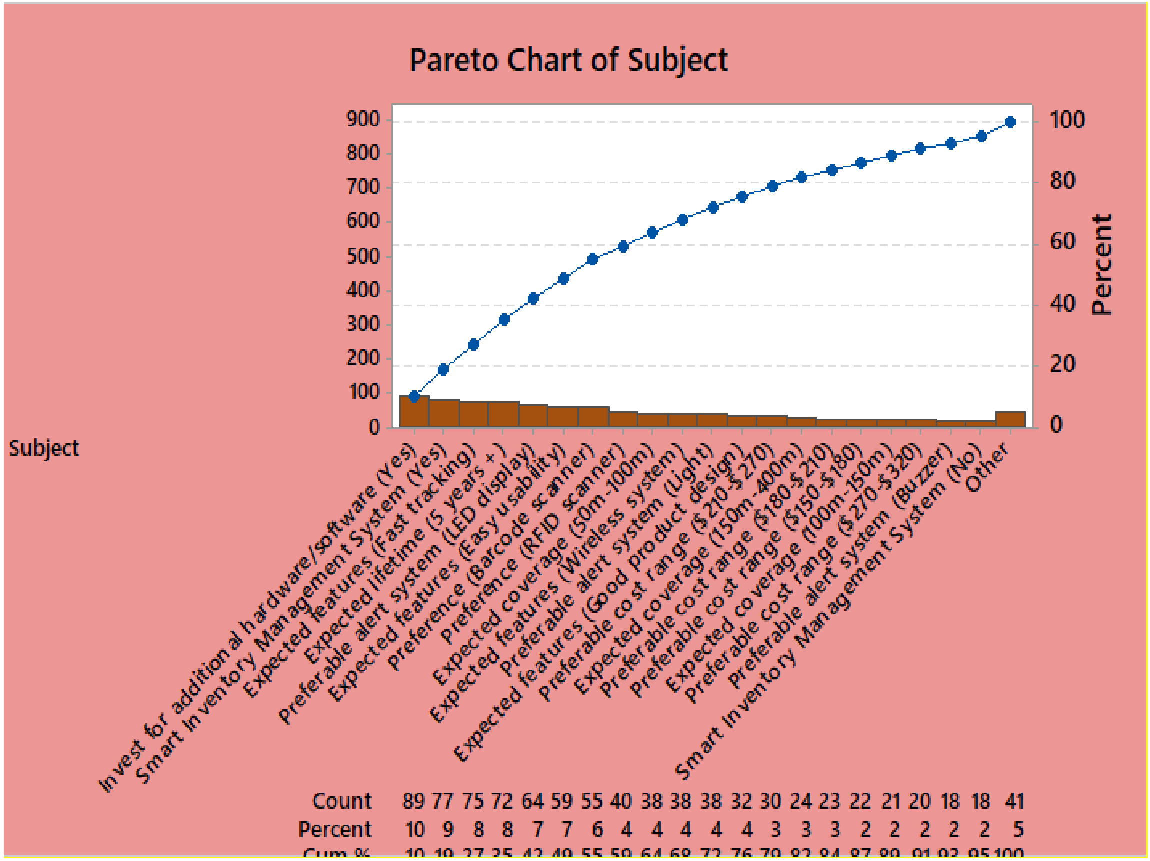
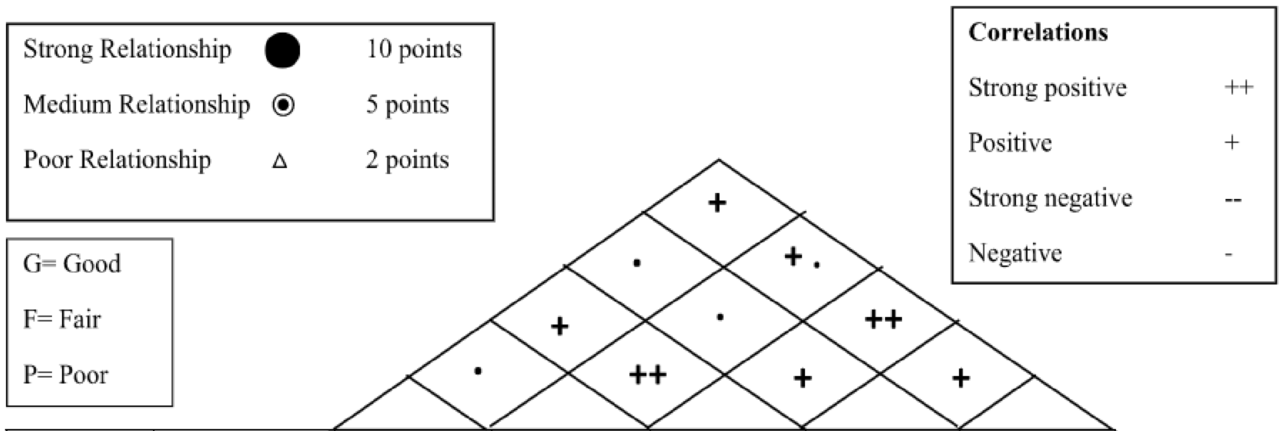


Figure 2:Pareto Chart for Low-cost Smart Management Inventory System

5 5. Methodology

5.1 5.1 Quality Function Deployment

Quality Function Deployment (QFD) serves as a methodological framework for translating qualitative user demands into quantifiable parameters, thereby facilitating the deployment of quality-forming functions and methods across subsystems, parts, and manufacturing processes. Comprising four pivotal phases—Product Planning, Product Development, Process Planning, and Production Planning—QFD endeavors to integrate customer satisfaction considerations into product development endeavors prior to initiating the production process. Distinguished by its pragmatic approach compared to alternative quality control techniques, QFD is instrumental in aligning product design with customer preferences and expectations. Central to the QFD methodology is the "house of quality," a foundational matrix resembling a house structure, delineating customer needs from technical requirements and facilitating independent evaluation of these factors, as illustrated in Figure 3.



Customer importance rating	The desired direction of improvement / Functional requirements (How's) → / Customer requirements (What's) ↓	Processor	Wireless connection	Alert system (Light, buzzer)	Power system	LED display	Our product
6	Fast tracking		●	●		●	F
5	Easy usability	●	◉	●	△	●	G
4	Covering range		●		◉		F
3	Lifetime	●	◉	◉	●	◉	G
2	Cost-effectiven ess	●		●	●	●	G
1	Good design			◉	△	●	F
Technical importance score		100	140	150	82	155	
Importance %		15.95%	22.33%	23.92%	13.08%	24.72%	
Priorities rank		4	3	2	5	1	

Figure 3:QFD for Low-cost Smart Management Inventory System

5.2 5.2 Functional Decomposition of the product

The comprehensive functional decomposition, delineated in Figure 4, elucidates the intricate architecture of the Smart Inventory Management System, detailing its constituent components and their interrelationships. Comprising the Control System Mechanism, Main Body, and Storage System Mechanism, the system embodies a multifaceted approach to inventory management. The Control System Mechanism encompasses vital elements like the button system, wifi transmitter, and alert system, facilitating seamless product selection, transmission, and identification. Complementary features such as the inventory shelf and wooden bodies augment the system's core functionalities. Additionally, auxiliary mechanisms including scanning and cloud storage are integrated to address potential system shortages, enhancing overall efficiency and reliability. This detailed breakdown, as illustrated in Figure 4, offers valuable insights into the system's design intricacies, serving as a foundational framework for further analysis and optimization in peer-reviewed research endeavors.

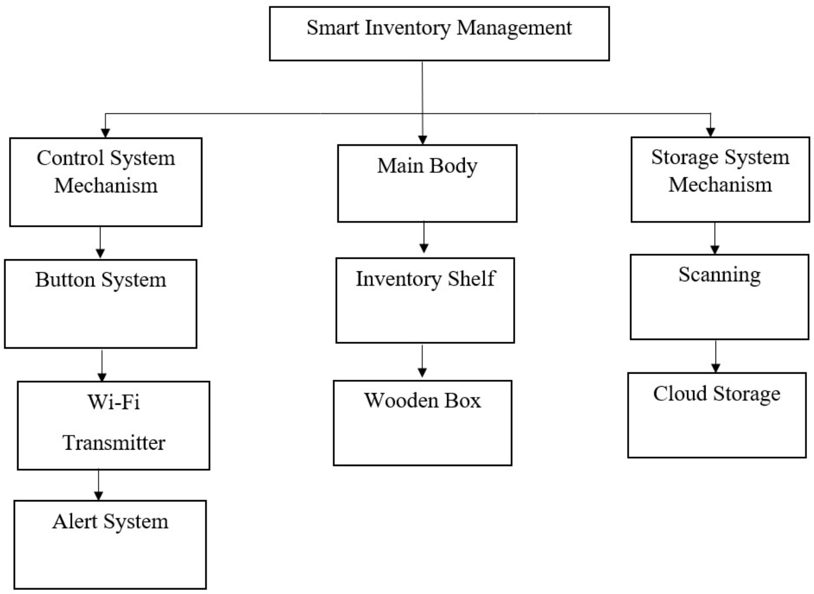


Figure 4:Functional decomposition for Low-cost Smart Management Inventory System

5.3 Black box

The black box model described herein, along with its inputs and outputs, is visually depicted in Figure 5. This model operates by accepting inputs such as energy, materials, and information, while producing outputs without revealing internal mechanisms. Energy input is facilitated through electrical power generation, materials input encompasses wireless, audio, and visual transmission capabilities, and the smart inventory management system stores the product as "unscanned" until needed, triggering user alerts upon product availability. Notably, the main component responsible for initiating and terminating system operations, as well as signaling product availability, is the information input. This visual representation succinctly encapsulates the fundamental workings of the black box model, emphasizing its role in efficiently managing inventory processes.

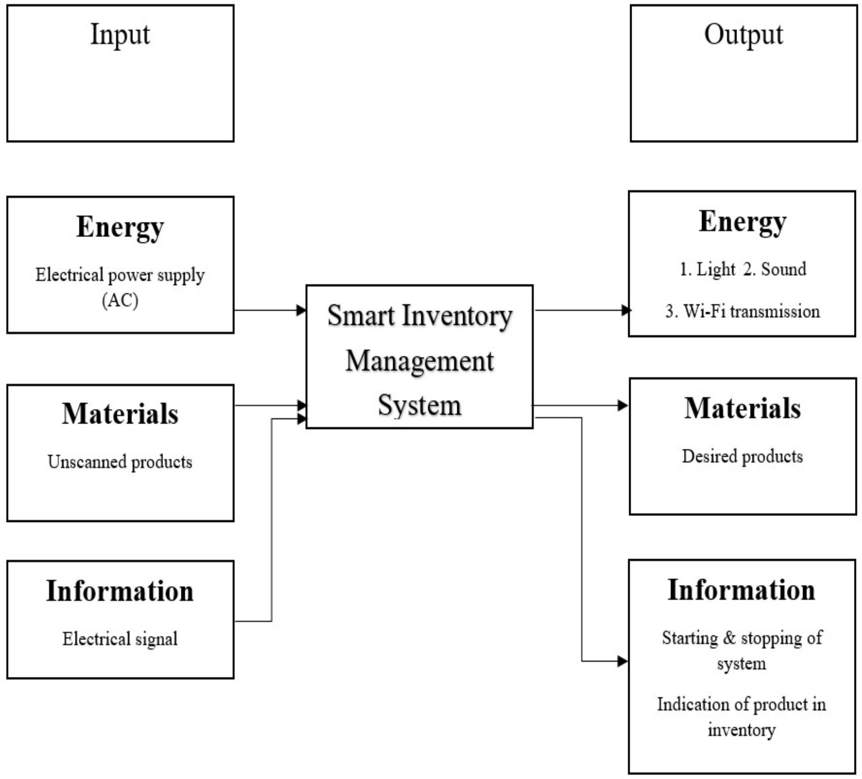


Figure 5:Black box for Low-cost Smart Management Inventory System

5.4 Material Selection

5.4.1 Inventory Shelf

In the material selection process for the smart inventory system, the primary focus is on the inventory shelf, which constitutes the main body of the product. Various criteria were considered essential for this selection, including strength, capacity, durability, atmospheric resistance, cost, and sustainability. Notably, sustainability and atmospheric resistance emerged as the most prioritized criteria, as indicated by their highest relative emphasis coefficients. These criteria were carefully evaluated to ensure that the chosen materials align with the overarching objectives of the smart inventory system, emphasizing longevity, environmental resilience, and cost-effectiveness.

Table 1: Determination of Relative Importance of Goals Using Digital Logic Method

Selection Criteria (Goals)	Number of positive decisions: n(n-1)/2 = 15																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Positive Decisions	Relative emphasis Co-efficient α
Strength	1	0	0	1	0											2	0.13
Durability	0					1	0	1	0							2	0.13
Capacity		1				0				1	0	0				2	0.13
Atmospheric resistance			1				1			0			1	1		4	0.27
Cost				0				0			1		0		0	1	0.07
Sustainability					1				1			1		0	1	4	0.27
	Total number of possible decisions (N) =															15	$\sum \alpha = 1$

Table 2: Numerical value (Rating)

Very High	5
High	4
Medium	3
Low	2
Very low	1

In accordance with the specified criteria, three materials (steel, aluminum, and wood) were initially favored for the sample model..

Table 3: Preferred material's properties & selection criteria of the product

Selection criteria	Aluminum	Steel	Wood
Strength	4	5	3
Durability	3	4	3
Capacity	4	4	4
Atmospheric resistance	4	4	3
Cost	2	3	5
Sustainability	4	3	5

Upon computation of the material performance index, it was observed that Steel attained the highest score of 86.4, trailed by wood at 84.8 and Aluminum at 84.35. Consequently, Steel was selected as the ultimate material for the inventory shelf.

Table 4: Calculation of the Material Performance Index

Selection criteria	Weighted factor, α	Steel		Aluminum		Wood	
		Scaled property, β	Weighted property, αβ	Scaled property, β	Weighted property, αβ	Scaled property, β	Weighted property, αβ
Strength	0.13	100	13	80	10.4	60	7.8
Durability	0.13	100	13	75	9.75	75	9.75
Capacity	0.13	100	13	100	13	100	13
Atmospheric resistance	0.27	100	27	100	27	75	20.25
Cost	0.07	60	4.2	40	2.8	100	7
Sustainability	0.27	60	16.2	80	21.4	100	27
Material Performance Index, $\gamma = \sum \alpha\beta$			86.4		84.35		84.8

6 Design guidelines

1. Design guidelines were applied to enhance the maintainability of the smart inventory system. To mitigate unnecessary movements of inventory shelves and other components, adjustments were made using fixed movable fittings, ensuring streamlined operations and minimizing potential disruptions. Simplified maintenance procedures were achieved by incorporating easily removable parts into the inventory shelf design, significantly reducing maintenance time and enhancing overall system efficiency. The elimination of unnecessary components such as wires and differently shaped joining parts improved system reliability, contributing to smoother functionality and reduced risk of malfunctions. Furthermore, parts utilized in inventory management were engineered to be easily replaceable and recyclable, aligning with sustainable design principles and promoting environmental responsibility. These design optimizations collectively resulted in a smart inventory system characterized by greater reliability and operational effectiveness.

7 Discussion & Result

The Smart Inventory Management System emerges as a versatile solution applicable across diverse industries and company scales, offering substantial benefits in productivity and profitability within order fulfillment processes. While the initial investment may pose a barrier, once implemented, the system yields significant advantages. The scalability of benefits correlates with the size of the company, indicating higher returns for larger enterprises. Seeking consultation with warehouse design experts prior to adoption ensures informed decision-making. Upon integration, the system enhances accountability, minimizing product loss and optimizing time utilization. Moreover, the investment typically recoups within four months, thereby reducing long-term operational costs. Notably, the system mitigates labor expenses, which often exhibit rapid fluctuations. Its versatility extends to enhancing capacity and efficiency in assembly, manufacturing, and warehousing operations, characterized by delicate product handling, reduced damage, and reliable execution of repetitive tasks.

8 Conclusion

This paper offers an in-depth exploration of the Smart Inventory Management System, focusing on user perspectives and operational efficiency. Through a systematic breakdown of the system's components and functions, it elucidates its versatility and applicability across diverse industries. With its ability to streamline repetitive tasks and minimize costs, SIMS emerges as a transformative tool for enhancing productivity and optimizing resource utilization. By facilitating rapid retrieval of items and reducing dependency on manual labor, SIMS revolutionizes traditional inventory management practices. Moreover, its cost-effectiveness and scalability make it an attractive investment for businesses seeking sustainable growth and competitive advantage in dynamic market environments. Overall, the Smart Inventory Management System represents a paradigm shift in inventory control methodologies, offering a robust foundation for operational excellence and future innovation.

9 References

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