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A Review of Existing Inventory Management Systems

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Abstract
This paper provides a thorough review of existing inventory management systems (IMS), tracing their evolution and examining the diverse methodologies and technologies that have been integrated over time. The study underscores the critical role of inventory management in ensuring that organizations maintain the right balance of stock, thus minimizing the risks of both excess inventory and stock outs. Starting from traditional manual methods, the review explores significant advancements such as the Just-in-Time (JIT) methodology, the introduction of barcode scanning, and the implementation of Radio Frequency Identification (RFID) technology. The analysis also considers the impact of modern technologies like the Internet of Things (IoT) on enhancing inventory tracking accuracy and efficiency. Despite these technological advancements, the paper highlights ongoing challenges in the effective integration of IMS with other business processes, particularly in complex, multi-location environments. The review further differentiates the needs of various industries and business sizes, emphasizing that the choice of an IMS should align with the specific operational requirements of the organization. Moreover, the paper discusses the importance of understanding the strengths and weaknesses of current systems to guide future research and development in the field. As businesses continue to adapt to rapidly changing market conditions and customer demands, the need for innovative and adaptable IMS solutions becomes increasingly important. This review not only provides insights into the current state of inventory management but also identifies areas for improvement and future research, aiming to contribute to the development of more efficient and effective IMS tools that meet the evolving needs of businesses.

Keywords: *Inventory, Inventory Management, Internet of things, Radio Frequency Identification, Stock out, barcode*

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I. INTRODUCTION

Inventory management is a critical function within any organization that deals with physical goods, whether in manufacturing, retail, or distribution. The goal of inventory management is to ensure that the right quantity of products is available at the right time, minimizing both excess inventory and stock outs [19]. Reducing expenses, improving customer satisfaction, and preserving operational efficiency all depend on effective inventory management. The necessity to handle these issues has fueled the development of inventory management systems (IMS), which have gradually incorporated a variety of approaches and technology [11].

The conventional manual techniques of inventory management were no longer adequate as firms became more sophisticated. After World War II, significant developments occurred in inventory management strategies, most notably with Toyota's introduction of the Just-in-Time (JIT) approach in the 1950s. By closely matching production schedules with demand, JIT sought to decrease inventory levels while also cutting waste and increasing efficiency [20].

Modern business environments have led to the evolution of inventory management systems, which now include cutting-edge technology like RFID, barcode scanning, and the Internet of Things (IoT). These technologies have made inventory tracking more accurate and efficient, decreased the possibility of human error, and made automated data collection possible [8].

Effective inventory management remains a concern for firms, notwithstanding recent developments. Integrating inventory management systems with other corporate operations is one of the main issues. Although enterprise resource planning (ERP) systems are designed to offer a holistic solution, it can be difficult and expensive to integrate different systems across many departments and locations.

Examining current inventory management systems can shed light on the unique requirements of various business sizes and industries. For example, a small local retailer's inventory management needs could be very

different from those of a major global organization. Acknowledging these variations enables firms to choose the best inventory management system for their particular requirements.

Furthermore, evaluating present systems might help direct future inventory management research and development. Innovative inventory management systems will become more and more in demand as companies continue to adjust to shifting market conditions and client needs. Researchers and developers can make better and more efficient inventory management solutions in the future by identifying the advantages and disadvantages of the systems that are already in use.

II. Review of Inventory Management Systems

2.1 Inventory Management Systems

[27] proposed an implementation of Inventory Management System. The research addresses the challenges and solutions related to inventory management in the context of e-commerce and other industries. The objective of the work is to develop an inventory management system that can efficiently store, update, and manage data related to dealers, suppliers, manufactured goods, and raw materials aiming to provide a user-friendly interface that can be accessed by individuals without technical backgrounds. The research proposes a system that uses MongoDB for backend data storage and Java on NetBeans for the frontend development. MongoDB was chosen for its ability to handle unstructured data, which is common in inventory management scenarios. The system is designed to track various modules, including departments, warehouses, raw materials, suppliers, and employees. The work describes the use of NetBeans to create a graphical user interface (GUI) that simplifies interaction with the system. The GUI is designed to be intuitive, allowing users to perform tasks like adding, updating, and deleting records without needing extensive technical knowledge. The system successfully addresses the issues of data fluctuation and improper inventory control. They highlight the system's ability to provide high levels of customer service by ensuring accurate and timely data management. The work suggest future directions for research, such as integrating the system with other enterprise resource planning (ERP) systems and exploring the use of artificial intelligence (AI) for predictive analytics

[25] developed inventory management system using application. The work addresses the need for efficient inventory management systems in the context of small and medium enterprises (SMEs). The authors highlight the limitations of traditional inventory management methods, such as manual record-keeping and spreadsheet-based systems, which are prone to errors and inefficiencies. The primary objective of the study was to develop a mobile application that could streamline inventory management for SMEs aiming at creating a system that would be user-friendly, accessible, and capable of providing real-time updates on inventory levels. The authors employed a structured analysis and design methodology to develop the proposed mobile application. The system was divided into various modules to ensure it could accommodate different user needs. The application was implemented using Android Studio for the front-end development and Firebase for the back-end database management. This combination provided a robust and scalable solution for managing inventory data. However, the paper could benefit from a more detailed discussion on the potential challenges and limitations of implementing such a system. For instance, the work did not explore issues related to data security, and lack comparison with other existing inventory management systems

[1] proposed Development of a Web-Based Platform for Automating an Inventory Management of a Small and Medium Enterprise, the research addresses the challenges faced by small and medium enterprises (SMEs) in managing inventory using manual methods. The authors highlight that traditional inventory management practices, such as using spreadsheets, are labor-intensive, error-prone, and inefficient. These methods often lead to issues like data inaccuracy, oversight, and internal shrinkage, which can significantly impact business operations. The primary objective of the research was to develop a web-based platform to automate inventory management for SMEs aiming to create a system that would streamline inventory processes, reduce errors, and improve overall efficiency. The authors employed a structured analysis and design methodology to develop the proposed system. They divided the system into various modules to ensure it could accommodate different user needs. The system was implemented using a MySQL database, which provided a robust and scalable solution for managing inventory data, the development of a web-based platform for automating inventory management can significantly benefit SMEs. The system addresses the limitations of manual inventory management methods, providing a more efficient, accurate, and user-friendly solution. The authors recommend the adoption of such computerized systems to improve service delivery, reduce unnecessary stress, and keep inventory records current. However, this work is limited by its lack of intelligence and built as a standalone system.

[21] worked on an Automated Inventory control system for a university cafeteria management, the research addresses the challenges associated with manual inventory control systems in university cafeterias. Manual systems are often labor-intensive, costly, and prone to errors, which can lead to inventory discrepancies and inefficiencies. In order to improve operational efficiency, minimize human error, and streamline inventory management procedures, the authors suggest an automated inventory control system. The study's main goal is to create and put into place an automated inventory control system for a Nigerian university cafeteria. The

system aims to efficiently handle the movement and tracking of goods without human involvement, ensuring real-time updates and accurate inventory status. The work employed a comprehensive analysis and design methodology to develop the proposed system. Key aspects of their approach include:

a. **System Design**: Python was used as the main programming language during the system's construction, and an object-oriented database was used to manage data.
b. **Implementation**: The implementation phase involved coding the system to automate inventory tracking and updates. The system was tested through observation and interviews with users to validate its effectiveness.
c. **Comparison with Existing Systems**: The study demonstrated the benefits of automation in terms of accuracy, efficiency, and cost-effectiveness by contrasting the automated system with the already in use manual systems.

The results of the study indicate that the automated inventory control system successfully handles the movement and tracking of goods without human involvement. Based on their findings, the authors recommend the adoption of automated inventory control systems in university cafeterias and other similar settings. They suggest that further research could explore the scalability of such systems and their application in different contexts.

[14] developed a Livestock Inventory Management System (LIMS). The system was designed to streamline the management of livestock inventories, enhancing efficiency and accuracy in tracking and managing livestock data. The research is motivated by the challenges faced by livestock farmers in managing their inventories. Conventional techniques are frequently labor-intensive, error-prone, and manual. The study highlights the requirement for a more efficient system that leverages modern technology to address these issues. The objectives of the research were to design a user-friendly LIMS that can be easily adopted by farmers and help enhance the efficiency and precision of managing livestock inventories. The research employed a systematic approach to develop the LIMS. The system was designed using Android Studio, XML, Java, and MySQLite. The choice of these technologies was driven by their robustness and compatibility with mobile devices, enabling a broad spectrum of users to access the system. The system was tested in a real-world environment to evaluate its performance. The authors conducted a series of tests to ensure the system's reliability, accuracy, and user-friendliness. Feedback from users was collected and used to make necessary improvements. The implementation of the LIMS showed significant improvements in the management of livestock inventories. The technology minimized errors and cut down on the time and effort needed for inventory management. Users reported high satisfaction with the system's ease of use and the accuracy of the data provided. The system developed was not an intelligent system and its built as a standalone system. The authors suggest that future research could explore the integration of additional features, such as predictive analytics and IoT devices, to further improve the system.

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[18] developed an auto parts inventory management systems The study highlights the challenges faced by businesses in managing inventory manually, which can lead to inefficiencies, errors, and increased operational costs. The proposed solution is a user-friendly inventory system using a QR-code scanner, designed to store large quantities of data and provide real-time updates on inventory conditions. The research employed a descriptive research method to develop the proposed system. The system was divided into various modules to ensure it could accommodate different user needs. The application was implemented using Apache, MySQL, and XAMPP for the back-end database management, and a graphical user interface (GUI) for the front-end development. This combination provided a robust and scalable solution for managing inventory data, . The system addresses the limitations of manual inventory management methods, providing a more efficient, accurate, and user-friendly solution. The authors recommend the adoption of such computerized systems to improve service delivery, reduce unnecessary stress, and keep inventory records current.

[3] presents a comprehensive study on the design and implementation of an Inventory Management Information System (IMIS) using the periodic review method. This system is aimed at improving the management of office equipment inventories in universities, addressing inefficiencies and challenges associated with traditional inventory management methods. This research is motivated by the need to move away from traditional methods which are often manual and error – prone which leads to over stocking or stock out. The primary objectives of the study were to design an efficient and user-friendly IMIS for managing office equipment inventories, implement the periodic review method to optimize inventory levels and reduce costs and provide a decision support tool for inventory replenishment based on statistical analysis. The work employed the waterfall method for the development of the IMIS. This method involves a sequential design process, including requirement analysis, system design, implementation, testing, and maintenance. The system was developed using MySQL and PHP, chosen for their robustness and compatibility with web-based applications. The system was implemented at a university and subjected to rigorous testing to evaluate its performance. The authors conducted interviews with stakeholders to gather feedback and make necessary improvements. The testing phase focused on the system's reliability, accuracy, and user-friendliness, the system developed using the periodic review method resulted in significant improvements in inventory management. The system automated the calculation of stock levels,

reducing the time and effort required for inventory management. It also helped in preventing overstocking and stock outs, thereby reducing inventory costs. The system developed is limited by its implementation on standalone systems and being an intelligent system. Future work can incorporate IoT devices.

[26] worked on the design and development of an inventory management mobile application, the study discusses the importance of inventory management in the supply chain and emphasizes the difficulties that manual method-using companies confront. These challenges include inaccurate demand forecasting, overstocking, stock outs, and poor supply chain coordination. The authors propose a mobile application to streamline inventory management processes, reduce errors, and enhance efficiency. The objective of the work was to automate inventory tracking to eliminate manual errors and improve accuracy and provide up-to-date information on inventory levels. The authors employed the Rapid Application Development (RAD) methodology, which emphasizes quick iterations and prototyping. This approach allows for the rapid development of a prototype based on gathered requirements and feedback from field testing. The application leverages smartphone capabilities to provide a user-friendly interface and real-time data access. The backend is developed using PHP and MySQL, while the frontend is built with HTML, CSS, and JavaScript

[22] proposed an inventory and bill management system. The research discusses the necessity of effective inventory and billing management systems in contemporary company, emphasizing the difficulties that companies encounter when handling these tasks by hand, which can result in errors, inefficiencies, and higher operating expenses. The primary objective of the study was to develop an Inventory and Bill Management System that could streamline inventory and billing processes for businesses. The research employed a structured analysis and design methodology to develop the proposed system. The system was divided into various modules to ensure it could accommodate different user needs. The application was implemented using C# for the front-end development and SQL Server for the back-end database management. This combination provided a robust and scalable solution for managing inventory and billing data The system developed addresses the limitations of manual management methods, providing a more efficient, accurate, and user-friendly solution. The authors recommend the adoption of such computerized systems to improve service delivery, reduce unnecessary stress, and keep inventory and billing records current. However, the developed system was unable to utilize smart technology to predict trends or automate tasks.

2.2 Smart Inventory Management Systems

[9] developed an intelligent warehouse management system using the Internet of Things. The creation of an intelligent warehouse management system (WMS) is the study's main goal that leverages IoT technologies to enhance operational efficiency, accuracy, and real-time monitoring. The work aim to address common challenges in traditional warehouse management, such as inventory inaccuracies, manual errors, and inefficiencies in tracking and monitoring inventory. The suggested system aims to offer real-time data, automate inventory tracking, and enhance decision-making processes through the integration of IoT devices. The study suggests a framework for automating inventory tracking and management by integrating IoT devices like RFID tags and sensors. The components of the system architecture for data processing, analysis, and gathering are made to give real-time insights into warehouse operations and inventory levels. The suggested IoT-based WMS's deployment resulted in notable gains in operational effectiveness, a decrease in manual error, and inventory accuracy. The ability of the system to monitor in real time facilitated improved resource allocation and decision-making. The report admits its limitations, including the requirement for a strong network infrastructure and the initial expense of integrating IoT technologies. Additionally, the work suggest that further research is needed to explore the scalability of the system in larger warehouse environments. The effectiveness of the IoT-based WMS depends on the availability of a robust network infrastructure. Poor network connectivity can

In order to track items at a steel company more quickly, [16] created an Android-based inventory management system with NFC enabled. In this study, a steel company's use of Near Field Communication (NFC) technology to deploy an Android-based inventory management system is investigated. The primary objective is to enhance the efficiency of inventory tracking and reduce the time required for stocktaking processes. The study employs a case study approach, focusing on a steel company where inventory management is crucial for operational efficiency. The methodology includes:

a. Development of the Application: The Android application was designed to read NFC tags attached to inventory items. This allows for quick and accurate data capture.
b. Participants: Eleven employees from the steel company participated in the study. They were tasked with performing stocktaking using both the new NFC-based system and the conventional method.
c. Data Collection: A total of 54 samples were collected for time evaluation. The time taken for stocktaking using both methods was recorded.

d. Data Analysis: A t-test was used to analyze the data and compare the time efficiency between the two methods.

The results of the study indicate a significant improvement in time efficiency with the new NFC-based system. Key findings include:

a. The average time required for stocktaking using the NFC-based system was significantly shorter than the conventional method.
b. The t-test results showed a statistically significant difference in time efficiency ($df = 26$, $t = -7.075$, $p < .001$), indicating that the new system is much faster[1].
c. The new system also reduced the likelihood of human error, as the NFC tags provided accurate and instant data capture.

The study illustrates how adding NFC technology to inventory management systems may have advantages. The results imply that the Android-based NFC system can greatly increase the accuracy and time-efficiency of stocktaking procedures. Although the study offers insightful information, more research with bigger sample sizes and a range of industry scenarios is advised to confirm the conclusions.

[2] developed an Artificially Intelligent Warehouse Management System. The research explores the development and implementation of an Artificially Intelligent Warehouse Management System (AI-WMS) designed to increase the effectiveness as well as the precision of warehousing operations. The framework leverages artificial intelligence (AI) to automate various warehouse processes, thereby reducing human intervention and improving overall operational efficiency. The principal aim of the research is to develop an AI-WMS that can manage warehouse operations more effectively by utilizing AI technologies. The system's aim is to increase inventory record accuracy, minimize operating expenses, and optimize inventory management. To create the AI-WMS, the research used a thorough methodology that included:

a. **System Design**: The system architecture was designed to integrate various AI technologies, including machine learning algorithms and computer vision, to automate warehouse operations
b. **Data Collection and Processing**: The system tracks warehouse activities in real time by collecting data from several sources, including cameras and sensors. Subsequently, the data is processed using machine learning algorithms to enable informed inventory management decisions.
c. **Implementation**: The AI-WMS was implemented using a combination of hardware and software components. The hardware includes sensors and cameras, while the software comprises machine learning algorithms and a user interface for managing warehouse operations
d. **Testing and Evaluation**: The system was tested in a real-world warehouse environment to evaluate its performance. The testing focused on assessing the system's accuracy, efficiency, and reliability.

The implementation of the AI-WMS resulted in several significant outcomes:

a. **Improved Efficiency**: The system automated various warehouse processes, reducing the need for manual intervention and improving overall efficiency
b. **Enhanced Accuracy**: The use of AI technologies improved the accuracy of inventory records, reducing errors and discrepancies
c. **Cost Reduction**: The automation of warehouse operations led to a reduction in operational costs, as fewer human resources were required to manage the warehouse
d. **Real-Time Monitoring**: The system provided real-time monitoring of warehouse activities, enabling better decision-making and resource allocation.

The paper presents a robust solution for improving warehouse management through the use of AI technologies. The AI-WMS offers significant improvements in efficiency, accuracy, and cost reduction.

[28] developed a new intelligent warehouse management system that is created and put into use with MySQL database technology. In response to company demands for improved material management, the study creates an intelligent warehouse management system (WMS) built on MySQL database technology. The system uses real-time data management and automated procedures to improve the accuracy and efficiency of warehouse operations. The main goal is to create a warehouse management system (WMS) that incorporates MySQL database technology to offer thorough and instantaneous administration of warehouse operations. Inventory management, warehousing management, procurement management, and system management are all covered by the system's design. The WMS was designed and implemented using an organized methodology in the study.

a. **System Design**: A variety of functional modules, including basic information management, system management, inventory management, warehousing management, and procurement management, were incorporated by design into the system architecture.

b. **Database Construction**: A MySQL database was built to store and manage all relevant data. The database design focused on ensuring data integrity, security, and efficient retrieval.
c. **System Implementation**: The system was implemented using MySQL database technology, with a focus on achieving high performance and reliability. The implementation included developing user interfaces and integrating the system with existing enterprise resource planning (ERP) systems.
d. **Testing and Evaluation**: The system underwent rigorous testing, including unit tests and integration tests, to ensure it met the expected requirements and performed within acceptable response times (within 3 seconds).

The paper presents a robust solution for improving warehouse management through the use of MySQL database technology. The intelligent WMS offers significant improvements in efficiency, accuracy, and real-time data management. However, the complexity of integration and scalability issues are challenges that need to be addressed for broader adoption

[15] developed a Smart warehouse management system. The research addresses the challenges in warehouse automation and digitalization, particularly in the context of Industry 4.0. Despite significant advancements in technology, many warehouses still struggle with effective automation and digitalization. The work propose an Internet-of-Things (IoT)-based architecture to enhance real-time warehouse management by dividing the warehouse into multiple domains. By segmenting the warehouse into several domains, the paper suggests an Internet-of-Things (IoT)-based architecture to improve real-time warehouse management. The research's goals were to design an Internet of Things (IoT)-based architecture for real-time warehouse management, build a working prototype system for effective data collecting and transmission, and validate the suggested system by implementing it in an actual environment—a textile factory, to be exact. The work employed a multi-faceted approach to develop the smart WMS. The methodology includes: System Architecture Design which integrates various components such as RFID tags, IoT sensors, and a central database. The architecture was designed to facilitate real-time data collection and processing. A prototype of the smart WMS was developed to demonstrate its functionality. The prototype includes hardware components like RFID readers and IoT sensors, as well as software components for data processing and user interface. The system was implemented in a controlled environment to test its real-time capabilities. The implementation phase involved setting up the hardware and software components, and conducting tests to evaluate system performance. The study presents several key finding, which include

a. **Reduction in Inventory Discrepancies**: Real-time updates on stock levels provided by the smart WMS help in maintaining accurate inventory records, minimizing discrepancies.
b. **Streamlined Warehouse Operations**: The system enhances efficiency in warehouse operations, resulting in quicker order processing.
c. **Reduced Labor Costs**: Automation and improved processes lead to a decrease in labor costs.
d. **Continuous Inventory Monitoring**: Ongoing monitoring facilitates timely decision-making and helps prevent stock outs and overstocking

Despite its promising results, the study acknowledges certain limitations:
a. Scalability: The prototype was tested in a controlled environment, and its scalability to larger, more complex warehouse settings remains to be evaluated.
b. Cost: Small and medium-sized businesses may find the initial setup costs for the smart WMS, which include both hardware and software components, to be prohibitive.
c. Technical Difficulties: Not all firms have access to the technical know-how needed to adopt RFID and IoT technologies.

The research offers significant perspectives on the creation and execution of an intelligent warehouse management system. Real-time monitoring, operational effectiveness, and inventory correctness are all markedly improved by the suggested method. However, further research is needed to address scalability, cost, and technical challenges to make the system more accessible and practical for widespread adoption.

[5] developed a Stock Management Using IoT. The study looks into how stock management systems can use Internet of Things (IoT) technologies. The goal of the project is to use IoT devices to improve inventory management's accuracy and efficiency. Creating an Internet of Things (IoT)-based stock management system, assessing the system's efficacy and performance in practical settings, and contrasting the system with conventional stock management techniques were the main goals of the research. To evaluate the efficacy of the Internet of Things-based stock management system, the study combines comparison and experimental methodologies. Important elements of the approach comprise:
a. System Development: The IoT system was designed to include sensors, RFID tags, and a central management application. These components work together to provide real-time data on stock levels and movements.

a. Implementation: The system was implemented in a warehouse setting to monitor stock levels and track inventory movements.
b. Data Collection: Data on stock levels, movements, and system performance were collected over a specified period.
c. Comparison: The performance of the IoT-based system was compared with traditional stock management methods to evaluate improvements in efficiency and accuracy.

The study's findings show that the IoT-based system significantly increases the accuracy and efficiency of stock management. The study illustrates how incorporating Internet of Things technologies into stock management systems may have advantages. The results imply that IoT-based solutions can greatly raise inventory management's accuracy and efficiency. Even though the study provides insightful information, more research is recommended to examine the scalability and long-term advantages of IoT in many industry scenarios. Real-time stock level data was made available via the IoT system, facilitating prompt decision-making and lowering the possibility of stock outs or overstocking. The human error that comes with manual stock management was reduced by the use of sensors and RFID tags. Lastly, the technology reduced the time and effort needed for inventory tracking by streamlining stock management procedures.

[24] developed A Smart Management Scheme for The Efficient Control of Industrial Inventory. The research addresses the vital requirement for effective inventory control in commercial environments. The work propose a database management system designed to enhance the accuracy, efficiency, and cost-effectiveness of inventory control. The study's main goal was to create a solid and dependable database management system that reduces inventory management expenses and errors. In order to minimize stock-outs and optimize inventory levels, the system seeks to precisely calculate the Economic Order Quantity (EOQ) and Reorder Level (ROL). The research employed Visual Basic 2017 for the front-end development and SQL Server for the back-end. The system was designed with a focus on zero tolerance for errors, incorporating a comprehensive scheme for coding and debugging. The methodology involved a comparative analysis between the automated system and traditional manual inventory management approaches. The system architecture was meticulously planned to ensure seamless integration between the front-end and back-end components. The user interface was designed to be intuitive and user-friendly, facilitating easy data entry and retrieval, SQL Server was chosen for its robustness and reliability in handling large datasets. The database schema was designed to store and manage inventory data efficiently, with tables for products, suppliers, transactions, and inventory levels. A significant emphasis was placed on error handling and debugging. The system was tested rigorously to identify and rectify any potential issues, ensuring high reliability and accuracy and the performance of the automated system was compared with manual inventory management methods. Metrics such as error rates, cost savings, and time efficiency were evaluated to highlight the benefits of automation. The implementation of the smart management scheme yielded significant improvements in inventory management efficiency. Key findings include:

a. Error Reduction: The automated system drastically reduced the number of errors compared to manual methods. This was attributed to the robust error handling mechanisms and the elimination of human errors in data entry and processing.
b. Cost Savings: The system demonstrated substantial cost savings by optimizing inventory levels and reducing stock-outs. The accurate determination of EOQ and ROL helped in maintaining optimal inventory levels, thereby minimizing holding and shortage costs.
c. Time Efficiency: The automated system significantly reduced the time required for inventory management tasks. The intuitive user interface and efficient data management capabilities facilitated quick and easy access to inventory data.
d. Improved Decision Making: The system provided real-time insights into inventory levels and trends, enabling better decision-making. Managers could make informed decisions regarding inventory replenishment and procurement, leading to improved operational efficiency.

The study presents a promising solution; it is not without limitations:

a. Industry-Specific Focus: The system was designed and tested in a specific industrial context. The generalizability of the results to other industries or larger-scale operations may require further validation.
b. Software Dependency: The reliance on specific software tools (Visual Basic 2017 and SQL Server) may limit the adaptability of the system to other technological environments. Organizations using different software platforms may face challenges in implementing the proposed system.
c. Scalability: The scalability of the system for larger organizations with more complex inventory management needs was not extensively tested. Further research is needed to evaluate the system’s performance in larger and more diverse industrial settings.

The research significantly advances the subject of industrial inventory management by providing a workable and reasonably priced database management system. According to the research, these kinds of technologies can lower expenses, increase overall operational efficiency, and improve inventory control. The study emphasizes the value of automation in contemporary inventory management and offers a strong framework for further investigation and advancement in this field.

[4] worked on the development of an IoT-based inventory management solution and training module using smart bins. addresses the increasing need for flexibility, transparency, and changeability in warehouse environments. This need arises from the demand for cost-efficient production of small batch sizes, which requires adaptable and transparent material and information flows. The primary objective of this research was to develop and validate an IoT-based inventory management solution and a corresponding training module. The solution aims to enhance the transparency and flexibility of material flows within warehouses by using smart bins equipped with weight mats and additional sensors. Through the use of weight mats to measure the content of the bins, independent of the specific component geometry, the smart bins at Werk150, the Factory on the ESB Business School campus allow logistics decision-makers to transparently base their decisions on the weights of the various components they track. The data collected is analyzed using AI-based algorithms to optimize processes and give logistics decision-makers a transparent basis for decision-making. These components are connected to an IoT hub to collect and analyze data on material consumption and manual handling operations. The study highlights the importance of integrating IoT technologies into inventory management systems to address the challenges posed by manual processes in warehouses. The smart bins' ability to provide real-time data on material consumption and handling operations is crucial for creating a transparent and efficient inventory management system. The training module developed alongside the IoT solution ensures that students and industry professionals can effectively implement and utilize these technologies in practice. While the study provides valuable insights into the benefits of IoT-based inventory management solutions, it is limited to the specific context of the ESB Business School's Werk150 factory. Further research is needed to validate the findings in different industrial settings and to explore the scalability of the solution.

[23] developed an advanced smart inventory management system using IoT. The research presents a modern approach to inventory management leveraging the Internet of Things (IoT) technology. The primary objective of the study is to develop an automated system for efficient inventory management using IoT aiming to provide real-time data on inventory levels, reduce management costs, improve operational efficiency and optimize inventory levels to reduce waste and ensure product availability. The system comprises various sensors and microcontrollers, including:

- **a. Sensors**: IR sensors, ultrasonic sensors, and load cell sensors are strategically placed to monitor various parameters such as quantity, presence, and weight of inventory items.
- **b. Microcontrollers**: Arduino Uno and NodeMCU are used to process sensor data and transmit it to the cloud.
- **c. Cloud Platform**: The cloud platform stores and processes the data, providing real-time insights into inventory levels.
- **d. User Interface**: A web or mobile interface allows users to monitor and control the system remotely.

The data flow in the system begins with the sensors collecting information about the inventory. This data is then processed by the microcontrollers and transmitted to the cloud. The cloud platform analyzes the data and provides real-time insights to the user through the interface. The system also includes status LEDs to indicate the current state of the inventory. The implementation of the IoT-based inventory management system has shown significant improvements in inventory management. While the system shows promise, the paper also discusses potential challenges and limitations, including:

- **a. Calibration**: Ensuring the accuracy of sensors requires regular calibration.
- **b. Data Security**: Protecting the data transmitted to and from the cloud is crucial.
- **c. Integration**: Integrating the system with existing enterprise systems can be complex.

The work suggests several areas for future research and development, including:

- **a. Enhanced Security**: Developing robust security protocols to protect data.
- **b. Scalability**: Ensuring the system can scale to handle larger inventories.
- **c. Advanced Analytics**: Incorporating advanced analytics to provide deeper insights into inventory trends.

[10] developed an Intelligent Inventory Management System. The research work addresses the critical need for efficient inventory management systems in modern businesses. Traditional methods often fall short in providing real-time data and accuracy, leading to inefficiencies and increased operational costs. The authors propose an intelligent system that leverages advanced technologies to overcome these challenges. The objectives of the research were to develop an intelligent inventory management system that provides real-time data on inventory levels, integrate weight sensors and advanced controllers to monitor and analyze inventory data continuously and enhance operational efficiency by reducing manual intervention and errors in inventory tracking.

The system employs several key components such as Weight Sensors which continuously monitor the weights of products, providing real-time data., Selec PID500-U Controller which also receives data from the weight sensors via RS485 communication and uses special variables to analyze the weight data. Human-Machine Interface (HMI) that displays the results, offering instant visibility of inventory levels The system successfully provides precise, real-time insights into inventory levels. This allows businesses to streamline operations, reduce costs and enhance productivity. The Intelligent Inventory Management System represents a significant advancement in inventory management by integrating state-of-the-art technology. It offers a revolutionary approach to inventory tracking, providing precise, real-time insights that enable businesses to thrive in competitive markets however, the work only manages one items and potential difficulties in integrating with legacy systems The authors suggest several areas for future research in developing more sophisticated algorithms for data analysis, exploring the system's application in other areas, such as chain of supply.

[13] worked on using barcode and RFID technology to increase inventory and supply chain management efficiency. The study examines how these technologies might be applied to raise the efficacy of supply chain and inventory management systems. The project's goal is to find out how barcode and RFID (Radio Frequency Identification) technology may improve the functionality of inventory and supply chain management systems. It emphasizes how these technologies may be used to track and monitor things effectively, which helps to optimize inventory levels and boosts overall operational efficiency.

The study compares and contrasts barcode and RFID technology. Important elements consist of:

a. Barcode technology: This uses parallel lines with varying widths and spacing to represent data. Line-of-sight scanning and human data entry are necessary for barcodes.
   The study assesses how these technologies are used at several phases of the supply chain, including asset tracking, logistics, and inventory management. Additionally, in order to synchronize inventory data with other business processes, it looks at how these technologies can be integrated with enterprise resource planning (ERP) systems.
b. RFID Technology: This system automatically detects and tracks tags affixed to things using electromagnetic fields. RFID tags allow real-time tracking without requiring line-of-sight scanning by wirelessly transmitting data to readers.

The results show that barcode and RFID technologies provide a number of advantages.
a. Inventory management: By accurately measuring inventory levels in real time, these technologies help businesses minimize excess inventory and stock outs. Cost reductions and increased inventory turnover result from this.

b. Supply Chain Efficiency: The supply chain is more visible and traceable thanks to RFID and barcode technologies. This visibility facilitates proactive decision-making to minimize disruptions, lowers lead times, and increases inventory accuracy.

b. Automation: Automated data collection and processing lowers the need for human interaction, lowers mistake rates, and improves overall productivity. The smooth interface with ERP systems is also made possible by this automation.

Nonetheless, there are issues with RFID standards that may compromise the technology's interoperability with other systems and organizations.

[12] developed an IOT based smart shelve inventory management system. The research focuses on developing a smart shelf inventory management system using IoT technologies to manage and track inventories more efficiently and automatically. The system's objectives are to give real-time inventory level data, minimize errors, and cut down on manual work. The principal aims of the research were to develop and execute a smart shelf system utilizing Internet of Things (IoT) technology for real-time inventory management, minimize the labor-intensive manual process associated with inventory tracking, and furnish precise and prompt notifications for inventory replenishment. The system makes use of several IoT components, such as:

a. ESP32 Module: Acts as the central processing unit for the system.
b. Ultrasonic Sensors: Measure the inventory levels on the shelves.
c. LCD Display: Shows real-time data on inventory levels.
d. Buzzer and Indication Light: Provide alerts when inventory levels drop below a certain threshold.
e. Power Supply and Voltage Regulator: Ensure stable operation of the system.

The methodology involves setting up these components to work together seamlessly. The ESP32 module collects data from the ultrasonic sensors and processes it to determine the current inventory levels. This data is then displayed on the LCD screen and used to trigger alerts via the buzzer and indication light when necessary.

The implementation of the IoT-based smart shelf system demonstrated several benefits:

a. Real-Time Monitoring: Decisions could be made promptly because the technology offered real-time data on inventory levels.
b. Error Reduction: Automated tracking reduced the likelihood of human errors in inventory management.
c. Efficiency: The system streamlined the inventory management process, saving time and labor.
d. Alerts and Notifications: The system effectively alerted users when inventory levels were low, ensuring timely replenishment.

The system showed promising results however, it also had some limitations:

a. The system's scalability to larger and more complex inventory environments was not extensively tested.
b. The system's performance is heavily reliant on the proper functioning of IoT components, which may require regular maintenance and updates. The study comes to the conclusion that by offering real-time monitoring, lowering errors, and increasing efficiency, IoT-based smart shelf solutions may greatly improve inventory management.
c. The findings suggest that such systems are valuable tools for modern inventory management, particularly in environments where timely and accurate inventory tracking is crucial.

III. CONCLUSION

In an effort to make the materials and methods utilized crystal clear, the report evaluated a few well-known previous research studies on inventory management systems. An enabled-IoT intelligent inventory management system will be developed in the future research as the strengths, opportunities, and weaknesses of the various methodologies have been well analyzed, suitably exploited, and deemed important components.

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