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Smart Inventory System using IoT and Cloud Technology

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Abstract: A smart inventory system is a computational time efficient system that helps businesses to manage and track their inventory levels, orders, and deliveries. It facilitate companies to have real-time visibility into their inventory and helps them make more informed and quick decisions about restock and how much to order. One key feature of a smart inventory system is its ability to automatically reorder items when they reach a certain threshold, eliminating the need for manual intervention. This helps to ensure that businesses always have the right amount of inventory on hand, reducing the risk of running out of stock or having excess inventory that takes up valuable storage space. This paper include deployment of this system in real world which benefits to handle smart inventory system with improved accuracy 30% and efficiency in inventory tracking around 10%, reduced lead times for ordering and restocking, and the ability to track inventory across multiple locations. This paper briefly elaborates the implementation of smart inventory system that greatly improves a business's inventory management process, leading to increased profitability by more than 50%, average foot fall increased to 25% and reducing the waiting time of customer by nearly 75% making customer more satisfied.

Keywords: *IoT, Cloud Server, Android application, ESP 32, Smart Inventory, Industrial Automation.*

1. Introduction

There are several picking locations and thousands of picks to be made each hour in complex warehouses. The warehouse workers must work quickly and accurately in these warehouses to fulfil consumer requests. The "Prototype" approach is one of several technological advancements in warehouse systems over the years [1].

As all stock needs to be handled, regulated, and tracked at all times and locations, inventory control is crucial to a company. Inventory management is even more essential to success and sustainability today. Accurate inventory management can prevent businesses from losing money. According to Chuang and Oliva's analysis of a retail store with an IRI of 29%, which results in the company losing 10% of profits, IRI (Inventory record inaccuracy) lowers a company's overall profits [2]. Manual stock management can be incorrect, time-consuming, and prone to human mistakes. Stock transaction mistakes, missing primary sources of stock, and stock misplacement are a few of the causes of inaccurate inventory records. The original Using light-directed picking technology, objects can be picked, arranged, and assembled without the use of paper [3]. To direct users to the appropriate product locations and amounts needed to fill an order, this prototype uses light devices positioned at item positions on shelving, workstations, or another storage medium. Prototype solutions decrease the walking and reading involved in paper-based or even other semi-automated picking methodologies, hence increasing pick rate productivity and order correctness.

The application includes a general organization profile, sales and purchase information, and the organization's remaining stock. A provision exists for updating the inventory as well. Along with the specifics of the transaction's value, this application also reveals the stock's remaining balance. Each new stock is made, given a name, and given a date of entry. It can also be updated as necessary based on the transaction or, in some cases, when sales are returned. Here, the login page is made to defend the organization's stock management against theft and improper usage of the inventory [4].

Phones running Android and iOS are considered smartphones. The idea of incorporating a mobile office into warehouse management and developing warehouse management software based on a smartphone is offered in this study, which uses an automated warehouse at a university as its research backdrop. In addition to WMS utilized on PCs, the program enables warehouse personnel to manage warehousing and access information anywhere in the warehouse using mobile terminals rather than a stationary PC[5]. The server-side database will get the commodity storage and retrieval information that was gathered through the application (app)[6].

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2. Literature Survey

Chih-Chin Liang [7] has shown An inventory prediction model was studied and proposed. The best inventory prediction accuracy using this proposed prediction model might be as high as 66.3%. The food processing and distribution sector can efficiently and reliably manage inventory by using sequential patterns based on professional judgments.

Souvik Paul [8] provided an overview of the IoT-based inventory management system. We predict positive development because our system has several advantages over the standard approach. Inventory management is an essential part of customer service and cost-cutting in every industrial system. It takes a lot of time and effort to maintain inventory for companies that have expanded internationally, has thousands of components, and have hundreds of warehouses. For robotic arms used for inventory picking and dropping, the fundamentals of conventional warehouse marking and tracking systems.

Rajesh Bose [9] developed a model, proposed a novel technique, and demonstrated how it could help the construction industry manage stockpiles of critical formwork shuttering items. Despite the fact that the focus of our research was on Indian construction enterprises, the findings of our study can be extended to a wide range of regions.

Ali Alwadi [10] provides an overview of the cutting-edge technology, algorithms, and methodologies employed in sophisticated RFID-based inventory systems in this study. Following a discussion of design challenges with RFID-based inventory management systems, a comprehensive evaluation of various RFID technologies, RFID types, and RFID architectures is provided. The most recent RFID middleware and infrastructure research are also appraised. This covers RFID tags that are passive, RFID antennae, RFID middleware, and the RFID reader. The study then examines collision and anti-collision algorithms for these types of applications, as well as the benefits and performance difficulties of various passive RFID techniques.

3. Methodology

A smart inventory system automates manual operations such as item tracking and counting, inventory database updating, report writing, and restocking, saving time and effort while eliminating the chance of human error.

Inventory visibility in real-time is the major need of smart inventory system for automating and eliminating the traditional manual operations such as item tracking and counting, inventory database updating, report writing, and restocking, saving time and effort while eliminating the chance of human error [11].

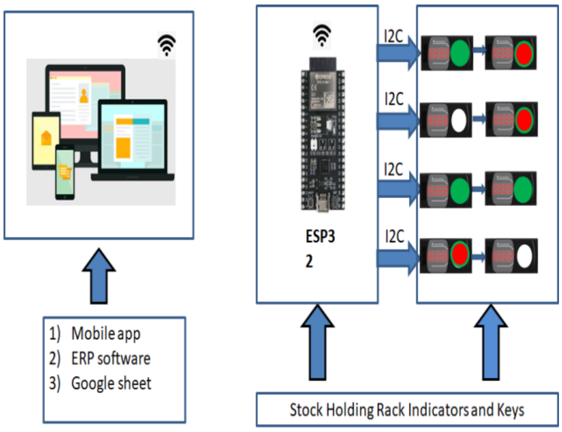

Fig. 1 Smart Ware House System

Fig. 1 depicts the overall implementation of smart warehouse system incorporating mobile app, ERP software and database. Inventory is updated timely whenevre changes occure in stock, the same is reflected to on rack display for warehouse rack handling person.

The stock can be verified through central software or from indiviual rack, both reflects similar count. The stock update algorithm runs whenever the stock is modified.

Fig. 2 Smart WarehouseApplication Software

Fig. 2 elaborates the smart warehouse application mobile version software, in this application user need to connect to the smart warehouse network through the ip address. Once the network connectivity established then user can be login through login page to access the overall operation of warehouse. To maintain wireless network one should take care of the availability of wifi network throuhout the warehouse by installing sufficient wifi switches repeaters.

Each rack has multiple shelve holding different containers with components and materials. Thus each contaier has unique number associated with each shelf unique ID. Thus the numbering is according to the material physical location and its on rack allotment inside the warehouse [12].

To make convienent a seven segment display is placed closed to each container so that user can easily understand the material count without accessing the central system. This design also facilitate the user to increment and decrement material count of material with keys provided for each container, in case if user directly removed or add material from the containers physical location without modifying central system. In such scenario the modified data is reflect back to central system and validated. This is the unique feature which is incorporated in this design.

3.1. Block Diagram

The racks has unique ID based on the IP address. Fig. 3 depicts the overall configuration of racks and container, where each rack hold multiple shelf which holds single or multiple container depending upon the shlef or material size. The unique ID for rack is through the programmed IP address allocated to WiFi modules, the onboard wifi module based microcontrollers boards are prefeered in this design to maintain simplicity, These Wi-Fi modules allow all the devices to communicate with one another. This design uses ESP 32 Wi-Fi module [13].

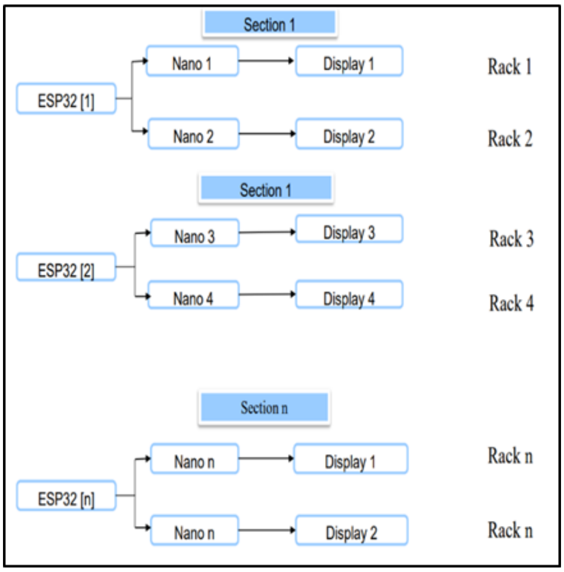

Fig. 3 Block Diagram of Racks, Shelf and Container

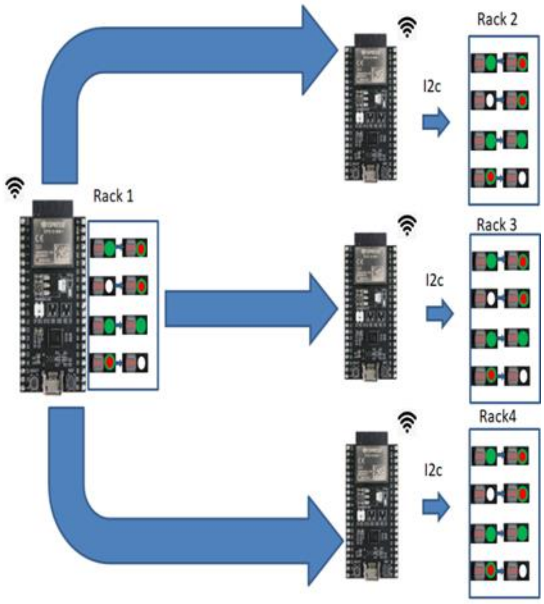

Fig. 4 Connection Diagram of Wi-Fi Modules Container Module

Fig. 4 describes the connection between each rack Wi-Fi modules and its associated container module. Once the Wi-Fi module is network-connected, the data will be retrieved from the cloud and transferred to the Arduino Nano for display on the seven-segment display. The variety of communication buses available over the AVR based board and these can be used to interact with a computer, Arduino board, or other microcontrollers. Each container indicators and associated keys are interfaced to its unique ATmega328P based arduino Nano development board, so as the easy communication established between ESP and different Nano boards over the rack through IIC bus communication.

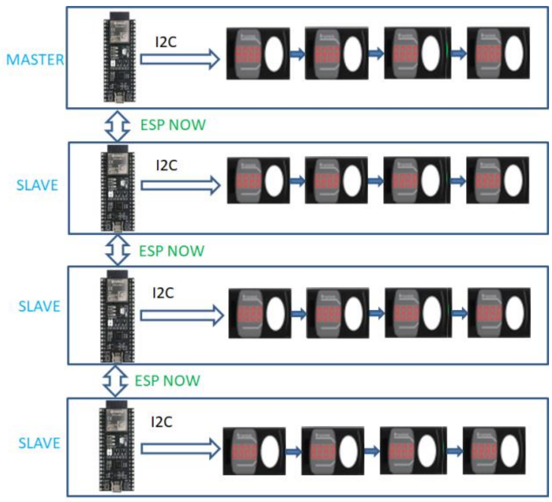

Fig. 5 Shelf and Container

A seven-segment display is a type of electronic display that can be used instead of more complicated dot matrix displays to show decimal numbers. Fig. 5 describes the arrngement of Shelf and Container, where to assist and update the use each container is designed with its unique display to showcase the current inventory count. The system incorporated three switches: one for adding and removing components, one for updating the data on the LCD and cloud database, and one for updating both. When we hit the increment or decrement button, the timer value is modified and updated, and the arduino Nano's Tx pin is utilized to transmit the modified material count value to the Wi-Fi module. The Wi-Fi module will connect to the Cloud in order to update the inventory system's real-time data as it receives data from the Arduino Nano. Thus the data updation is done through the established connection between the cloud database and the android application.

3.2. Flowchart

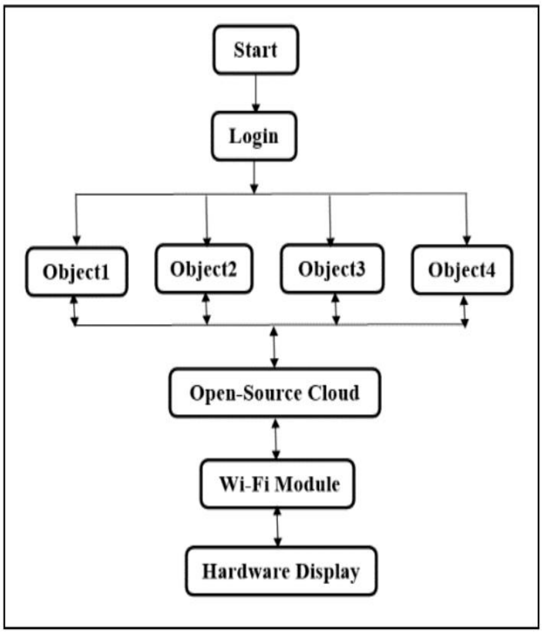

Fig. 6 Flowchart for Application

Fig. 6 depicts the Flowchart for overall application implementation of smart warehouse system incorporating mobile app, ERP software and database. Once User login, then the updated inventry is visible and can do further operations using the application software. Whenevre changes occure in stock, the same is reflected to on rack display for warehouse rack handling person and cloud database for central persons.

3.3. Algorithm

There are two sections to this system. software and hardware. The system's flow is also bidirectional. The algorithm's flow is as follows.

From Software to Hardware:

i Start the application.

ii To log into the application, enter your ID and password .

iii User enter the number of components.

iv A database open-source cloud stores data.

v Data will be fetched in the hardware by the Esp32 wi-fi module from open-source cloud.

vi Then Data will be display on the 7-segment display.

vii Repeat step iii to vi

From Hardware to software:

i Wait till the action on the switch.

ii Using switches on the hardware, data will be manually changed in accordance with requirements.

iii Data will be fetched on the open-source cloud by using Esp32 wi-fi module from the hardware.

iv Once data will be stored on the open-source cloud then it will be changed on the android application respectively.

v Go to step i

4. Implementation and Results

The real world implementation and testing of the said system is done in the local electronic components shop selling approximately 10,000 components in a day. This shop open for six day a week and all the months in a year. It is Observed that the net time required to identify the correct component container is drastically reduce for both new employee or experienced. Thus the total delivery per time increased and it saves overall standing time of customer, increasing more footfalls and sale. Thus the store now accommodates more components with very small laydown time. The only constraint is to keep the power up of all wifi modules during the shop opening time. The inventory is tracked lively and orders are placed whenever the component or material shortage occurs. The Android application designed in Android Studio is installed in various devices. This mobile app is connected to the open-source cloud based database. Both the program and the Wi-Fi module provide real-time data. Initially user has to login successfully to connect in to the Android app, then user will be able to modify the app's data and update it on the open source cloud. You can also use the addition and subtraction buttons. Manual processes such as item tracking and counting, inventory database updating, report writing, restocking, and so on can be automated with the assistance of a smart inventory system, saving time and effort while reducing the possibility of human error.

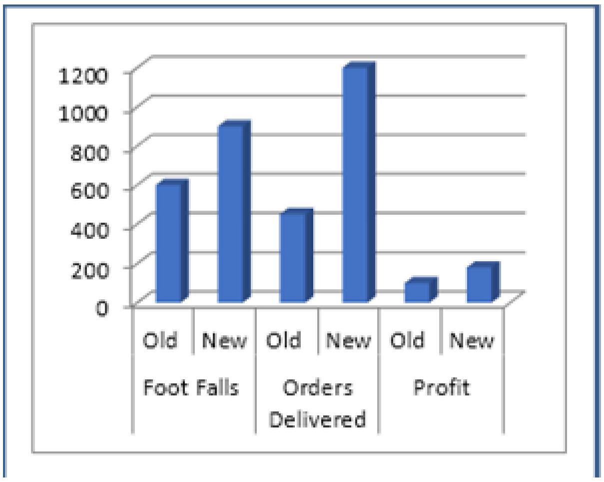

Fig. 7 Footfalls, Average Order Delivered and Profits

Fig. 7 shows the graphical representation of average daily footfall in the stores along with average waiting time and the profit margin. From the diagram it is cleared that the footfall without the smart inventory management is much less than the new footfalls with implementation of smart inventory system. However it's almost increases by 50% with respect to old footfalls. This effect is due to the quick delivery of goods to the customer and reduced waiting time simultaneously. From the diagram clearly states number of order delivered without the smart inventory management is much more than the order delivery time with implementation of smart inventory system. It's almost decrease by 75% with respect to old delivery time. Thus the overall waiting time of customer is reduced due to the quick delivery of goods to the customer. The overall profit ration for the day also increases as the above parameters improve.

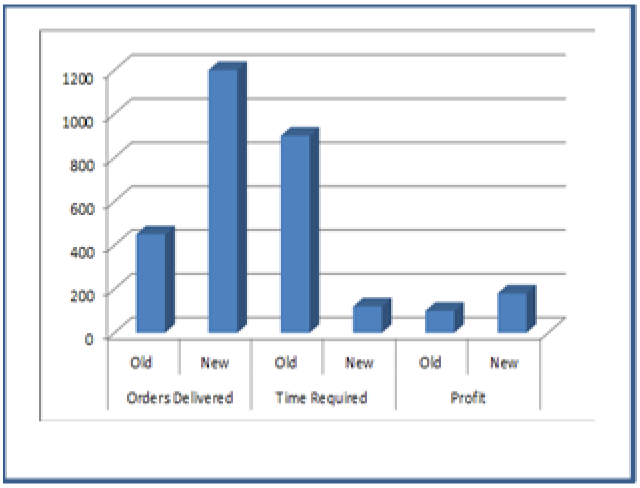

Fig. 8 Order Delivered, Time Required and Profits

Fig. 8 shows the graphical representation of average daily order delivered from the stores along with average waiting time and the profit margin. From the diagram it is cleared that the profit is less when the store not using smart inventory management, however the profit parameter improves once the store is supported by the smart inventory system which improves average waiting time for order, average footfall and delivery time.

5. Conclusion

This paper demonstrated the complete design aspect of Smart Warehouse Management System, It also elaborate the implementation of the same which improves overall parameter such as average customer footfalls, delivery time, waiting time, profit. The major advantage of this system, it improves the average footfalls approximately 50% due to the quick delivery of goods to the customer and reduced waiting time simultaneously. Even order delivery time also improves by 75% with respect to old delivery time improving overall profit. The system can updated by two way i.e. the inventory numbers can be updated through the dedicated keys available at each component container or through the computerised system. Manual processes such as item tracking and counting, inventory database updating, report writing, restocking, and so on can be automated with the assistance of a smart inventory system, saving time and effort while reducing the possibility of human error. The system provides paperless inventory management system in the smart inventory system.

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