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RFID Technology in Smart Shelf

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Abstract: The evolution of enterprises is occurring alongside developments in technology, particularly within the retail sector. In order to survive in the contemporary market, it is necessary to make use of a variety of technologies. The most recent development in the sector is recognized as Radio Frequency Identification. In order to reduce the amount of work that is done by humans, this technology is now frequently employed in the logistics industry. This article discusses the use of RFID technology in the retail industry and its impact on inventory management.

IndexTerms **- Inventory management, Radio frequency identification, RFID scanners, RFID tags, smart shelf, etc.**

1.INTRODUCTION

Contemporary shopping incorporates digital technologies to enhance customer convenience [1]. There are several components of the value chain that serve to bridge the gap between consumers and producers. One of these components is the inventory management system. Inventory management solutions that are based on the Internet of Things aid in tracking the things in real time. Furthermore, the products are equipped with barcode labelling or RFID identifiers to facilitate their identification and scanning by the system [2].

Future computing is anticipated to heavily rely on radio frequency identification, or RFID. RFID is a wireless technology used for data collection and automated item identification. Systems that are enabled by RFID have been implemented in a variety of fields, including the logistics sector, armed forces, medical services, and handling emergencies, to mention just a few of these many domains. A number of major retail chains, including Wal-Mart and Target, have made it mandatory for all suppliers to use RFID technology. The most fundamental component of RFID systems is the attachment of miniature transponders or tags to various items [3]. RFID technology is used to monitor and charge things in real-time. Hence, it increases the overall efficacy of purchasing by doing away with the demand for traditional billing methods that have been normal practice [4]. Additionally, to reducing management concerns, smart retail may boost revenue and lower expenditures by transferring work to consumers (e.g., self-scan) or streamlining operations (e.g., digital shelves) [5].

2. LITERATURE REVIEW

Isharyani et al. [5] found that traditional suppliers in developing countries face challenges in adopting smart retail technology due to financial constraints, lack of competence, and perceived complexity. Nevertheless, potential benefits, competition, and official support may facilitate adoption. The study promotes tailored solutions and governmental interventions to facilitate the transition.

Tamilselvi T et al. (2023) [4] introduce an invoicing cart system self-organizing suitable for use by retail organizations. The product is monitored through the use of RFID technology, IoT for data administration purposes, and analytical purposes by Raspberry Pi. LCD display with rapid information, multilingual help, a locater for products, and innovative system designed to suggest a product. The cart promises to elevate the experience of purchasing through automatic invoicing of the customer, reduced checkout waits times, and much easier inventory management. This study advances retail technology by providing a solution that optimizes efficacy for both consumers and enterprises.

Arpit Jain et al. [6] proposed a smart purchasing system using RFID and IoT in 2022. The system automatically scans merchandise, using radio frequency identification tags on objects and readers on shopping carts. It further helps in faster checkout and enhances

tracking of the inventory. This technology is better because it can scan goods faster and from a farther distance than the conventional barcode scanners. Hence, it is an excellent option for modern retail settings.

Tandel et al. (2020) [7] present a smartphone application for Indian local shops with sales forecasting and inventory management. The system has the objective of giving small businesses, which are without the means of proprietary software, an inexpensive option. It is equipped with key features such as barcode detection, inventory management, and multivariate analysis-based sales projection. Sales report generation, invoice generation, and adding, updating, and deleting product categories are some of the features available on the application. The authors suggest a mobile-based strategy by referring to the rapid adoption of smartphones in India. This research helps small businesses become more profitable and competitive by equipping them with tools commonly found in large retail chains.

Alat et al. (2018) [8], present a smart retail shopping cart which addresses the cumbersome problems of scanning a barcode at a retail outlet by using RFID technology. In this approach, an RFID tag is inserted on objects and an RFID scanner is mounted on the cart for the scanning of objects. Prime features involve auto-generation of bills that are displayed on an LCD screen that can be mounted on the cart to decrease the time taken during a bill generation process. It delves into the adoption of IoT in retail based on the reason that the system could supply information relating to an item in real time and raise bills accordingly.

3. Radio Frequency Identification

Radio-frequency identification is the process of extracting and storing data from tags attached to an item using radio waves. A tag can be read at a distance and does not have to be in the reader's direct line of understanding for tracking purposes. Radio-frequency identification is the process of collecting and interpreting data from a tag attached to an item using radio waves. As an added measure of tracking, it does not require the tag to be seen within the line of sight of the reader. Many feet away the tag may be read since RFID technology can recognize and track uniquely associated things with tags.

An RFID system consists of two parts: a tag or sticker and a reader. RFID tags or stickers include both a transmitting element and a receiver. A microchip for data storage and analysis and an antenna that is used for data transmission and reception make up an RFID tag. The tag has the unique serial number of a specific item. An interrogator, also known as a reader, is a radio with transmitter-receiver that signals the tag and reads the data it contains using an antenna. The tag's storage system contains information that is necessary to react. The interrogator will send the read results to an RFID computer software. The data transmission is driven by a small battery housed which is powered by a battery RFID tag.[2]

Metadata is included in each RFID system tag. Information that may be recorded in computerized binary form can be anything from just one digital bit to huge arrays of bits, such as an identifying code.[3]

This sort of technology provides clients with the most current knowledge on what products are available, helps with managing inventory, and reduces the possibility that items may run out of order.[4]

3.1 RFID technology in shelfs

In order to improve the functionality of store shelves in a shop, we may make use of RFID technology. First things first, we need to attach the RFID tags to the product on the product. Information about the product, which will also be referred to as meta data about the product, will be included inside these tags. We will install RFID scanners at the beginning of the shelf, and these goods will be put within the shelf throughout the installation process.

The information pertaining to the product is saved in the dashboard, which is used for the purpose of inventory management. The RFID Scanner is linked to the dashboard since it is connected to the cloud.

In the case where we remove a product from the shelf, the tag that is attached to the product will be scanned by the scanner. The product will then be removed from the inventory. If the same tag is scanned again, the database will add the product once again. The system for managing inventory will be managed by this, and the count of goods will be maintained.

Through the use of this technology, people are able to see the items that are going to be finished. Additionally, it is able to determine which products have not been sold at all, as well as which products have failed to meet the expectations of the consumers and are being restocked by the customers.

3.1.1 RFID System Architecture in Smart Shelves

A common RFID-based smart shelf system is built with four primary components:

1. **RFID Tags:** Passive or active tags affixed to every product. Every tag has a unique Electronic Product Code (EPC), which codes the product.

2. **RFID Reader:** Mounted on or inside the shelf frame, readers pick up and decode signals radiated by the tags.
3. **Middleware/Edge Processor:** Serves as an intermediary between RFID hardware and the central inventory system. It performs tag filtering, duplicate suppression, and data formatting.
4. **Inventory Management Server:** A centralized system that maintains real-time stock levels, low inventory alerts, and movement data logging for analytics.

Table.1 Comparison of the systems

Feature	Barcode System	RFID-Based Smart Shelf
Line-of-sight Required	Yes	No
Real-Time Tracking	No	Yes
Anti-Theft Capability	Low	High

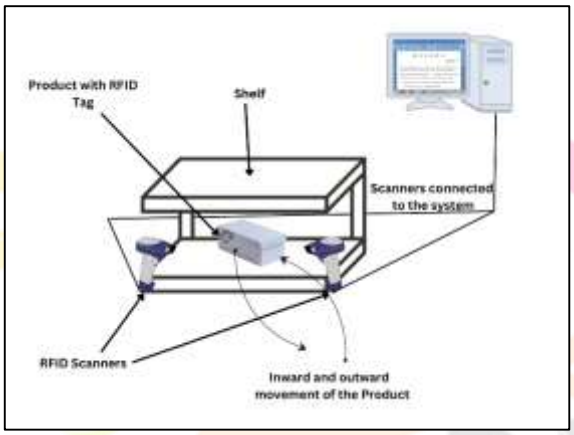

Fig.1 Architecture of the smart shelf

4. Conclusion

It is tough to manually manage inventory and keep track of items, which presents a number of challenges during inventory management. In order for a system to function without any hiccups, it requires an automated technology. Using RFID technology in numerous sectors is a continuous development. RFID is steadily acquiring the market in each and every field. RFID on shelfs has made the process simpler of controlling the inventory and keeping the count of the objects. This may help the firm to keep a check on the supply of a given product, notify that the product is being sold the most, which product is held back into the self again. This could assist in the enhancing the quality of things.

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