Intelligent Retail Shopping System Based on RFID

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***Abstract*:**
One of the biggest issues one encounters while shopping in malls is having to wait in line and bill. It is a tiresome process, particularly during festival time or during rush hour. Manual invoicing can occasionally be difficult. Additionally, these existing systems have greater rates of shoplifting, which results in substantial losses for retail vendors and merchants. In the case of manual billing, a lack of staff leads to long lines and influences consumer choice because many people may choose to forego the transaction and not buy any goods. Customer churn can result from this pattern as well. The objective of this paper is to implement a distributed application which relieve customers from this hassle. The goal of this study is to build an automatic checkout sys- tem, where customers can handle billing and payments themselves. In order to plan production and, ultimately, boost sales, merchants can use the system's Business Analysis Model to analyze customer demand and product sales. The goals of self-service checkout system are to speed up client checkout times, lower labor costs, and provide business analysis to retailers.

***Keywords*: RFID Based Shopping System, RFID Checkout System, and IoT;**

(Article history: Received: Oct 31,2023 and accepted Jan, 31,2024)

I. INTRODUCTION

People used to line up for cash withdrawals and adhere to specific procedures in the early days of banking. Previously, bank employees would distribute the necessary cash quantities to customers. It was a tiresome task. The concept of "ATM Machines" was introduced to address this problem. This drastically cut costs by reducing majority of efforts on both sides (Bankers and Users), as the cost of machine assembly was a one-time investment. Similar issues arise with the shopping checkout process in modern times. We have suggested an equivalent concept, paralleled with the example above, for tackling these challenges. A cutting-edge shopping device that can be used in retail establishments. With this method, any customer can complete the checkout process easily and quickly. The suggested system consists of an RFID scanner, RFID tags attached to each item, and a billing application linked to the entire system. RFID readers are fixed to the billing counters. The scanners attached to the rim of the basket assist in reading the RFID identifier on the object when it is placed inside. When an item is scanned through the basket, the billing software immediately logs the item in for bill generation and payment. Each product's RFID tag is turned off for security clearance after any successful transaction. The bill is saved as a record in the "Sold Database" at the backend after a transaction is complete. The business analysis model uses the "Sold Database" for a particular period to forecast demand for any item and plan production or importation of that item in accordance with that demand. This is beneficial for supply management to retail stores because it provides a thorough study and a review of the sales of each item. For instance, compared to other seasons, the selling of jackets and scarves typically increases during winter. Here, merchant businesses can use a business analysis model to analyze their production and compare it to sales data from various locations and seasons. A machine learning algorithm is then fed the gathered sales data to forecast trends.

II. LITERATURE SURVEY

A long queue when entering the checkout process in a grocery store is an undesirable condition for the consumers and may result in a decrease in both the number of customers and their loyalty. Making the checkout procedure efficient is therefore required because giving customers more time to do other things in their lives would benefit them. The goal of this research is to develop a system that enables self- scanning of items while requiring only payment from the cashier. This system will include smart shopping carts, a smartphone application serving as an interface, and an application for the cashier integrated with the server and database to support data transmission. utilising the Waterfall process, this system was created utilising tools including the Arduino Uno, RFID, and Visual Studio Code, Flutter, PostgreSQL, REST, React dan Node.js. Efficiency increases with more items and consumers by modelling the process with different variables gleaned via observation [1].Large crowds can be seen in shopping malls because of how much the level of living for people has improved thanks to contemporary technologies. It's crucial to shorten the billing procedure in order to give clients more time. This is accomplished via an RFID-based smart shopping system. The bill is generated and shown once each item in a smart shopping cart is read individually. The customer pays the bill using the pre- charged cards that the shopping centre has provided when the final bill has been generated. The goal is to cut down on the amount of time required for the billing system [2].Fashion is a fast-moving sector with patterns that can last up to eight months. It is also a very competitive one where trends are often changing. Knowing the trends and producing accurate projections in keeping with the constantly shifting patterns can significantly impact a company's success. Forecasting is an important aspect of business. In order to better understand which methods should be implemented for the greatest results, it is crucial to look into the many approaches put out to reach a more effective manner of predicting demands and consumer wants the essential point of determining is to more readily comprehend the examples that effect markets and purchaser needs [3]. The most cutting-edge forecasting techniques for predicting fashion industry market patterns were examined in this paper. This analysis explains the fore- casting methods used, the models and algorithms within them, the datasets used, and the trade-offs for each system and model. The fashion industry's forecasting efforts are supported by a wide range of Machine Learning models, which will be the focus of the analysis. Comparing our proposed system with the existing system, incorporation of self-billing machines drastically reduces the waiting time in queues at billing counters in current scenario. Also, the dependency on cashiers/billing personnel is negligible, which makes the billing and verifying free of human-error and cheating. Moreover, use of RFID technology eliminates the need for barcodes, which strengthens the ‘security’ aspect as barcodes can be tampered with. On the other hand, RFID tags can only be disabled once payment for the respective product is done. Interactive billing screen increases transaction transparency for customers [4]. Compilation and processing of Sold Items data for business analysis is automated through a network of cloud instances. Business analysis model provides merchant companies the ability to predict demand, forecast fashion trends and plan strategies for future production based on past sold data. In the proposed model and for our research work, we used MySQL DB, phpMyAdmin, Python, Apache XAMPP TensorFlow and Microsoft Excel for the development of billing software, creation and maintenance of ‘Sold’ database and building of the business analysis model. We also used Suitable RFID Module with Tags and an Arduino Uno Board for the hardware components of this system.[5]. This study comprises of three major modules involving both hardware and software: RFID Scanning, Data Collection and Processing and Business Analysis [6].

III. PRAPOSED SYSTEM

The Advanced Shopping System provides an efficient and convenient checkout process for customers in retail establishments. It uses RFID technology to track items purchased by customers, with each item tagged with an RFID tag that can be scanned by an RFID reader [7]. The system also features a billing application linked to the RFID POS Machine, which logs each item for bill generation and payment. Each product is assigned with identification numbers. This number can be used to track or record the item. The item is identified and listed for billing when the tag is scanned at the scanning area. The customer can view and proceed with the list of items on the interactive billing screen. One can cover the bill and continue to self-checkout. The sold data is also updated by the POS machine on the connected server's live database for further processing. Afterwards, the system's Business Analysis Model analyzes customer demand and sales patterns, enabling merchants to forecast demand for specific items and plan production or importation of those items in accordance with that demand [8]. The overall goal of the Advanced Shopping System is to streamline the checkout process, reduce labor costs, and provide valuable business analysis tools for mer- chants. There are three main phases of the application as shown in below architecture.

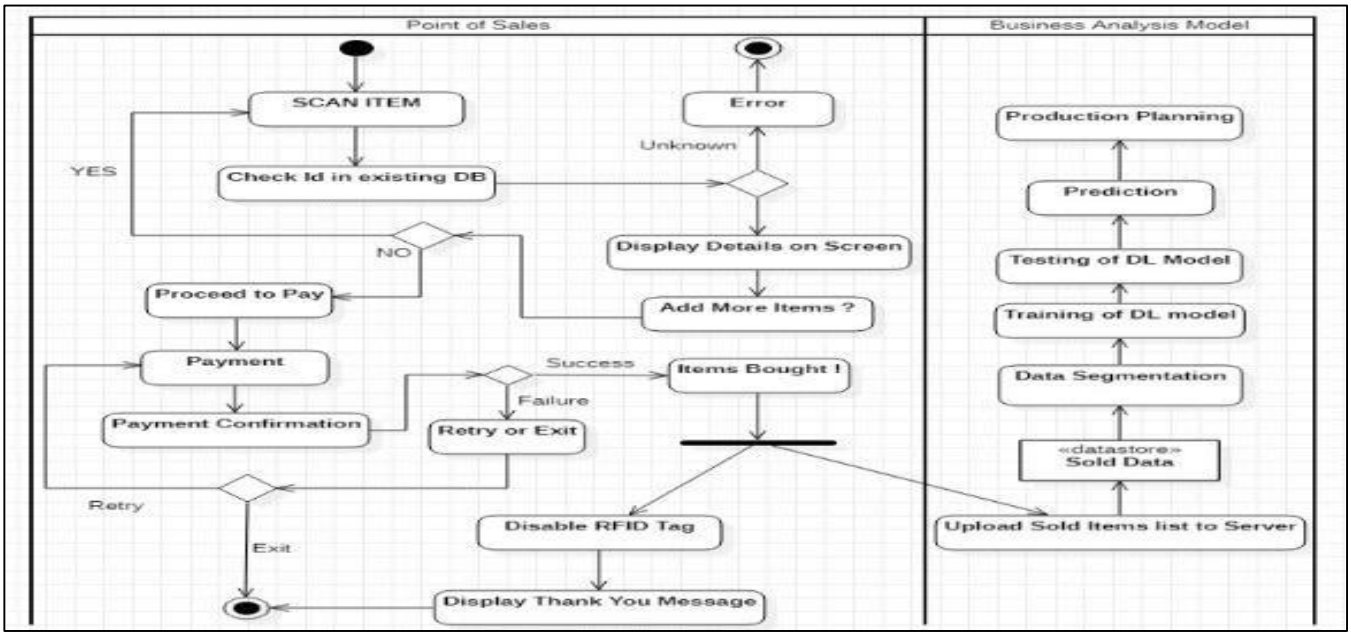

Fig1:Proposed Architecture of Application

A. *POS (Point of Sale) Machine:*

This Consists of a Physical Machine with Components such as RFID Reader as shown in fig 1 , Microcontroller, Interactive Screen, and other minor components. Arduino UNO as a microcontroller is connected to RFID module RC522 as it allows the Arduino to read and write the data present in the RFID card. By connecting the Arduino UNO to the RFID reader, the user can use code to control the data. This opens a wide range of potential applications such as access control, tracking inventory, unique identity to each object, etc. The system here will be able to identify products through RFID tags, read the associated product information from an internal inventory database. After reading it will display the information on that object along with its cost in the Interactive Screen or the device connected. Once, the payment is made, the system can drop the items automatically[5].The Arduino microcontroller will be responsible for reading and decoding the signal from the RFID reader. This will generate a unique ID for each product which can then be used to lookup the associated product information from the internal database or external web service. The Arduino hosted program is responsible to calculate the total cost of the items in the cart and display it on the interactive screen. Third party software or gateways can be used for payment purposes considering ease of payment using UPI and other options. The Arduino code will be programmed to send a signal to the system to disable the respective ids when the payment and verification are successful, so that the items can be dispensed. Finally, the Arduino program will record the transaction data and save it for legal purposes[9].

B. *Data Collection and Processing:*

Item lists are saved on the server when bills are processed in the Billing Machine, where they are compiled into the data for the sold products. The gathered information is then to be handled as sure at accolades, for example, offers applied to specific products, time stamps, storage ids, etc. are useless in processes that follow a purchase. Similar operations are to be performed on information before it is to be sent for business analysis. This is second module as per fig.1

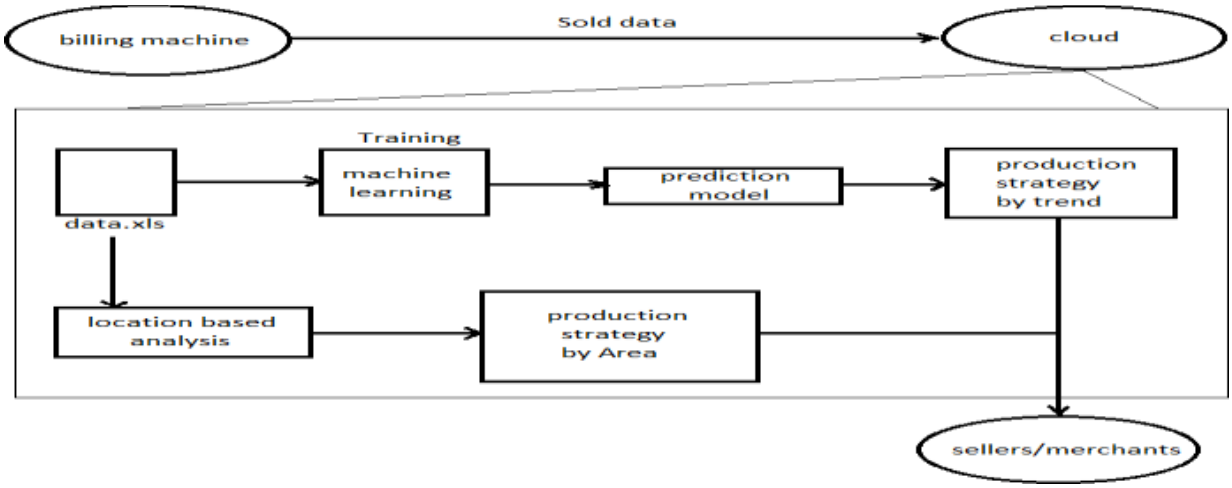

Fig 2. Depiction of Business Level Operation

Item lists are saved on the server when bills are processed in the Billing Machine, where they are compiled into the data for the sold products. The gathered information is then to be handled as sure at accolades, for example, offers applied to specific products, time stamps, storage ids, etc. are useless in processes that follow a purchase. Similar operations are to be performed on information before it is to be sent for business analysis [10]. This is second module as per fig.2

C. Business Analysis Model:

In the context of sales data coming from a retail merchandise store, the proposed Business Analysis Model (BAM) as shown in figure 1 offers several options for processing the data. These options include using advanced software such as MS Excel, Tableau, Power BI, etc. or using simple Python functions on Pandas data frames and data visualization with the help of Matplotlib Plotting library[11,12,13]. The data is subjected to a series of operations, including data cleaning and preprocessing, exploratory data analysis, feature engineering, model building, and prediction and evaluation. The model building stage involves selecting a suitable machine learning algorithm based on the quantity of sales data available and the scale of the retailer, and training the model on a subset of the data [14, 15]. For smaller retailers with moderate quantities of sales data, the Prophet algorithm and ARIMA model are recommended for forecasting sales data. These algorithms consider trends, seasonality, and other factors that may impact sales. For larger retailers with large amounts of sales data, Deep Learning Neural Networks such as the LSTM algorithm is recommended for analyzing and predicting sales trends based on time-series data.[6] Overall, the proposed Business Analysis Model provides a comprehensive approach to analyzing sales data from a retail merchandise store, helping businesses to optimize their operations, plan their inventory, and make informed decisions about marketing and sales strategies.

IV. METHODOLOGY

In the proposed system, as shown in Fig 2 each product is assigned an ID and is attached with the RFID Tag and when an RFID reader reads the RFID Tag and the Product ID and compares it with the connected inventory data base if the information is available, the product data is retrieved from the data base and is displayed on the screen. These Scanned products are added to a digital cart on the POS Machine. After that user can add and remove added items in this cart. If the user wants to remove any product, he/she may do so by pressing remove button. If they need to add a product, they can do by simply scanning it. After the customer finishes the shopping the total number of product user had placed in the cart and amount of final shopping list will be displayed on the screen. After that the user must pay the bill using payment methods of his/her choice. Once the confirmation of payment is received by the server, the scanned tags are disabled for secure checkout. The sales data after each transaction is updated in the live database. Which from time to time is exported by retailers or mer- chants as data sheets for Analysis. The exported Sheets are subjected to analysis methods of their choice. [7]

A. Algorithm

For the Proposed Business Analysis Model (BAM) to function we have several options for processing the sales data such as Use of Advanced Software such as MS Excel, Tableau, IBM Cognos Analytics and Power BI – This is one option for stores with less quantity of sales data and for those retailers who have trained and qualified Staff to operate the system according to the proposed methods Use of Simple Python Functions on Pandas data frames (sales data) and data visualization with the help of Matplotlib Plotting library For Further Analysis of the data and to make conclusions based on the previous analysis, The data is subjected to a series of operations –

Data Cleaning and Preprocessing:

Model Building:

Select a suitable machine learning algorithm based on the quantity of sales data avail- able and the scale of the retailer. Train the model on a subset of the data and test it on another augmented subset to evaluate its performance. Fine-tune the hyperparameters of the model to improve its accuracy. Prediction and Evaluation Use the trained model to make predictions on new data and evaluate its accuracy using appropriate metrics such as accuracy, precision, recall, F1- score, and ROC-AUC.Prediction Models are possibly made using a few listed algorithms which gives us options to decide from based on size of data and Scale of Retailer. Use of Machine Learning algorithms for Smaller Retailers with moderate quantity of sales data.

B. Prophet Algorithm

Prophet algorithm can be used for forecasting sales data in the merchandise market. Specifically, it can be used to predict future sales values based on historical sales data, taking into account trends, seasonality, and holidays that may impact sales. The algorithm can be trained on historical sales data and can generate forecasts for future periods, such as weeks, months, or years. [8] The Prophet algorithm is well-suited for sales data in the merchandise market, which can be affected by a variety of factors such as promotions, seasonal trends, and holiday shopping periods. By incorporating these factors into the forecasting model, Prophet can provide accurate and reliable predictions for future sales, allowing businesses to make informed decisions about inventory management, marketing campaigns, and other important aspects of their operations. Overall, Prophet provides a powerful tool for analyzing and predicting sales data in the merchandise market, helping businesses to optimize their operations and maximize their profits.[13]

C. ARIMA Model (Autoregressive Integrated Moving Average)

ARIMA algorithm is a statistical method that can be used for forecasting sales data in the merchandise market. ARIMA model uses the historical sales data to make predictions for future sales values, considering trends, seasonality, and other factors that

may impact sales. The ARIMA model can be particularly useful in the merchandise market, where sales data can be influenced by many factors such as promotions, seasonal trends, and changing customer preferences. By analyzing the past sales data, ARIMA algorithm can identify patterns and trends in the data, and use this information to generate accurate forecasts for future sales. The ARIMA algorithm is highly customizable, allowing users to specify the number of autoregressive terms, degree of differencing, and number of moving average terms that are included in the model. This flexibility allows the model to be tailored to the specific characteristics of the sales data, ensuring that the predictions are as accurate as possible. Overall, ARIMA algorithm provides a powerful tool for analyzing and predicting sales data in the merchandise market, helping businesses to optimize their operations, plan their inventory, and make informed decisions about marketing and sales strategies.

D. RFID Tags

Smart barcodes are used by RFID tags, a sort of tracking device, to identify objects. Since "radio frequency identification" is what RFID stands for, radio frequency technology is used by RFID tags. These radio waves carry information from the tag to a reader, which forwards it to an RFID computer programme. In addition to being widely utilised for commerce, RFID tags can be used to track cars, animals, and even Alzheimer's sufferers.

Another name for an RFID tag is an RFID chip.

V. EXPERIMENTAL ANDRESULT SECTION

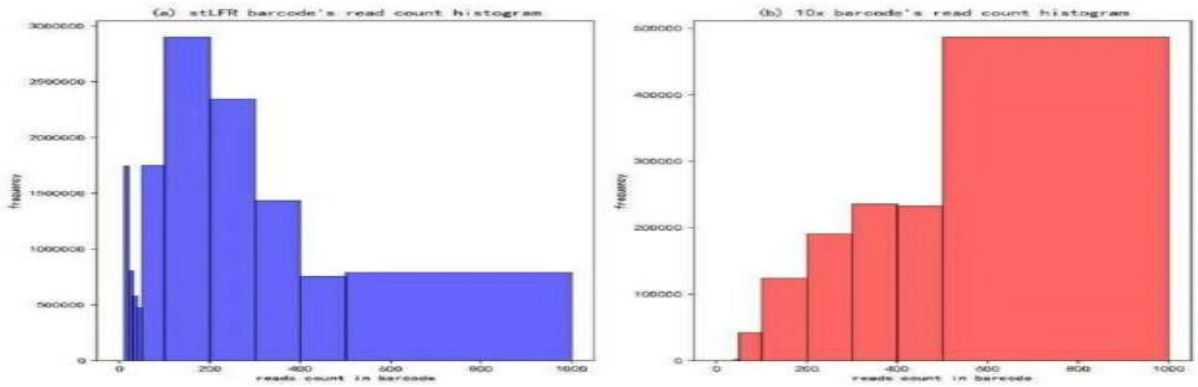

Fig3:HistogramforBarcodeandRFIDDataset

The grocery shelf with the RFID tag attached and the shopping cart fitted with an RFID reader comprised the simulated market where the suggested approach for route planning and guidance was used. When shoppers buy at a supermarket, the RFID reader may automatically read the data from RFID tags affixed to the shelves surrounding the shopping cart (the consumer location). With the use of the data from RFID tags, the position coordinates of the customer were found. Installation ofPoint-of-Sale Checkout Machines gives customers a hassle-free experience of shopping as there is no dependency on sales personal Payments become more secure as buyer does that first hand Use of RFIDs make inventory management more easy Real time data updating makes data collection and processing much faster and efficient Analysis Options based on size of data makes it feasible and efficient for retailers to predict sales and strategize production or retail. With RFID detection the time required for payment and check put process can be redued.

Automatic processing of data reduces efforts for sellers/retailers and provides them with intelligent conclusions some specific analysis and predictions or conclusions that can be deduced are

What products are selling more?

We can use techniques such as frequency analysis or association rule mining to identify the most popular products or the products that are frequently purchased together.

Chart of buyers based on gender:

We can create a bar chart or a pie chart to visualize the distribution of buyers based on gender.

What is the trend among the buyers?

We can use techniques such as time series analysis or regression analysis to identify trends in sales over time, or to predict future sales based on historical data.

What are the chances of each product to be in demand in the future?

We can use techniques such as demand forecasting or predictive modelling to predict the future demand for each product based on historical sales data and other relevant factors.

A. Comparative Analysis

TABLE I. COMPARISON BETWEEN BARCODE AND RFID SCANNER

Sr. No.	TraditionalBarcodeBasedRetailShopping System	NewRFIDBasedRetailShoppingSystem with IntegratedAnalysisTool
1.	Needofasalespersonhenceregularexpenditure	Autonomousmachine/self-checkout(onetime installationandcheap maintenance)
2.	Needtoscanbarcodeoneveryitemforgeneratingbill	Justneedtoplacetheitemsinthescanningarea. IDsaredetectedon theirown
3.	Highdependencyoncashierandunwantedpro-motionofotheritems	Simplebillingprocesswithno2nd personinterface
4.	Limitedpaymentoptionswithprivacyconcerns incaseofcardPINsand passwords	Morepaymentoptionsandself-checkouthence securepayment
5.	Complexandseparatedsalesdatamanagementand manual data processing	Automaticsalesdatamanagementandprogramming data processing

On the surface, RFID seems like the clear choice. It can scan multiple items at once, whereas barcoding requires a person to physically scan each item individually. But if it is truly more efficient, why hasn't it replaced barcoding entirely? Like all technologies, both have their own benefits and limitations, and its unlikely RFID will replace barcodes altogether anytime soon. Finally RFID based system has following advantages over Bar code system.

1. Efficiency: Can scan multiple items at once
2. Durability: Can handle exposure to sun and rain
3. RFID allows for greater security than barcodes

B. Actual Vs. Predicted Analysis

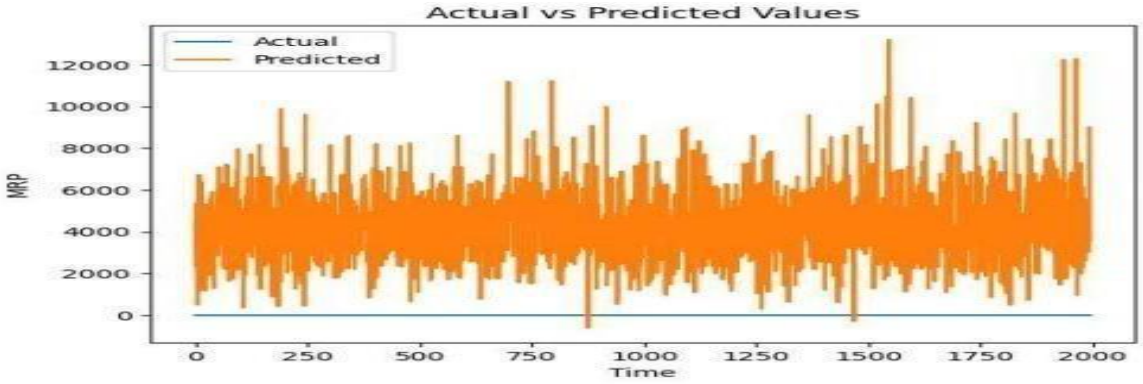

Fig 4: Actual vs. Predicted Value

VI. CONCLUSION AND FUTURE WORK

The blend of self-checkout framework and RFID innovation with the goal that it very well may be utilized in shopping centers to take care of the issue of remaining in lines and hanging tight for quite a while for charging in the wake of utilizing the self-checkout framework. It is possible to quickly and accurately scan all inventory items using RFID, and once a theft occurs, it is simple to track the object's location. As it requires greater investment for charging the items due to remaining in lengthy lines, so we utilize the innovation of RFID for transmission and photodiode for gathering. In addition, once the Process of Product Sale is finished, the sales data are used to predict public trends and fashion trends. It likewise helps traders in building creation systems and arranging shipment as per seasons and patterns. In future application is enhanced for RFID scanner with reduction in time for scanning.

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