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IOT Based Smart Shopping Cart using RFID

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***Abstract*—Now a days billing of purchased items in malls or supermarkets is very difficult process, after collecting the items customer must wait to pay the bill for purchasing products. In response to this challenge, we introduce a pioneering solution: the Smart Billing System. By harnessing Radio-Frequency Identification (RFID) technology, this system revolutionizes the billing paradigm. Each product is affixed with a unique RFID barcode, which serves as a digital identifier. When placed in the vicinity of the Smart Trolley, equipped with an RFID reader and an LCD display, the RFID barcode triggers an instant information exchange. The RFID reader swiftly deciphers the barcode, accessing the corresponding product details and price. This information is then displayed on the integrated LCD screen, granting customers real-time visibility into their selected items and associated costs. This synergy of RFID technology and real-time information display circumvents the traditional checkout delays, resulting in a streamlined, efficient, and customer-centric billing experience. At its core, the Smart Billing System embodies the convergence of the IOT and RFID. Through this fusion, the once-static shopping cart evolves into an intelligent companion, enabling seamless interactions between physical items and digital systems.**

***Keywords*—Internet of things, RFID cards, RFID reader, node MCU, Sensors.**

I. INTRODUCTION

Internet of Things (IoT) devices are everyday objects that are equipped with computing power and communication capabilities, allowing them to connect to the internet and collect and transmit data. This data can then be used to improve efficiency, reduce costs, enhance the customer experience, and create new business opportunities.

A smart billing system is an advanced approach to billing and invoicing that leverages technology, automation, and data analysis to streamline the billing process and improve accuracy. It often includes features like real-time billing, automated data collection, and analysis, online payment options, and customizable billing formats. These systems are commonly used in various industries to enhance billing efficiency and provide a better experience for both businesses and customers.

Smart shopping carts are technologically enhanced shopping carts that incorporate various features to improve the shopping experience for customers and gather data for retailers. Some common features of smart shopping carts include: Automatic Scanning, RFID Technology [1], Weight Sensors, Navigation Assistance, Payment Integration, Inventory Alerts, Data Analytics. Smart shopping carts aim to enhance convenience and efficiency for shoppers while also providing valuable data for retailers to improve their operations and customer experiences.

By making it more effective and transparent, current technology like RFID (Radio Frequency Identification) and wireless networks have paved the way for a speedier pace of buying. When brought within range of a reader, RFID tags are the tiny transponders (transmit and respond) [2] that communicate wirelessly by releasing an identification like a serial number. By design, an RFID tag is a special kind of wireless card with an embedded chip and loop antenna. A distinctive twin digit card number is stored on this chip. Magnetic signals at up to 125 kHz are produced by RFID reader circuits.

Shopping in today's world involve going to crowded stores or busy malls, choosing and evaluating a product, placing it in a heavy shopping cart, carrying the cart to the checkout counter, and then waiting in a long line to have the products scanned for the consumer goods purchased. Customers waste a lot of time during this process. In some cases, the buyer is aware that the total cost of their purchases exceeds their budget. Today, barcodes are utilized to identify product data, therefore barcode scanners are employed on the billing desks of shopping malls, although they must be pointed directly at the product [3]. Therefore, a system that can recognize products without scanning the environment is suggested in our project time of shopping. [4]

Governments are promoting laws and strengthening regulations for electronic transaction and payment systems, which is a sign that economists believe a cashless society would be the new paradigm in a technology-driven economy. Governments and citizens alike have been under pressure to adopt the new norm of conducting transactions online as a result of the recent COVID-19 outbreak [5]. While lockdown scenarios keep the majority of businesses and public services closed, mobile payments will skyrocket. Despite the large range of mobile applications that are available for ordering and delivery, individuals still like going to stores like supermarkets and shops over making purchases online for a variety of reasons. More than half of

those interviewed for this study in Oman said they prefer to visit stores and markets, but they are open to adopting mobile applications for some things. .[6]

People used to make lists of goods to buy when they went grocery shopping, but in the last ten years, technology has completely changed the way people shop [7]. Additionally, the introduction of smartphones has fundamentally altered the traditional purchasing experience. To ensure that their customers are happy with their overall shopping experience, businesses are constantly attempting to improve it. Various initiatives have been made in the past to reduce long waits for merchandise at retail outlets. One of the most well-known strategies was the installation of self-checkout lanes, which significantly increased customer convenience [8]. Due to their low overhead costs, self-checkouts have gained popularity ever since. However, larceny and decreased operational efficiency are seen as two main negatives in the retail sector. But the two biggest drawbacks in the retail industry are thought to be theft and a decline in operational effectiveness. The expectations in a grocery store and a name-brand clothing store can differ greatly, making it difficult to select a single piece of technology that can be used to enhance the shopping experience [9–10]. It was also shown that customers would rather make purchases when provided with item-level information. The demands for privacy and visual technologies also have a significant impact on customer pleasure.

Therefore, it's crucial to find strategies to enhance the buying experience while taking into account variables like return on investment, anticipated sales growth, and meeting

II. Related Work

The research that has been done in the past years on the use of radiofrequency identification in retail is shown in this section. Numerous authors have discussed their opinions and theories in this area and created useful working models that can benefit both the client and the store. Ultimately, this is advantageous from both the viewpoints of the shop and the customer.

A. RFID Technology

Tapan et al. [11] has proposed the design of a smart trolley for shopping, which aims to simplify the shopping experience and billing process. This system uses RFID reader, RFID tags, and an Arduino board, ESP8266 Wi-Fi module, and a database manager. Customers can shop using the smart trolley, receive an e-bill via email, and access their purchase details on the shop's website. The system aims to reduce wait times, offer online shopping details, and benefit both customers and shop owners. The RFID system involves using RFID tags on products, and an RFID reader scans and adds selected items to the cart. The customer can then proceed to the billing stage. The system intends to enhance the shopping experience and store management while utilizing IOT technology.

Similarly another approach by Naveenprabu et al. [12] [2020] is the smart shopping trolley system aims to make shopping more convenient for customers. It utilizes an automatic billing system and allows users to control the trolley's movement through an Android application on their mobile devices. Billing and Connectivity: Products selected by the customer are automatically billed through the use of RFID tags and readers. The system establishes a local area network (LAN) using Bluetooth to update the product details and cost on the customer's mobile application. The system leverages the Internet of Things (IOT) to send the billing information to the shop's administrative system, eliminating the need for traditional checkout processes. The trolley is equipped with obstacle avoidance technology to ensure smooth and efficient movement within the store. The keywords associated with this system include IOT, Bluetooth, RFID tags and readers, obstacle avoidance, and Android application.

J.C. Narayana et al. [13] developed an Interactive Kiosk based cart that utilizes RFID (Radio Frequency Identification) technology to identify product details which are available in the database. The identified products added to the cart and an interactive kiosk to display the product details and generate a bill for the customer. The following system also has an aspect that allows customers to save their shopping list to the cloud and access it from anywhere. The primary objective is to eliminate queues in shopping malls during the billing process, making shopping more convenient.

Martinus et al. [14] has to created a system that enhances checkout process efficiency by enabling customers to perform self-scanning of items while cashiers handle only the payment process. The system involves Smart Shopping Carts, a smartphone app, and integrated applications for cashiers, servers, and databases to support data transmission. The created system uses the Waterfall technique and multiple technologies—Arduino, RFID, Visual Studio Code, Flutter, PostgreSQL, REST, React, and Node.js—are used in the developed system. As the number of items and clients rises, the efficiency of the simulation results increases.

Mobeen et al. [15] proposed a system for a smart shopping cart that is built on the Internet of Things and has Bluetooth, Arduino, RFID, and mobile application capabilities. RFID sensors play a key role in wireless communication, with RFID tags attached to products and RFID readers efficiently collecting product information. The collected product information is displayed in a mobile application, allowing customers to manage their shopping lists. The products information is transmitted to a server through wireless network, where billing is automatically generated, eliminating time-consuming processes and service quality issues.

Kowshika.S et al. [16] described the use of RFID with ZigBee for wireless communication between RFID tags and the main server. Discusses advantages of Bluetooth over ZigBee for shopping communication. The proposed system aims to streamline the shopping experience by allowing customers to scan products, monitor their bill in real time, and make payments conveniently through a mobile app. It incorporates RFID technology, load cells for theft prevention, and Raspberry Pi for processing. The system can potentially improve shopping efficiency and customer satisfaction.

The challenges solved by the Nishitha et al. [17] was the IOT based automatic billing system for shopping malls. A system aims to enhance the shopping experience by automating the billing process, preventing theft, and providing real-time billing Information to customers. The system uses RFID tags attached to products and RFID readers installed in shopping carts and at checkout counters. The RFID readers scan the RFID tags of products as the

customer adds them to their cart. When the customer is ready to checkout, The total bill amount is computed by the RFID reader at the checkout counter and shown on a screen when the customer at the checkout counter. The customer can then pay the bill using their credit or debit card. The system can potentially improve efficiency and security in mall shopping.

Sakorn et al. [18] have developed the smart shopping system based on RFID technology. Utilizes smart shopping carts equipped with RFID technology to assist consumers in finding desired items, receive product recommendations, and calculate billing information during their shopping. Aims to reduce waiting times at checkout counters and improve supermarket supervision. The system updates the number of products and their status on the main server in real-time, enhancing inventory management efficiency.

Rupanagudi et al. [19] the proposed solution involves the development of a smart trolley system that can guide consumers to the products they need and assist them in carrying items. The system uses video processing technology and aims to be a cost-effective and environmentally friendly alternative to existing RFID-based solutions. The text mentions that further details about the setup, methodology, results, and cost-effectiveness will be provided in subsequent sections, indicating that the paper presents a novel approach to solving common shopping problems in a cost-effective manner.

Rajlakshmi et al. [20] introduced a SCAR system, aims to enhance the shopping experience by offering quick billing and product recommendations to customers in supermarkets. It leverages RFID technology and ARM algorithms for this purpose, with a focus on reducing waiting times and improving customer satisfaction. The comparison between barcode and RFID technologies is also discussed, highlighting the advantages of RFID in terms of accessibility, information capacity, and reliability.

Ashok Sutagundar et al. [21] have proposed a system, including RFID tags, LCD displays, Android applications, Wi-Fi (ESP8266), and cloud integration (Amazon cloud). Explains that all products in the shopping mall are tagged with RFID tags, and when customers place products in their trolley, the RFID code is detected, and product details are displayed on an LCD. Describes how data is sent to the Amazon cloud through Wi-Fi and can be accessed via an Android app. Highlights the system's ability to provide real time information about product availability in the shopping mall. Mentions that the system aims to save customer time and effort while improving overall efficiency in the shopping mall.

Shilpa et al. [22] have developed a user operated billing system in malls aims to streamline the billing process in crowded malls using technology, including barcode scanning, IOT, and cloud-based services. The smart shopping cart with an automated billing system using RFID and arduino. The system uses RFID tags to identify and track products in the cart. The cart also has a barcode scanner that allows customers to scan and add items to their cart. When the customer is finished shopping, they can simply tap their credit card on the cart's reader to pay for their items. The system's key objectives are to reduce queue times, enhance the shopping experience, and improve overall efficiency in billing processes.

Akshay et al. [23] proposed a smart shopping cart system using image processing and the Internet of Things (IOT). The system consists of a camera, a microcontroller, and a wireless module. The camera is installed on the shopping cart. The microcontroller is used to process the images captured by the camera. The wireless module is used to send the processed images to a central server. The central server then identifies the products in the images and calculates the total price of the items in the cart. The total price is then sent back to the microcontroller and displayed on a screen on the shopping cart.

Ria singh et al. [24] describes the development of a smart shopping complex that uses RFID and IR technology to enhance the convenience and efficiency of both customers and store employees. The proposed system uses RFID tags to identify each product and assign it a unique position in the storehouse. When a product arrives at the storehouse, an RFID reader detects and reads the code sends it to a three-dimensional motor, which guides the product to its assigned position. This system eliminates the need for manual stock management and makes it easier to keep track of inventory levels. Customers can use smart carts to shop in the store. The smart carts have RFID readers that can scan the products that customers add to their carts. The cart automatically calculates the total bill and displays it to the customer. When the customer is ready to checkout, they can simply pay their bill at the checkout kiosk without having to unload their cart and wait in line. The store also uses IR sensors to track the movement of smart carts and conveyor belts. This information is used to optimize the flow of traffic in the store and to prevent congestion.

B. Raspberry Pi Technology

S.KShankar et al. [25] has proposed a smart trolley is designed to monitor the total cost as items are added to the cart, helping customers stay within their budget. It also communicates with an in-store section to facilitate mobile payments. Customers have the option to make online payments through the application. The system reduces wait times at checkout counters, enhances the efficiency of the checkout process, and provides customers with real-time pricing and item information. The system addresses common customer issues, such as finding items in the store or seeking assistance from store employees. It includes features like item tracking, a store map, and a purchase history, enabling customers to make informed decisions and aiding the supermarket in understanding customer trends.

Jaishree. M et al. [26] has describes the objective of creating a smart shopping cart that reduces shopping time, automates billing, and enhances the overall shopping experience. The system is designed for use in physical stores, such as supermarkets, to improve the experience for both customers and retailers. This section briefly mentions some related works and concepts, such as RFID-based automated billing trolleys and QR code scanning. It highlights the use of RFID tags and readers in previous systems but notes the potential limitations and cost factors associated with RFID technology.

Hanooja.T et al. [27] Describes the system's features, including RFID-based item identification and billing within the trolley. The goal of improving customer satisfaction and reducing billing queues. The proposed system aims to enhance the shopping experience by

automating the trolley's movement, making it easier for customers to shop and calculate their bills. It leverages RFID technology and image processing to achieve these objectives. The system is expected to provide benefits such as reduced effort for customers and improved overall efficiency in supermarkets or grocery stores.

Viswanadha. V et al. [28] has describes the proposed system's components, including Raspberry Pi, barcode scanner, touchscreen display, and a push button. Explains how each product is tagged with a barcode, allowing customers to scan items before placing them in the cart. Details how the system calculates and displays the cost of products, the total number of items, and the total cost. Discusses the removal of items from the cart using a push button. Mentions the use of a QR code for generating e-bills that customers can pay through various methods. Highlights the benefits for both customers and shopping mall owners, including reduced costs and increased product placement.

C. Barcode Scanning Technology

T R Lekha et al. [29] has proposed a system that uses barcode scanners integrated into shopping carts. Each product in the supermarket has a unique barcode tag. When a customer places a product in the cart, the barcode reader scans the product's barcode, and the information is displayed on a digital screen. The Bolt ESP8266 module is introduced as a key technology for connecting and coordinating various components of the system. The Bolt ESP8266 allows for easy control and monitoring of devices over the Internet, and it is cost-effective for prototyping. It providing real-time cost information and reducing waiting times at the billing section. The system leverages IOT technology for efficient operation.

Sakorn et al. [30] introduced the concept of a smart basket, which is designed to address these issues and improve the shopping experience. The smart basket is equipped with a barcode reader on a device, enabling shoppers to scan products and automatically record their prices and names. Additionally, the basket includes a weight sensor system (load cell) to ensure accurate pricing of products during the process. The total cost of the customer's products or items is calculated and stored in the memory of the smart basket's microcontroller. The microcontroller transmit the data to the central billing system through a transmitter. The primary goal is to eliminate the need for shoppers to wait in long lines and constantly calculate expenses while shopping.

Charles Paul et al. [31] has proposed a smart shopping application design with two parts: Navigation and Recommendation. Discusses manual and fixed modes for product location navigation within the supermarket. Indicates that the proposed system provides a solution to eliminate the need for manual billing and queues. The research presents a mobile application-based solution using IOT and recommendation systems to streamline the supermarket shopping process, reduce waiting times, and enhance the overall shopping experience for customers.

Susila et al. [32] proposes a smart shopping cart that uses RFID tags to identify products and keep track of the items in the cart. The cart also has a built-in display screen that shows the customer a running total of their purchase. This Android app turns a smartphone into a barcode scanner. It can be used to scan barcodes and QR codes, and the scanned data can be sent to other apps or devices via Bluetooth or email. A smart goods billing management and payment system that uses a mobile app and cloud computing. The system allows customers to scan product barcodes, view their shopping list, and pay their bills through the app. This is a solution that enables customers to scan products with their smartphones, display the cost on their mobile screens, and pay using UPI platforms. Suggests an anti-theft method involving CCTV-based robbery detection and shoplifter tracking. Emphasizes the importance of object detection and motion tracking technology.

TABLE I. COMPARISION OF METHODS

Ref. No	Methods	Data Sets
Das et al. [11] [2020]	RFID, Arduino Board, ESP8266 Wi-Fi module, database management	Product information, Transaction data, Location Data.
Naveenprabu et al. [12] [2020]	RFID, Bluetooth, Android Application, Automatic Billing, Online Database.	Producct Database, Customer Database, Shopping Cart Database, Store Layout
Martinus et al. [14] [2021]	Waterfall Methodology, RFID, Flutter, Postgre SQL, Node.js	Observation data, Questionnaire data, Simulation data, Real-world data, Checkout process time
Sakorn et al. [18] [2020]	RFID Technology, Recommendation System, Real-Time Inventory Management.	Product catalog, Customer purchase history, Smart cart data, Store layout
Rupanagudi et al. [19] [2015]	FPGA(Field-Programmable Gate Array), RFID, robotic Assistant, video processing	Product dataset, Customer transaction dataset,Customer demographic dataset, Customer review dataset
Shankar et al. [25] [2021]	IOT, Raspberry Pi, Mobile Application, Data Analysis, Cloud Connectivity	Product Dataset, Customer Dataset, Store layout dataset, Real-Time Inventory data, Customer feedback Data
Hanooja et al. [27] [2020]	Raspberry Pi, Pi cam, Gear Motors, LCD display and Ultrasonic sensors	Customer tracking, Product identification, Billing, RFID tag data, Store layout
Viswanadha et al. [28] [2018]	Raspberry Pi3B+, Barcode Scanner, Digital Push Button, Battery Raspbian Stretch OS, Python 3	Product images and prices dataset, customer review dataset, sensor dataset
Lekhaa et al. [29] [2019]	Barcode Scanning, Bolt ESP8266, Bolt Cloud Platform, Database	Product Information Database, Customer Purchase History database, Store Layout Dataset, Customer Demographics datasets.
Paul et al. [31] [2021]	Mobile Application, Recommedation System, Payment Authenticaton, Optional Transport Facility.	Product Catalog dataset, User purchase history dataset, User demographics dataset, Sales data

III. ANALYSYS AND DISCUSSION

The smart billing system has the potential to revolutionize the way we shop. It is a more convenient and efficient

system for both customers and retailers. Customers can skip the checkout line and pay for their purchases quickly and easily, while retailers can reduce errors and collect data on customer purchase patterns. The potential of the smart billing system to improve the customer experience. Customers often complain about long wait times at the checkout counter. The smart billing system eliminates this problem by allowing customers to pay for their purchases without having to wait in line. This can make the shopping experience more enjoyable for customers and encourage them to return to the store. The smart billing system can help retailers to improve their bottom line. By reducing errors and improving efficiency, the smart billing system can help retailers to save money. Additionally, the data collected by the smart billing system can be used by retailers to improve their inventory management and marketing strategies. This can lead to increased sales and profits for retailers.

IV. Conclusion

This project aims to develop and implement a smart shopping cart application attached to a trolley, and the application creates an automated central billing system in the malls. This process is done by using Radio Frequency identification technology (RFID). The products information is sent to the billing system to eliminate the need for customers to wait in long queues for billing process. The proposed system is trustworthy, highly reliable, and time-efficient. Additionally, it reduces the time customers spend searching for products, as they can simply type the product name they want to purchase in the search box, then the trolley automatically guide them to the product location.

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