

# RFID Based Smart Shopping Trolley Using IOT

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**Abstract**—The retail industry is undergoing a significant transformation driven by the need for enhanced customer experience and operational efficiency. Traditional queuing systems at checkout counters remain a primary source of customer dissatisfaction and time wastage. This research presents the design and implementation of an IoT-based Smart Shopping Trolley aimed at automating the billing process and eliminating long waiting times. The proposed system integrates Radio Frequency Identification (RFID) technology with the Internet of Things (IoT) to create a seamless shopping environment. Each product in the store is equipped with a unique RFID tag containing essential product information. The smart trolley is integrated with an ESP8266 NodeMCU microcontroller, which acts as the central processing unit and provides Wi-Fi connectivity. An MFRC522 RFID Reader is mounted on the trolley to scan items as they are placed inside. Upon scanning, the product details and price are instantly retrieved and displayed on a 16x2 I2C LCD, which maintains a real-time running total of the bill. To ensure system integrity and accuracy, an IR Sensor is utilized to detect the physical movement of items into the cart, triggering the scanning process. Furthermore, a Servo Motor is implemented to provide an automated physical response, such as a locking mechanism or a gated entry/exit for scanned items, enhancing the security of the automated system. Data synchronization is achieved through the built-in Wi-Fi module of the NodeMCU, which transmits the billing information to a centralized server or mobile application. This allows for instantaneous payment processing and inventory management. The system not only empowers consumers by providing transparency in spending but also assists retailers in reducing labor costs and improving throughput. Experimental results demonstrate that the prototype is highly reliable, cost-effective, and capable of significantly reducing the average checkout time compared to conventional methods. This project contributes a scalable solution to the evolving landscape of smart retail environments.

**Index Terms**—IoT, Smart Trolley, RFID, ESP8266 Node MCU, Automated Billing, Retail Automation, Real-time Monitoring.

## I. INTRODUCTION

The retail industry is currently undergoing a massive digital transformation driven by the need to enhance customer experience and streamline operational efficiency. Traditional shopping methods often involve significant bottlenecks, particularly at checkout counters where long queues lead to consumer frustration and lost revenue for retailers. As the "Internet of Things" (IoT) continues to bridge the gap between the physical and digital worlds, the concept of a Smart Shopping Trolley has emerged as a robust solution to modernize the brick-and-mortar shopping experience. This project proposes an automated system that integrates Radio Frequency Identification (RFID) technology with the ESP8266 NodeMCU to create an intelligent, self-billing environment. By shifting the billing process from a centralized counter to the individual trolley, the system empowers the consumer, reduces human error, and optimizes the flow of traffic within a retail space.

The core functionality of this system revolves around the seamless identification of products using RFID tags and an MFRC522 RFID reader. Unlike traditional barcodes, which require a direct line of sight and manual scanning, RFID technology allows for near-instantaneous data acquisition as soon as an item is placed within the trolley. When a customer selects a product, the reader captures the unique identification code from the tag, and the ESP8266 NodeMCU—serving as the central processing unit—retrieves the corresponding price and product information. This

data is immediately displayed on a 16x2 I2C LCD, providing the shopper with a real-time running total of their expenditure. This transparency helps users manage their budgets effectively while they shop, eliminating the "sticker shock" often experienced at the final checkout.

To ensure the integrity of the automated billing process, the system incorporates an IR Sensor to detect the physical entry or exit of items from the trolley. This sensor acts as a secondary verification layer, ensuring that the number of items detected by the RFID reader matches the physical contents of the cart. Furthermore, a Servo Motor is integrated into the design to provide a mechanical gate or locking mechanism, which can be programmed to secure the trolley or signify a successful scan. The hardware architecture is unified by the ESP8266's built-in Wi-Fi module, which connects the trolley to a centralized database or cloud platform. This connectivity allows the retail management team to monitor inventory in real-time, analyse consumer behaviour patterns, and update product pricing across the entire fleet of trolleys simultaneously.

## II. LITERATURE SURVEY

The development of an RFID-based Smart Shopping Trolley using IoT addresses the critical need for automation in the retail sector, specifically targeting the reduction of long queues at checkout counters. Traditional barcode systems are often time-consuming as they require a line-of-sight between the scanner and the product, leading to significant delays. Research into Radio Frequency Identification (RFID) technology has shown that it offers a more efficient alternative by allowing for simultaneous and non-line-of-sight scanning of multiple items. Early literature in this field focused primarily on standalone RFID systems that displayed the total cost on a local LCD. However, recent advancements have integrated the Internet of Things (IoT) using controllers like the ESP8266 NodeMCU, which allows for real-time data synchronization between the trolley and a centralized billing database via a Wi-Fi module.

Several studies have explored the integration of MFRC522 RFID readers and passive RFID tags for item identification. When a customer places a product equipped with an RFID tag into the trolley, the reader

captures the unique ID, and the microcontroller retrieves the corresponding price and product name from the database. This information is then displayed to the user on an I2C 16x2 LCD, providing an interactive shopping experience. To ensure the integrity of the system, researchers have proposed the use of IR sensors to detect the physical entry or removal of items, preventing customers from bypassing the RFID scanner. Furthermore, the inclusion of a Servo Motor has been documented as a mechanism to automate the trolley's locking or gate system, ensuring that items are only cleared once the billing process is initiated or completed. Advanced implementations discussed in recent journals highlight the transition from local storage to cloud-based monitoring. By leveraging the ESP8266's Wi-Fi capabilities, the smart trolley functions as an IoT node, transmitting billing data to a web or mobile application. This allows store management to track inventory in real-time while providing customers with a digital invoice, thereby eliminating the need for manual scanning at the exit. Comparative analysis between different microcontrollers suggests that the NodeMCU is preferred for such projects due to its built-in Wi-Fi and low power consumption compared to traditional Arduino-based systems that require external modules.

The literature also emphasizes the security aspects of smart billing. The use of RFID tags offers a level of data encryption that barcodes lack. Scholars have noted that while the initial setup cost of an RFID-based infrastructure is higher than barcode systems, the long-term benefits in terms of labor reduction and customer satisfaction are substantial. The integration of I2C communication for the LCD minimizes the wiring complexity, making the hardware design more robust for a mobile environment like a shopping cart. Future trends identified in the survey suggest the inclusion of automated weight sensors to further validate the items scanned and the use of machine learning to analyse consumer behaviour based on the data collected by these IoT-enabled trolleys.

## III. ESP8266 NODE MCU

The ESP8266 NodeMCU is an open-source LUA-based firmware and development board specifically designed for Internet of Things (IoT) applications. It is powered by the ESP-12E module, which contains the



Code (EPC) that distinguishes individual items from one another globally. In a smart trolley system, the MFRC522 reader emits a high-frequency electromagnetic field that powers the passive tag when it enters range. Once energized, the tag transmits its stored data back to the reader, which then identifies the product and its price. These tags are highly durable and can store significantly more data than traditional linear barcodes. In retail environments, they enable real-time inventory management and rapid, automated checkout processes. Their integration with IoT modules like the ESP8266 allows for seamless data synchronization between the physical trolley and a cloud-based billing server.

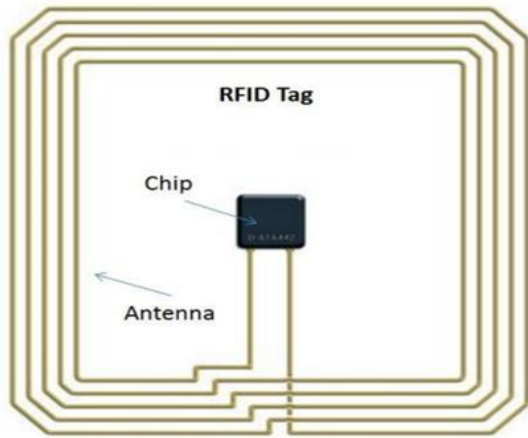


Figure 3: RFID Tag

### VI. I2C LCD (16X2)

The I2C LCD is a popular display module used in embedded systems because it significantly reduces the number of pins required to interface a standard 16x2 screen with a microcontroller. While a traditional LCD requires at least 6 to 10 digital pins, the I2C version uses a small backpack module (usually based on the PCF8547 chip) to communicate via only two wires: SDA (Serial Data) and SCL (Serial Clock). This efficiency is crucial for projects using boards like the ESP8266 or Arduino Nano, where pin availability is limited. The module operates by converting serial data from the I2C bus into parallel data for the LCD controller. It features a built-in potentiometer on the back to adjust the contrast of the characters manually. Additionally, it includes a jumper to enable or disable the LED backlight programmatically to save power. Most I2C LCDs have a default hardware address, often

0x27 or 0x3F, which the code uses to identify the device on the bus. This setup supports multiple devices on the same two wires, provided they have different addresses. It is widely favoured for IoT projects due to its simple \$5 or \$3.3 wiring and its ability to display real-time sensor data clearly.



Figure 4: LCD

### VII. SERVO MOTOR

A Servo Motor is a specialized rotary actuator designed for high-precision control of angular position, velocity, and acceleration. Unlike standard DC motors that rotate continuously, a servo typically operates within a limited range, such as 180° or 360°, using an internal feedback mechanism to sense its current position. It consists of a DC motor, a gear train to increase torque, a potentiometer for position sensing, and a control circuit. The motor is driven by Pulse Width Modulation (PWM) signals, where the width of the electrical pulse determines the specific angle the output shaft will hold. Because of this closed-loop system, the motor can automatically correct its position if an external force tries to move it. They are widely used in robotics for joint movements, in RC vehicles for steering, and in industrial automation for precise tool placement. Standard servos generally operate at voltages between 4.8V and 6V, making them highly compatible with microcontrollers like the ESP8266 or Arduino.



Figure 5: Servo Motor

### VIII. IR SENSOR

The IR (Infrared) sensor is an essential electronic device used to detect obstacles or measure distances by emitting and receiving infrared radiation. It primarily consists of an IR LED (transmitter) that sends out infrared light and a photodiode (receiver) that detects the reflected light from an object. When an object comes within range, the infrared light bounces off its surface and returns to the photodiode, triggering a change in the output signal. In your smart trolley project, it serves as a reliable mechanism to detect when an item is physically placed into or removed from the cart. These sensors are highly favored in DIY electronics because they are cost-effective, compact, and consume very little power. They operate effectively in real-time, allowing the ESP8266 to immediately process the presence of a product. However, their performance can be influenced by ambient light or the color of the object, as dark surfaces tend to absorb more infrared radiation. Most modules include an on-board potentiometer to manually adjust the detection sensitivity and range. Overall, the IR sensor acts as the "eyes" of the system, ensuring the digital billing matches the physical contents of the trolley.



Figure 6: IR Sensor

### IX. WI FI MODULE

The ESP8266 NodeMCU serves as the heart of your project's connectivity, acting as a low-cost, standalone SoC (System on a Chip) with an integrated TCP/IP protocol stack. It enables your smart trolley to connect to a local Wi-Fi network, allowing it to transmit real-time billing data from the RFID reader to a central server or mobile application. Operating primarily on the 2.4 GHz frequency, it supports standard 802.11 b/g/n protocols, ensuring compatibility with most

modern routers. In your system, the module processes signals from the IR sensors and MFRC522, then formats this data to be displayed on the I2C LCD or sent to the cloud. Its ability to function in both Station (STA) and Soft Access Point (AP) modes provides flexibility in how users interact with the trolley. Furthermore, the module's GPIO pins allow for seamless pulse-width modulation (PWM) control of the Servo motor for gate mechanisms. Because it operates at 3.3V, it requires careful power management to avoid damage while communicating with 5V components. Ultimately, the Wi-Fi module transforms a standard cart into an intelligent IoT node, bridging the gap between physical hardware and digital inventory management.

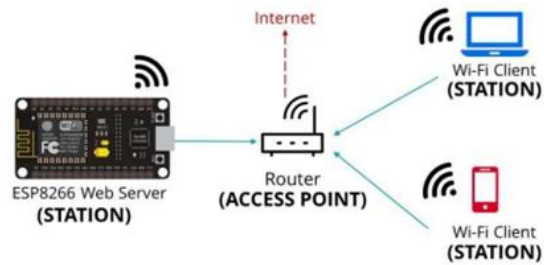


Figure 7: Wi-Fi

### X. CONCLUSION

The development of the RFID-based Smart Shopping Trolley successfully integrates IoT and embedded systems to address the long-standing challenges of traditional retail queuing and inventory management. By utilizing the ESP8266 NodeMCU as the central processing unit, the system achieves seamless communication between hardware components and the cloud via the integrated Wi-Fi module. The implementation of the MFRC522 RFID Reader and tags allows for instantaneous item identification and billing, while the I2C LCD provides real-time transparency for the consumer's total expenditure. Furthermore, the inclusion of an IR sensor for item detection and a Servo motor for automated gate or locking mechanisms adds a layer of security and automation to the shopping experience.

This prototype demonstrates a significant reduction in checkout time, effectively eliminating the bottleneck at manual billing counters. The system not only

enhances customer satisfaction through a more streamlined, "grab-and-go" experience but also offers retailers a scalable solution for real-time inventory tracking. Future iterations of this work could incorporate advanced features such as automated weight verification to prevent theft or the integration of mobile payment gateways directly through the IoT interface. Ultimately, this smart trolley serves as a robust framework for the next generation of intelligent retail environments, proving that the convergence of RFID and IoT is essential for the evolution of modern commerce.

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