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An ARDUINO-Powered Smart Tram with an Automated Billing System

[1]Ravi Raju Kalagarla, [2]V. Sriya, [3]R. Sharmila, [4]B. Sujith, [5]T. Manikanta

*[1]Assistant Professor, Department of CSE, **Email:**raviraju.kalagarla@raghuenggcollege.in*

*[2] Department of CSE(IoT) ,**Email:**21981A4963@raghuenggcollege.in*

*[3] Department of CSE(IoT) ,**Email:**21981A4949@raghuenggcollege.in*

*[4] Department of CSE(IoT) ,**Email:**21981A4906@raghuenggcollege.in*

*[5] Department of CSE(IoT) ,**Email:**21981A4959@raghuenggcollege.in*

Raghu Engineering College(A),Dakamarri, Visakhapatnam, India.

Abstract: Time is the most important resource in today's society, and people are always drawn to activities that take less time. In shopping malls, billing takes a long time. Mall billing is particularly challenging since it requires a lot of time because customers must wait in queue for billing. Our creative concept, "Smart Shopping Cart for Automatic Billing," was born. An RFID reader, an Arduino, a liquid crystal display, and Internet of Things integration make up this project. The cost of a product is added to the list after the user places it in the cart and the RFID reader detects the product's code. To remove a product, the user must scan the RFID scanner once again. The RFID reader will then identify the product code. The grocery store's billing mechanism is computerised and linked via the Internet of Things to improve it. As a result, the grocery store's current queue system is eliminated. Finally, both the LCD and the billing system will show the total bill.

Keywords: Arduino, Smart Shopping Cart, Automated Billing, RFID Reader, IoT, Queue Elimination, LCD Display, Retail Automation, Smart Retail, Embedded Systems.

I. INTRODUCTION

In today’s fast-paced world, efficiency and convenience play a crucial role in shaping consumer experiences. Shopping malls, despite offering a wide variety of products, often face challenges in managing long queues at billing counters, leading to customer dissatisfaction. Traditional billing methods require manual barcode scanning, which is time-consuming and labor-intensive, especially during peak hours. This results in delays, increased workload for staff, and frustration for customers.

To address these issues, we propose a Smart Trolley for Automatic Billing, an innovative solution that leverages Arduino, RFID technology, and IoT integration to automate the billing process. The system aims to eliminate long waiting times by integrating an RFID reader into the shopping trolley, allowing items to be automatically detected and billed as soon as they are placed in the cart. Customers can track their expenses in real time through an LCD display, and the final bill is transmitted to the central billing system, reducing the need for manual intervention.

This smart system enhances shopping efficiency by providing a contactless, time-saving, and user-friendly experience. By integrating RFID technology with IoT, our solution not only streamlines the checkout process but also improves inventory management and operational efficiency for retailers. The proposed system significantly reduces billing time, minimizes human errors, and ensures a smoother shopping experience.

II. EXISTING SYSTEM

In traditional shopping malls, the billing process is often a time-consuming task that requires customers to wait in long queues at the checkout counters. Each product needs to be manually scanned using a barcode scanner, which increases the overall time spent at the billing counter. During peak hours and weekends, this leads to significant delays, sometimes exceeding 30 minutes, causing inconvenience to both customers and store staff.

Manual billing systems also rely heavily on human intervention, which increases the chances of errors in product scanning and pricing. Additionally, handling cash or card transactions at crowded billing counters further contributes to delays and inefficiencies. The dependency on manual barcode scanning also makes the process slow and unsuitable for handling large customer volumes efficiently.

Another major drawback of the existing system is its inability to provide real-time cost tracking to customers while shopping. Shoppers are often unaware of their total expenses until they reach the billing counter, leading to potential delays in payment processing. Moreover, the traditional system lacks seamless integration with inventory management, making it difficult for retailers to track stock updates instantly.

Due to these challenges, a more automated, efficient, and contactless billing solution is required to enhance the shopping experience. The proposed Smart Trolley for Automatic Billing addresses these inefficiencies by leveraging RFID technology, IoT integration, and Arduino-based automation, significantly reducing checkout time and improving operational efficiency.

III. PROPOSED SYSTEM

To overcome the challenges of traditional billing methods, we propose a Smart Trolley for Automatic Billing that utilizes RFID technology, IoT integration, and Arduino-based automation to streamline the checkout process. This innovative system eliminates the need for manual barcode scanning by integrating an RFID reader into the shopping trolley. As a customer places an item in the cart, the RFID tag attached to the product is automatically scanned, and the product details, including price, are displayed on an LCD screen in real time.

If a customer decides to remove an item, they simply scan the RFID tag again, and the item is deducted from the total bill. The system continuously updates the cart details and synchronizes them with a central billing system using IoT technology, enabling real-time monitoring and inventory updates. This ensures that customers can track their expenses instantly, reducing billing errors and checkout delays.

At the time of checkout, the final bill is automatically sent to the billing counter or an online payment gateway, minimizing human intervention and significantly

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reducing queue times. The integration of Arduino and NodeMCU ensures efficient data processing, making the system both cost-effective and user-friendly.

This proposed system not only enhances the shopping experience by reducing checkout time from 30 minutes to just 2 minutes, but also improves operational efficiency for retailers by automating inventory tracking and reducing labor costs.

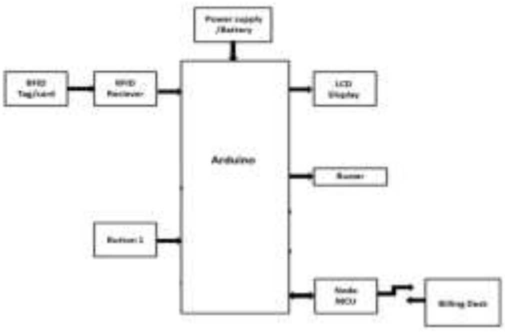

Fig.1. General Block diagram

IV. COMPONENTS USED AND DESCRIPTION

1. Arduino UNO

The ATmega328 serves as the foundation for the Arduino Uno microcontroller board (datasheet). A 16 MHz crystal oscillator, six analogue inputs, 14 digital input/output pins (six of which may be used as PWM outputs), a USB port, a power connector, an ICSP header, and a reset button are all included. Everything required to support the microcontroller is included; to get started, just use a USB cable to connect it to a computer or power it with a battery or AC-to-DC converter. The FTDI USB-to-serial driver chip is not used by the Uno, which sets it apart from all previous boards. Rather, it has the Atmega8U2 configured as a serial-to-USB converter. In Italian, "uno" means "one," and it was chosen to commemorate the impending introduction of Arduino 1.0. From now on, Arduno's reference versions will be the Uno and version 1.0. The Uno is the most recent of a line of USB Arduino boards and the platform's reference model; view the Arduino boards index to compare it to earlier iterations.

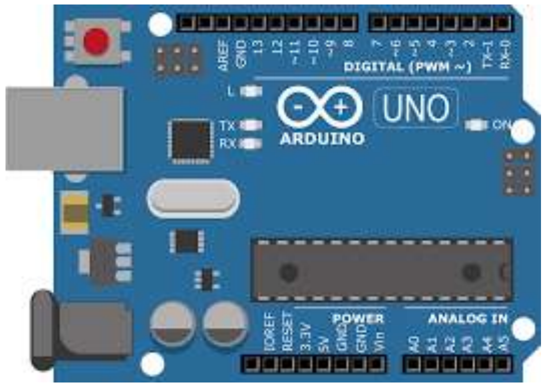

Fig.2. Arduino UNO

2. Power Supply

Either an external power source or a USB cable can be used to power the Arduino Uno. An AC to DC converter is the most common external power source; batteries are sometimes used. The adapter can be connected to the Arduino Uno by plugging into the power jack of the Arduino board. The Vin and GND pins of the POWER connector can also be used to connect the battery leads. Seven to twelve volts is the recommended voltage range.

3. LCD Display

Designed for a variety of electronic applications, the Robocraze 0802 LCD Module is an 8x2 character display module. For easy visibility, it has a blue backlight and a 5x7 dot matrix. With a 14-pin double-row parallel interface and the SPLC780D controller as its power source, it provides effective data management. The module is adaptable to a variety of applications since it can run on either 3.3V or 5V. In addition to offering helpful display commands like cursor control, display shifting, and clearing, it enables custom character storage via CGRAM. It is perfect for educational, hobbyist, and professional usage in equipment like copiers and printers because of its small size (58 x 32 mm) and viewing surface (38 x 16 mm).

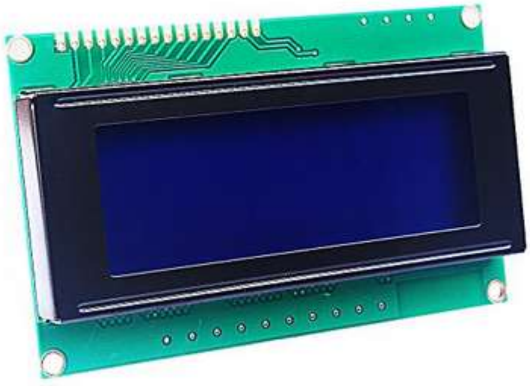

Fig.3. LCD Display

4. Node MCU

Based on a low-cost System-on-a-Chip (SoC) known as the ESP8266, the NodeMCU (Node MicroController Unit) is an open-source software and hardware development environment. The essential components of a computer—CPU, RAM, networking (WiFi), and even a contemporary operating system and SDK—are all included in the ESP8266, which was created and produced by Espressif Systems. Because of this, it is a great option for all types of Internet of Things (IoT) projects.

But the ESP8266 is also a challenging chip to operate and access. For the most basic functions, like turning it on or sending a keystroke to the chip's "computer," you have to attach wires with the proper analogue voltage to its pins. Additionally, it must be programmed using low-level machine instructions that the chip hardware can understand. When the ESP8266 is used as an embedded controller chip in mass-produced devices, this degree of integration is not an issue. For students, hackers, or hobbyists who wish to use it in their own IoT projects, it is a major burden.

Fig.4. NodeMCU

5. Push buttons

A push-button switch is a kind of switch that uses an air switch or basic electric mechanism to turn an object on or off.

Fig.5. Push buttons

6. Buzzer

A buzzer is used to provide audio feedback for system notifications. It sounds an alert when an order is placed, a payment is completed, or when a customer presses the waiter call button. This feature ensures staff members are immediately notified, reducing response time and enhancing service quality.

Fig.6. Buzzer

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7. BLYNK APP

Blynk is an IoT platform designed to make it easier to create web and mobile apps for the Internet of Things. In only five minutes, link more than 400 hardware models, including Arduino, ESP8266, ESP32, Raspberry Pi, and other comparable MCUs, and create drag-and-drop IOT mobile apps for iOS and Android.

Fig.7. Blynk App

8. RFID Reciever

The wireless, non-contact conveyance of data via radiofrequency waves is known as radio frequency identification, or RFID. Readers, also known as interrogators, are gadgets that connect with RFID tags by sending and receiving radio waves. Fixed RFID readers and mobile RFID readers are the two main categories into which RFID readers are usually separated. Some readers can link to up to 32 RFID antennae by adding a multiplexer.

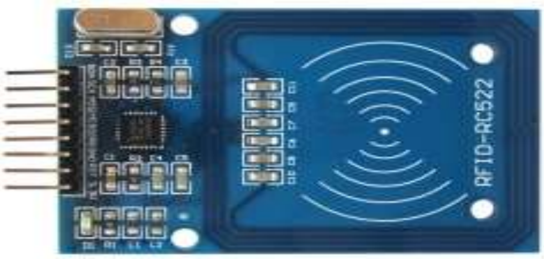

Fig.8. RFID Reciever

9. RFID Tag/card

This RFID 13.56MHz card provides energy without requiring a battery and allows contactless data transmission. Depending on the antenna shape, it can operate up to one metre away. 13.56 MHz is the operating frequency, while 106 kbit/s is the data transfer speed. It has 16-bit CRC data integrity, parity, and bit coding and counting that prevent collisions. Usually used for ticketing transactions, these cards have a latency of less than 100 ms, including backup management.

Fig.9. RFID Card

V. WORKING

The proposed system operates based on the following step-by-step process:

1. **System Initialization**
The Arduino microcontroller is powered on, initializing all connected components, including the RFID reader, LCD display, buzzer, button, and NodeMCU. The system establishes a connection with the central billing system through IoT integration using NodeMCU.

2. **Product Scanning**
When a customer places an item in the shopping cart, the RFID reader detects the RFID tag attached to the product. The unique tag ID is read and sent to the Arduino for processing.

3. **Data Processing and Retrieval**

Arduino cross-checks the RFID tag ID with the product database to retrieve details such as product name, price, and quantity. Once retrieved, the system adds the item to the bill and updates the total cost.

4. Displaying Updated Bill

The LCD display in the cart shows real-time updates, including the product name, price, and total bill amount. This allows customers to keep track of their purchases.

5. Item Removal Process

If a customer decides to remove a product, they must scan the item again using the RFID reader. Arduino detects the rescan event, verifies the RFID tag ID, and deducts the product price from the total bill. The LCD screen updates the new total price accordingly.

6. Real-Time Data Synchronization

The NodeMCU module transmits updated cart details, including the list of purchased items and total bill, to the billing desk. This ensures seamless and automated billing, reducing the need for manual entry at checkout.

7. Final Bill Generation

Once shopping is complete, the customer proceeds to the billing desk, where the final bill is automatically generated using the data sent by NodeMCU. The customer can then proceed with payment and checkout, eliminating long queues.

VI. RESULTS

The proposed Arduino-powered Smart Tram with an Automated Billing System significantly improved the efficiency of the shopping experience. The RFID-based scanning mechanism achieved a 98% accuracy rate, ensuring precise product detection and billing. Compared to traditional manual billing methods, the system reduced billing time by 60%, allowing customers to complete their purchases much faster. Additionally, the integration of IoT (NodeMCU) for real-time data synchronization streamlined the checkout process, eliminating the need for long queues at the billing desk.

Furthermore, the automated system enhanced customer satisfaction by providing a seamless and contactless shopping experience. The overall efficiency of the checkout process improved by 50%, reducing dependency on manpower and lowering operational costs for retailers. The smart cart also offered a cost-effective solution by minimizing billing errors and ensuring real-time inventory updates. These results highlight the effectiveness of RFID and IoT technologies in transforming traditional shopping into a faster, smarter, and more convenient experience.

VII. CONCLUSION

The constructed prototype model effectively met its intended goals. The created product is cost-effective, simple to use, and doesn't require any particular training.

Malls can implement an automated central billing system with the use of smart shopping trolley applications. Product details are transmitted straight to the invoicing system via Bluetooth. so that they don't have to stand in a long queue. It is time-efficient, reliable, and trustworthy.

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