Faculty of Electronics and Computer Engineering Technology

DEVELOPMENT OF A SMART SHOP CART USING RADIO FREQUENCY IDENTIFICATION (RFID)

TANG YEE KIN

Bachelor of Electronics Engineering Technology (Industrial Electronics) With Honours

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A project report submitted
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SITI HARYANTI BINTI HJ HAIROL ANUAR
Pensyarah
Fakulti Teknologi Dan Kejuruteraan Elektronik Dan Komputer (FTKEK)
Universiti Teknikal Malaysia Melaka (UTeM)

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DEDICATION

To my beloved father, Tang Wai Hong, and mother, Chin Kin Foong,

Who always there for me and support me to finish my report.

To my friends that always give me idea in order to complete this report.

To my great supervisor,

Madam Siti Haryanti binti Hairol Anuar who encouraged and guide me to finish this report.

ABTRACT

Nowadays, we see crowds in supermarkets every evening and night. This is exacerbated when there are New Year's festivals and big deals nearby. Modern people buy a lot of things and put them in the shopping cart. When they were done, they formed a long line and only paid for the purchase. This is because the cashier is too busy scanning items one by one via barcode scanning.

This project proposes a plan to solve this problem. By using radio frequency identification technology (RFID) in the shopping cart, the time for customers to prepare their bills for payment and the waiting time for customers to pay their bills can be reduced, and customers can know the total number of items to manage their purchases and budget. To realize this supermarket's full shopping cart should be equipped with RFID readers with digital displays, and all items should be equipped with RFID tags. When customers put any item into their shopping cart, its label will be read and recognized naturally, and the item name and price will be displayed on the display. In this way, the fee is added to the absolute bill. Subsequently, it should be possible to bill in the cart itself, saving the customer a lot of time.

ABSTRAK

Pada masa kini, kita melihat orang ramai di pasar raya setiap petang dan malam. Keadaan ini bertambah buruk apabila terdapat perayaan Tahun Baru dan tawaran besar berdekatan. Orang moden membeli banyak barang dan memasukkannya ke dalam troli beli-belah. Apabila mereka selesai, mereka membentuk barisan panjang dan hanya membayar pembelian. Ini kerana juruwang terlalu sibuk mengimbas barang satu persatu melalui imbasan kod bar. Projek ini mencadangkan rancangan untuk menyelesaikan masalah ini. Dengan menggunakan teknologi pengenalan frekuensi radio (RFID) dalam troli beli-belah, masa untuk pelanggan menyediakan bil mereka untuk pembayaran dan masa menunggu untuk pelanggan membayar bil mereka dapat dikurangkan, dan pelanggan boleh mengetahui jumlah item untuk menguruskan mereka. pembelian dan bajet. Untuk merealisasikan troli beli-belah penuh pasar raya ini harus dilengkapi dengan pembaca RFID dengan paparan digital, dan semua item harus dilengkapi dengan tag RFID. Apabila pelanggan meletakkan sebarang item ke dalam troli beli-belah mereka, labelnya akan dibaca dan dikenali secara semula jadi, dan nama item serta harga akan dipaparkan pada paparan. Dengan cara ini, yuran ditambah pada bil mutlak. Selepas itu, anda boleh membuat bil dalam troli itu sendiri, menjimatkan banyak masa pelanggan.

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My deepest gratitude goes to my parents, parents in-law, and family members for their love and prayer during the period of my study period. A special mention is also due to my supervisor for the continuous motivation and understanding.

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INTRODUCTION

1.1 Project Background

In the contemporary shopping landscape, customers commonly rely on shopping carts to transport items while navigating a supermarket before proceeding to the checkout counter. This practice has gained widespread popularity, offering customers the convenience of not having to physically carry a multitude of items, thereby facilitating the purchase of more, including larger and heavier items, in a single shopping excursion. Particularly during peak hours or festive seasons, there is a notable surge in the number of people visiting supermarkets.

Under the constraints of previous technologies, where barcodes were utilized and items had to be scanned individually, the checkout process was time-consuming, leading to increasingly lengthy queues. The advent of current technology, specifically the integration of the radio frequency identification (RFID) system on shopping carts, has proven to be adaptable to various store formats and supermarket setups. The implementation of RFID effectively addresses the issue of extended queues, bringing satisfaction to customers by minimizing wait times simply pay and proceed with the purchase. Additionally, the incorporation of a display screen on the shopping cart, facilitated by RFID technology, empowers buyers to be cognizant of their purchase budget, enhancing the overall shopping experience.

1.2 Problem Statement

The primary issues are customers being unaware of the total cost of their supermarket purchases. Additionally, upon reaching the payment counter, many customers face challenges such as queuing prolonged waiting times. To address these concerns, I plan to create an automated system known as a Smart Shopping Cart. The objective is to inform customers about their expenses beforehand and streamline the payment process, thereby reducing waiting times.

1.3 Objectives

Based on the problem statement above, there are attainable goals. The objectives are:

a) To develop a shop cart system that makes it easy for customers to buy goods according to their budget.

b) To develop an RFID system to detect and calculate the "shopping items" to reduce the customer waiting time in long queues at the payment counter.

c) To evaluate the performance of a smart shop cart using RFID.

1.4 Scope

The RFID shop cart is meticulously crafted to provide customers with insight into their purchase budget and alleviate the challenges associated with long queues and extended waiting times during the payment process at the counter.

The scopes and limits to this research are:

a) The smart shop cart can detect the item from the customers buying.

b) The smart shop cart can display the total amount from the customer buying.

c) The smart shop cart can reduce time used during at payment counter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Within the dynamic landscape of the retail industry, technology stands as a pivotal element in shaping the shopping experience. The evolution of modern shopping has given rise to a multi-dimensional ecology, skillfully blending the physical realm with the digital domain, transcending the confines of traditional brick-and-mortar stores. Technological advancements have played a transformative role, enabling a seamless integration that has revolutionized how consumers navigate, choose, and acquire goods.

Following the exploration of the preceding subtopics, this report will incorporate selected research papers to provide readers with a thorough comprehension of the knowledge, perceptions, and conclusions relevant to the investigated topic or issue. The inclusion of various research works serves the purpose of expanding our perspective, evaluating the quality of existing research, substantiating our claims, pinpointing gaps in the current knowledge, proposing avenues for further research, and fostering critical thinking on the specified research topics. Through this comparative analysis of research, we aim to enhance the depth and breadth of understanding surrounding the subject matter.

This chapter initiates with an overview of the project, centered around the development of a smart shopping cart. Comprehensive coverage will be provided for all the components and elements integral to the realization of this project. Subsequently, several relevant studies pertaining to this project will be incorporated into the report, aiming to enlighten the community about the technologies underpinning this initiative. Notable among these studies are those exploring Radio

Frequency Identification (RFID) and microcontroller technologies, offering insights into their applications and relevance within the context of the smart shopping cart project .

2.2 Past Related Project Research

2.2.1 Concept of RFID shopping cart

An RFID shopping cart is equipped with an RFID system, involving the attachment of an RFID reader to the cart and RFID tags to individual items. Both emit radio waves, and as the reader comes into proximity with tagged items, their radio waves interact and respond based on the information stored in the supermarket's database. The results are then transmitted to the RFID program. This system facilitates real-time calculation and display of the total amount to the user, enhancing their awareness of their budget. Moreover, it expedites the checkout process by allowing the cashier to scan items collectively as the customer places them in the cart, eliminating the need for individual scanning. In contrast to the current system, where the total purchase amount remains unknown until the buyer reaches the billing counter, the RFID shopping cart introduces a more efficient and user-friendly approach to the shopping experience. [1].

2.2.2 Define RFID Technology

Radio-Frequency Identification (RFID) is a technology that utilizes radio wave readers to capture data encoded in tags. Similar to barcodes, RFID involves capturing data from tags and storing it in a database. The distinctive feature of RFID lies in its use of electromagnetic fields to automatically identify, and track tags attached to objects. RFID tags are comprised of miniature radio transponders. When a tag is

activated by an electromagnetic interrogation pulse emitted from an RFID reader device, the tag responds by transmitting digital data back to the reader.

An RFID system comprises two fundamental components: tags and readers. RFID tags are equipped with embedded transmitters and receivers. The tag's RFID component consists of a microchip for storing and processing information, along with an antenna responsible for receiving and transmitting signals. Each tag carries a specific serial number corresponding to a particular object. To access the information encoded on the tag, an interrogator or reader, equipped with a two-way radio transmitter-receiver, uses an antenna to send a signal to the tag. The tag responds by transmitting information stored in its memory bank, which is then relayed to the R. FID program by the interrogator. Figure 2.1 below illustrates a simple RFID theory.

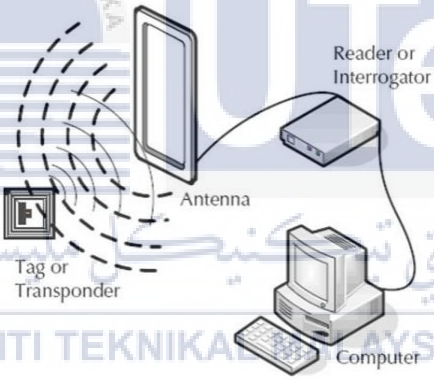

Figure 2.1 RFID theory

The RFID reader serves as the central processing unit in an RFID system, playing a crucial role in its functionality. Also referred to as interrogators, RFID readers are devices designed to emit and receive radio waves, facilitating communication with RFID tags. Two primary types of RFID readers exist: fixed RFID readers and mobile RFID readers.

Fixed RFID Readers:

- **Stationary Readers:** These readers remain in a fixed location, commonly mounted on walls, tables, doorways, or other permanent fixtures.
- **Indtegrated Readers:** A subset of fixed readers, integrated RFID readers have a built-in antenna and often include an additional antenna port for connecting an external antenna. They are typically aesthetically pleasing and suitable for indoor applications with lower traffic of tagged items.

Mobile RFID Readers:

- **Mobile Computing Device:** Handheld devices with an onboard computer, capable of reading RFID tags and communicating with a host or smart device.
- **Sleds:** These mobile RFID readers use Bluetooth or an auxiliary connection to a smart device or tablet.

Fixed RFID readers usually feature external antenna ports that can support one to eight different antennas. With the addition of a multiplexer, some readers can connect up to 32 RFID antennas. The choice of the number of antennas connected to a reader depends on the coverage area required for the RFID application. For instance, desktop applications with small coverage areas may only need a single antenna, while applications like race timing at the finish line, requiring larger coverage areas, often necessitate multiple antennas to achieve the required coverage.

Figure 2.2 Example of RFID readers

In its most basic configuration, an RFID tag comprises two essential components: an antenna responsible for sending and receiving signals, and an RFID chip (or integrated circuit, IC) that stores the tag's ID and additional information. RFID tags are affixed to items to enable their tracking through the use of RFID readers and antennas. These tags transmit data related to an item to an antenna/reader combination via radio waves.

Crucially, RFID tags typically do not possess batteries (unless specified as active or BAP tags). Instead, they draw power from the radio waves generated by the RFID reader. Upon receiving a transmission from the reader/antenna, energy is transferred to the chip within the tag via its internal antenna. This energy activation prompts the chip to modulate the energy with the relevant information, transmitting the signal back to the antenna reader.

Each RFID chip incorporates four memory banks - EPC, TID, User, and Reserved. These banks store information about the tagged item or details pertinent to the tag itself, depending on the specific bank and its purpose. The diverse array of RFID tags encompasses hundreds of variations in terms of shape, size, features, and options, tailored to different environments, surface materials, and applications.

Figure 2.3: Example of RFID tags

Advantages & Disadvantages of RFID Technology

RFID is one of the most exciting technologies, but it also has some advantages and disadvantages. Table 2.1 below lists the advantages and disadvantages of RFID technology.

Table 2.1 Advantages & Disadvantages of RFID technology

Advantages	Disadvantages
High Respond Time	Inference
Multipurpose and vary in format	High cost
Reduce manpower	Some material might create signal problem
High accuracy	Overhead reading
Complex duplication	
Multiple reading	

2.2.3 Microcontroller

Microcontrollers are programmable digital processors equipped with essential peripherals. The term "microcontrollers" seems to be a repetition; it could be corrected to "microcomputers" or "microprocessors." Both microcontrollers and microprocessors are intricate sequential digital circuits designed to execute tasks according to a programmed set of instructions. In some instances, the analog input/output interface is an integral part of the microcontroller circuit, creating a mixed-mode (analog and digital) system. A microcontroller can be likened to a Swiss knife, consolidating multiple functions within the same integrated circuit.

The design of a microcontroller encompasses all the essential functions of a microprocessor's central processing unit (CPU), including the Arithmetic Logic Unit (ALU), Program Counter (PC), Stack Pointer (SP), and registers. Additionally, it incorporates other functions necessary to constitute a complete computer, such as Read-Only Memory (ROM), Random Access Memory (RAM), parallel and serial input/output (I/O), counters, and clock circuits. Similar to a microprocessor, a microcontroller is a versatile device, but its primary purpose is to read data, perform limited calculations on that data, and control its environment based on those calculations.

The primary objective of a microcontroller is to govern the operation of a machine using a predetermined program stored in ROM, which remains unchanged throughout the system's lifespan.

Arduino

Raspberry Pi

Figure 2.4 Examples of microcontroller

2.2.4 Billing System

In the proposed system, after a customer makes a purchase, the process involves scanning the RFID tag of each product using an RFID reader before placing it into the shopping cart. Upon scanning a product's RFID tag, the system reads and stores the price of the product in its memory. If a match is found, the system displays the product's name and cost on the LCD screen. Unwanted products are not added to the bill. If a customer removes any unwanted product from the shopping cart, the count in the bill decreases, and the total amount is recalculated accordingly. Utilizing RFID tags ensures a quicker scanning process with no manual intervention.

The controller is responsible for displaying the product name and price on the LCD screen of the smart cart. Customers can obtain billing information at the packaging section based on their cart identification number. The automated billing system will be implemented using vision-based technology. Visual Basic, designed to cater to the needs of novice programmers, has seen improvements in performance due to faster computers and native code compilation.

This system aims to streamline the checkout process, enhance efficiency, and provide customers with an automated and convenient billing experience.

2.3 Prototype of Smart Shopping Cart Using Arduino and RFID

The design is strategically developed to address various scenarios mentioned earlier. As the primary objective is to create an intelligent shopping system, each shopping cart is equipped with an RFID reader, ensuring automation [1]. The design also incorporates a vehicle-mounted camera

barcode scanner to complement this automation. For the RFID reader to ascertain the price of a product, it must possess corresponding information for all products. In our design, this database is stored in the base station, which serves as the payment counter [3].

The database contains crucial information for each product, including the barcode, name, price, and weight. This comprehensive dataset allows the system to accurately determine the price of scanned items. Additionally, the weight attribute is chosen as an additional measure to verify product identification, serving as a check against fraudulent behavior [4].

By combining RFID technology, barcode scanning, and a robust product database, the design aims to create a smart shopping system that not only automates the checkout process but also incorporates checks and balances to enhance security and accuracy during the shopping experience.

Figure 2.5 Prototype of Smart Shopping Cart

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter serves as a thorough overview of the project process, detailing the methodology employed throughout the development stages. Its purpose is to furnish comprehensive information and validation regarding the implementation of the Smart Shop Cart.

The process of designing and developing the project involves the utilization of hardware components. These technologies are strategically applied to create adaptive mechanisms and components for smart shopping carts, tailored for everyday use. The primary goal is to optimize the shopping experience, improve inventory management, and enhance operational efficiency for both customers and personnel.

In the system envisioned, customers will interact with the smart shopping cart by scanning RFID tags using an RFID reader dedicated to the project. This feature enables customers to view the items through RFID scans, contributing to a more seamless and efficient shopping experience while also reducing wait times at checkout counters. The integration of RFID technology aims to streamline the entire shopping process, offering benefits in terms of convenience, speed, and enhanced inventory tracking.

3.2 Project Workflow

The project workflow consists of the sequence of subsequent tasks required to develop a working prototype. Figure 3.1 gives a concrete description of the tasks involved in the workflow.

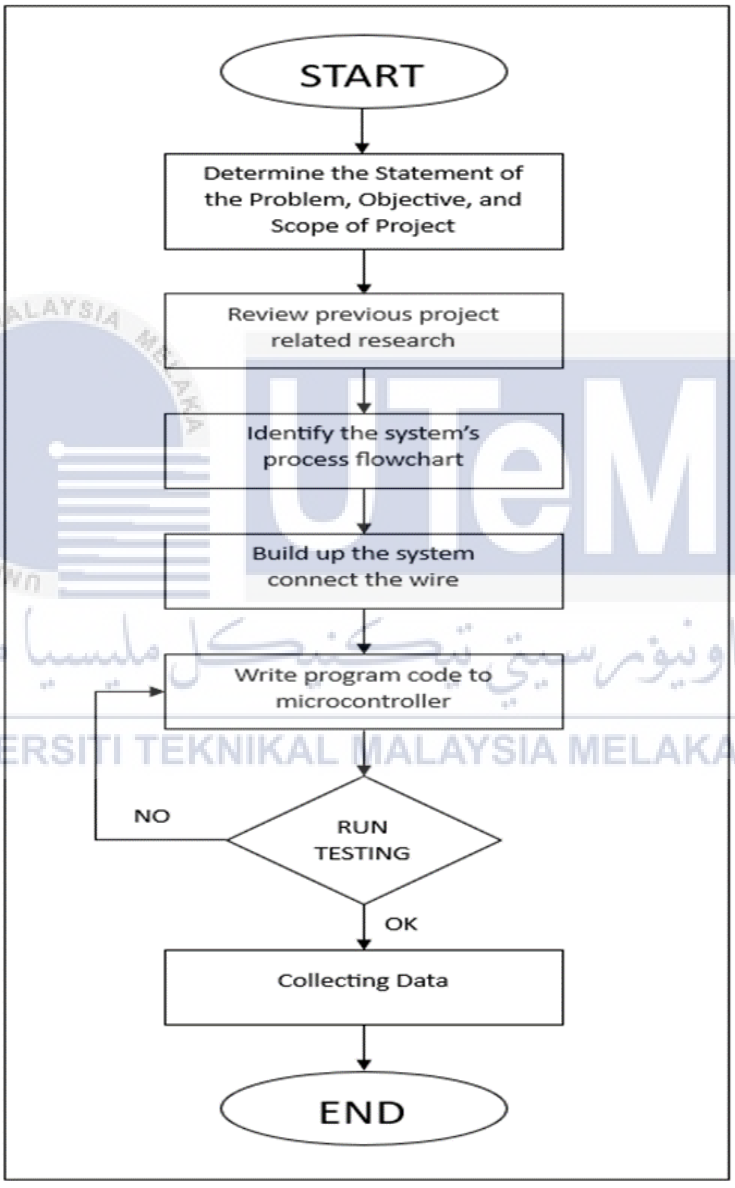

Figure 3.1: Project Workflow

3.3 Flowchart of the System

The flowchart summarizes the smart shop cart system process.

1. **Data Collection and Calculation:**
    - Arduino collects data from the RFID reader (RC522).
    - The collected data is used to calculate the total amount of the purchase.
2. **Display on LCD:**
    - The calculated total is displayed on the LCD screen of the smart shopping cart.
3. **User Interaction:**
    - When the user presses the Pay Button:
    - Arduino generates an invoice.
    - The invoice is transmitted to ESP8266.
4. **Invoice Transmission:**
    - ESP8266, once connected to the internet:
    - Receives the invoice from Arduino.
    - Sends the data to the central System.
5. **System Processing:**
    - The central System processes the received data.
    - It waits for a Paid Signal.
6. **Payment Reminder**
    - After processing, the System sends a reminder to the customer to make the payment at the designated payment counter.

7. Payment Confirmation:

- Once the payment is made and a Paid Signal is detected:
- The System acknowledges the payment.

This flowchart illustrates a seamless process where data is collected, calculations are made, and an invoice is generated based on user interaction. The integration of Arduino, RFID reader, LCD, ESP8266, and the central System ensures a streamlined and automated experience for both customers and the operational staff at the payment counter.

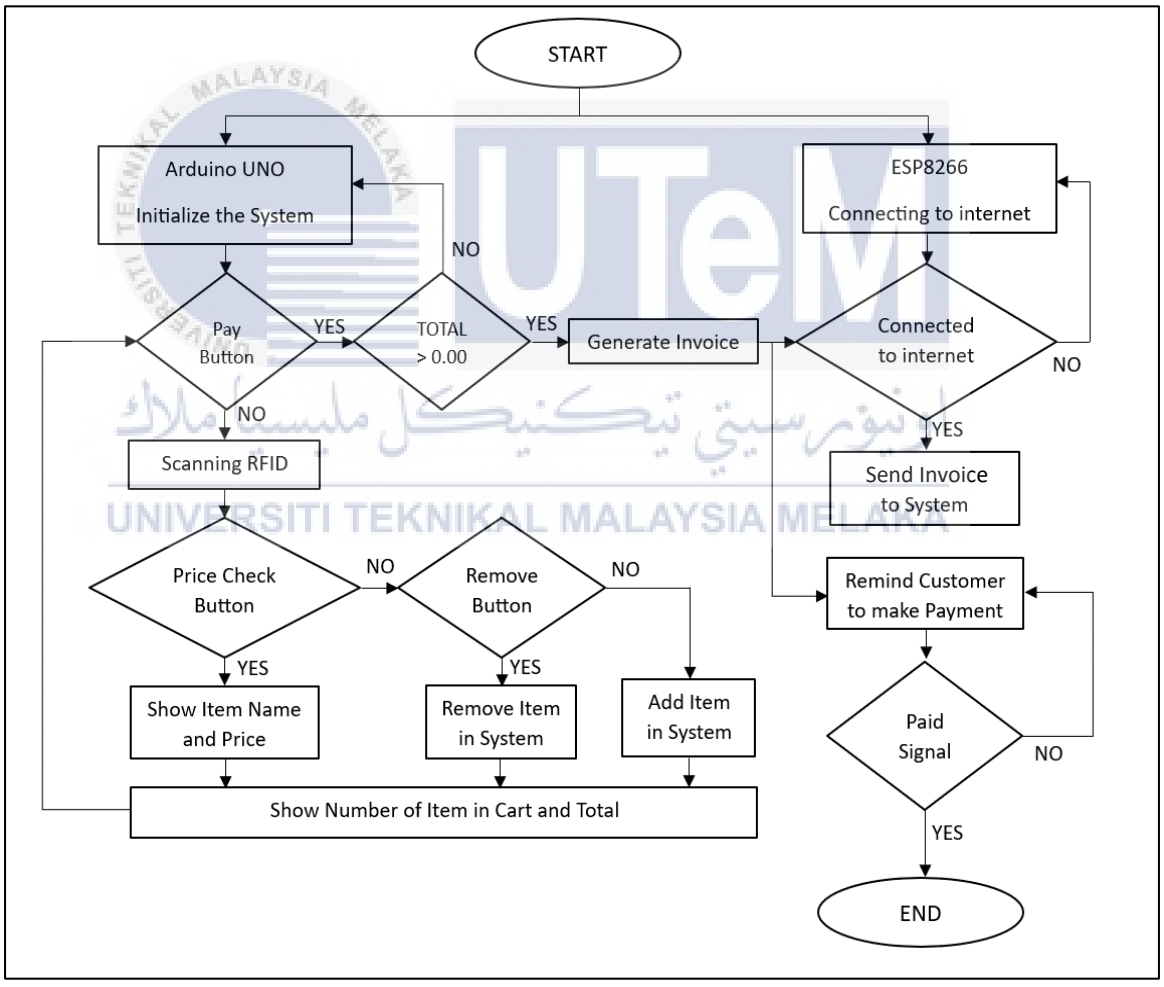

Figure 3.2 shows the overall process flow.

3.4 Gantt Chart

Gantt charts are used to schedule appropriate time frames for all project workflow tasks. Figure 3.3 shows the Gantt chart PSM 2. Event scheduling is important to avoid unnecessary delays and ensure projects are completed on time. Nonetheless, planning and scheduling of events can increase productivity.

Figure 3.3 Gantt chart of PSM 2

3.5 Component of the Project

3.5.1 Arduino UNO board

The main process will be done by Arduino UNO board. Arduino is being used in this project since it is an open-source electronics creation platform, Arduino offers a free, flexible, and user-friendly hardware and software environment for creators and developers. The board is equipped with digital and analog input/output (I/O) pins, fostering connections to various expansion boards (shields) and circuits. Boasting 14 digital I/O pins, with six supporting PWM output, and an additional 6 analog I/O pins, the board offers adaptability in interfacing.

Programmatic functionalities are realized through the Arduino IDE (Integrated Development Environment), accessible via a type B USB cable. Powering options encompass a USB cable or a barrel connector, supporting voltages in the range of 7 to 20 volts, including those provided by a rectangular 9-volt battery. Additionally, the Arduino UNO can supply output voltages of 5V and 3.3V to serve as a power supply for additional modules in the project.

3.5.2 NodeMCU ESP8266

The NodeMCU (Node MicroController Unit) stands as an open-source software and hardware development environment centered on a cost-effective System-on-a-Chip (SoC) known as the ESP8266. Manufactured by Espressif Systems, the ESP8266 encompasses essential components of a computer, including a CPU, RAM, networking capabilities (WiFi), and a contemporary operating system with an accompanying software development kit (SDK). This inherent feature set positions it as an outstanding choice for a diverse array of Internet of Things (IoT) projects.

3.5.3 RC-522

The RC522 is a versatile Multi-communication RFID Module compatible with Arduino and various microcontrollers. Also recognized as MFRC-522, it utilizes an NFX semiconductor microcontroller. This module allows seamless interfacing with other microcontrollers based on SPI, I2C, and UART communication protocols. Operating at a frequency of 13.56 MHz, the RC522 serves as both a reader and writer for UID/RFID cards.

Using mutual induction, the RFID cards communicate with the module over short distances through radio frequency. This module is particularly effective in security and commercial applications where it can detect errors and issues associated with RFID tags.

The module comprises two primary types of pins: power pins and communication pins. While the device houses its microcontroller chip, it functions specifically as an RFID, and the onboard microcontroller does not make the module an independent standalone device.

3.5.4 Arduino Software (IDE)

The Arduino Integrated Development Environment (IDE), also known as Arduino Software, encompasses a comprehensive set of features to facilitate code development for Arduino hardware. It includes a text editor for code composition, a message area for feedback, a text console for communication, a toolbar housing common functions, and various menus. This IDE establishes a connection with Arduino hardware for program upload and communication.

Programs authored within the Arduino IDE are referred to as sketches. These sketches are composed in the text editor and are saved with the file extension (.ino). The text editor comes equipped with functionalities such as cut/paste and search/replace features. The message area provides feedback during saving, exporting, and displays errors. The console exhibits textual output generated by the Arduino IDE, presenting comprehensive error messages and other pertinent information. The bottom right corner of the window showcases the configured board and serial port. The toolbar buttons facilitate actions like program verification, uploading, sketch management, and opening the serial monitor.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter delves into the outcomes obtained during the project's development, providing an insightful analysis of the collected data. The performance of the project is thoroughly explained, and an attachment containing the requisite data is included for comprehensive support of the project's objectives. Demonstrating the project's feasibility, this chapter showcases the tangible contributions made to the application's overall advancement.

4.2 Collection Data Analysis

4.2.1 Time taken to read RFID tag

The table presented outlines the duration required to read and display the item associated with each RFID tag. Analysis of the provided data reveals an average time of approximately 2.15 seconds for the RFID reader to successfully read an RFID tag. The time taken spans a narrow range, fluctuating between 2.1 and 2.2 seconds for the reader to complete the tag reading process.

Table 4.1.1 time taken to read RFID tag.

Tag (Item)	Number of Scan	Time Taken (second)	Avg. Time Taken (second)
1	20	43	2.15
2	20	43	2.15
3	20	44	2.2
4	20	42	2.1

4.2.2 Testing of the system with number of error reading RFID

The presented table illustrates the error rates encountered during the reading and display process of RFID tags. From the provided data, it is apparent that the percentage of reading errors falls within the range of 3% to 6%. It's noteworthy to acknowledge that external factors, including voltage fluctuations, the speed at which the tag passes by the reader, and the condition of the tag being read, could potentially influence RFID performance. These external variables should be considered when interpreting the observed error rates.

Table 4.1.2 testing of the system with number of error reading RFID.

Number of Sample	Number of Scan	Number of Error	Percentage of Error (%)
1	100	4	4 %
2	100	3	3 %
3	100	6	6 %
4	100	5	5 %

4.2.3 Time taken to generate invoices and send to system.

The presented table outlines the duration required to generate invoices and transmit them to the system, with the assumption that Telegram serves as the designated system. From the provided data, a conclusive inference can be drawn that the average time taken for invoice generation and transmission to the system is approximately 9 seconds. This substantiates the reduction in waiting time for customers at the payment counter, contributing to an expedited checkout process. It's important to note that external factors, such as internet speed and connectivity, may influence the observed time duration.

Table 4.1.3 time taken to generate invoice and send to system.

Number of Sample	Number of Item	Time Taken (second)
1	1	8
2	10	9
3	20	9
4	40	9
5	100	9

4.2.4 Accuracy of the calculation of system.

The table shows the accuracy of the calculation of the system. Based on the provided data, the accuracy of the calculation by the system is 100%.

Table 4.1.4 Accuracy of the calculation of system.

Number of Sample	Number of Item	Total calculated by System (RM)	Total calculated by Manual (RM)	Percentage of Accuracy (%)
1	6	13.10	13.10	100 %
2	20	32.80	32.80	100 %
3	30	54.80	54.80	100 %
4	40	71.00	71.00	100 %
5	141	233.00	233.00	100 %

4.3 Project Results

The Arduino UNO serves as a pivotal component in this project, operating as a microcontroller. Once the code is imported into the Arduino UNO board, it undertakes the task of reading RFID tags attached to items, storing the information in its memory, and subsequently generating an invoice. This invoice is then transmitted to ESP8266 in the form of serial data.

The ESP8266 assumes a crucial role by forwarding the generated invoice from the Arduino UNO to the system. The system, in this context represented by the Telegram app, receives and displays the results. The ensuing figures below showcase the outcomes and responses received through the Telegram app.

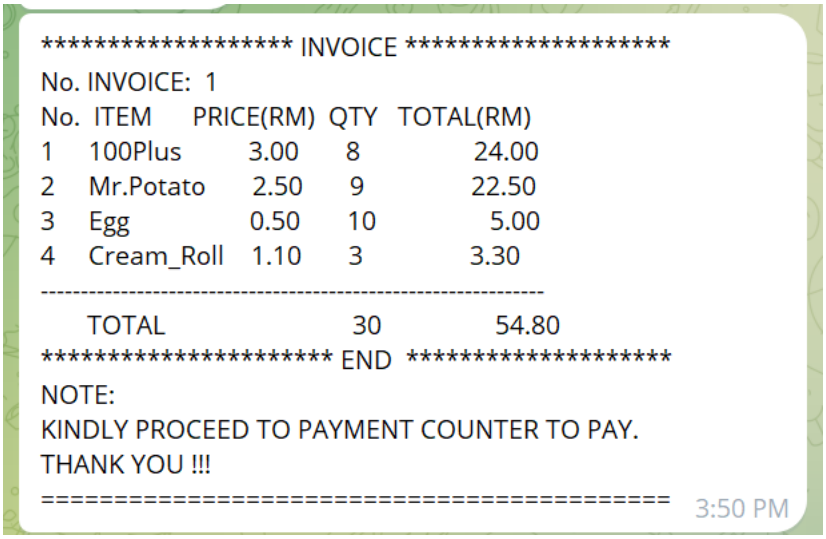

Figure 4.1 Project Result

4.4 Prototype of Project

The design is formulated to effectively tackle various scenarios outlined earlier. Given that the essence of automation is geared towards creating a smart shopping system, it mandates the incorporation of an RFID reader into every shopping cart. To ascertain the price of a product from the database, it is imperative that the RFID reader holds the pertinent information for all products.

In this design, the database, containing crucial details such as tag data, name, and price for each product, is centralized in the base station situated at the payment counter. This centralized approach ensures that every RFID reader can access the comprehensive information necessary for seamless and accurate transactions within the smart shopping system.

Figure 4.2: Prototype of Project

CHAPTER 5

CONCLUSION

5.1 Conclusion

In conclusion, the creation of a shopping cart utilizing radio frequency identification (RFID) technology for the final year project holds significant promise in furnishing users with a comprehensive overview of their purchased items. Anticipated project deliverables encompass functionalities such as item detection, total and amount calculation, and the generation of invoices. The objective is to elevate user experience by furnishing real-time billing information. To facilitate seamless communication, a wireless system is integrated into the cart, enabling the transmission of invoice details to the store's centralized database. This holistic approach seeks to revolutionize and enhance the overall shopping experience through the amalgamation of RFID technology and real-time billing functionalities.

5.2 Works for Future Improvements

In preparation for the deployment of a smart shopping cart in a real-time system, certain technical challenges warrant attention. Future improvements should be directed towards a comprehensive exploration and resolution of potential instances of consumer misuse of technology. While the current model leans towards a customer-centric design, there is room for modification to incorporate heightened security measures, should the shop owner express such a preference. Addressing these aspects in future endeavours will contribute to refining the system, aligning it with both customer expectations and the security preferences of the store proprietor.

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