GROUP DESIGN PROJECT

NMJ31903 SESSION 2023/2024

PROJECT REPORT

TITLE : SMART SHOPPING CART

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ABSTRACT

Changes in technology and what people want when they shop are making a big difference in stores. Smart Shopping Carts are part of this change. They're here to make shopping better by fixing some of the problems we face in stores. These high-tech carts are designed to make shopping easier, faster, and more personalised. So, with these smart shopping carts, stores can be more efficient, and customers can have a better experience. This project focuses on the development and implementation of a Smart Shopping Cart system that incorporates weight sensor, IoT, RFID, and barcode technologies. The Smart Shopping Cart aims to modernise the retail experience by offering consumers a convenient and efficient shopping journey while providing retailers with valuable insights to improve operations and to assess the effectiveness and feasibility of deploying the Smart Shopping Cart in real-world retail environments through user feedback and performance metrics evaluation. By analysing its impact on key performance indicators such as customer satisfaction and operational efficiency, we aim to demonstrate its potential to revolutionise the retail landscape. By analysing its impact on key performance indicators such as customer satisfaction and operational efficiency, we aim to demonstrate its potential to revolutionise the retail landscape. Through the integration of weight sensors, the Smart Shopping Cart automatically detects items placed within the cart, enhancing convenience for consumers. IoT technology enables real-time communication between the SSC and the retail environment, facilitating features such as personalised recommendations and inventory management. RFID and barcode scanning capabilities further enhance the Smart Shopping Cart's functionality by providing accurate item identification and tracking. By leveraging RFID tags and barcode labels on products, the Smart Shopping Cart can identify items as they are placed into or removed from the cart, ensuring accurate inventory data and optimising inventory management processes. In conclusion, by integrating weight sensors, IoT, RFID, and barcode technologies into the Smart Shopping Cart, we present a comprehensive solution to address key challenges in retail such as reducing checkout queues, enhancing item quantity checking, and enabling real-time price monitoring. This innovative approach not only enhances the retail experience for consumers and retailers but also contributes to the advancement of the retail industry, improving efficiency and convenience in the shopping process.

ABSTRAK

Perubahan dalam teknologi dan keinginan ketika membeli membuat perbezaan besar di dalam kedai. Troli Beli-belah Pintar adalah sebahagian daripada perubahan ini. Troli ini adalah untuk membuat pengalaman membeli lebih baik dengan memperbaiki beberapa masalah yang kita hadapi di kedai. Troli Beli-belah Pintar canggih ini direka untuk menjadikan pembelian lebih mudah, lebih cepat, dan lebih peribadi. Jadi, dengan Troli Beli-belah Pintar ini, kedai boleh menjadi lebih berkesan, dan pelanggan boleh memiliki pengalaman yang lebih baik. Projek ini memberi tumpuan kepada pembangunan dan pelaksanaan sistem Troli Beli-belah Pintar yang menggabungkan teknologi sensor berat, IoT, RFID, dan barcode. Troli Beli-belah Pintar bertujuan untuk memodenkan pengalaman membeli dengan menawarkan membeli yang mudah dan cekap kepada pengguna sambil memberikan peniaga dengan pandangan berharga untuk memperbaiki operasi. Kajian ini bertujuan untuk menilai keberkesanan dan kebolehan pelaksanaan Troli Beli-belah Pintar dalam persekitaran peruncitan sebenar melalui maklum balas pengguna dan penilaian metrik prestasi. Melalui integrasi sensor berat, Troli Beli-belah Pintar secara automatik mengesan barang yang diletakkan dalam troli, meningkatkan kemudahan untuk pengguna. Teknologi IoT membolehkan komunikasi secara masa nyata antara Troli Beli-belah Pintar dan persekitaran peruncitan, memudahkan ciri-ciri seperti cadangan peribadi dan pengurusan inventori. Kemampuan pengimbas RFID dan barcode meningkatkan fungsi Troli Beli-belah Pintar dengan menyediakan pengenalan item yang tepat dan pengesanan. Dengan memanfaatkan tag RFID dan label barcode pada produk, Troli Beli-belah Pintar dapat mengenal pasti barang-barang sebagaimana mereka diletakkan ke dalam atau dikeluarkan dari troli, memastikan data inventori yang tepat dan mengoptimumkan proses pengurusan inventori. Dengan menganalisis kesan terhadap penunjuk prestasi kunci seperti kepuasan pelanggan dan kecekapan operasi, kami bertujuan untuk menunjukkan potensinya untuk mengubah landskap peruncitan. Sebagai kesimpulan, integrasi sensor berat, IoT, RFID, dan teknologi barcode ke dalam Troli Beli-belah Pintar menawarkan penyelesaian yang menjanjikan untuk memperbaiki pengalaman peruncitan untuk kedua-dua pengguna dan peniaga. Melalui penyelidikan ini, kami bertujuan untuk menyumbang kepada kemajuan industri peruncitan dan meningkatkan kecekapan dalam proses membeli.

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APPROVAL AND DECLARATION SHEET

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has been found satisfactory in terms of the scope, quality and presentation as partial fulfilment of the requirements that are needed for the Bachelor of Engineering (Computer Engineering) in University Malaysia Perlis (UniMAP).

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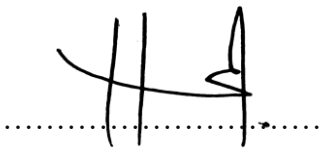

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CHAPTER 1 : INTRODUCTION

1.1 Project Background

The retail industry is undergoing rapid transformation driven by technological advancements and changing consumer expectations. Traditional shopping experiences are increasingly being supplemented, and in some cases replaced, by digital solutions that offer convenience, personalization, and efficiency. In this context, the Smart Shopping Cart emerges as a promising innovation aimed at revolutionising the retail landscape.

The idea of the Smart Shopping Cart is rooted in the desire to streamline the shopping experience for consumers while providing retailers with valuable insights to improve operations and drive profitability. By integrating cutting-edge technologies such as weight sensors, IoT, RFID, and barcode scanning capabilities, the Smart Shopping Cart aims to address various main points experienced by both consumers and retailers in traditional retail environments.

Consumer expectations for convenience and efficiency continue to rise, driving demand for solutions that simplify the shopping process. Weight sensors integrated into the Smart Shopping Cart enable automatic detection of items placed within the cart, eliminating the need for manual scanning at checkout. This not only saves time for consumers but also minimises obstacles in the shopping journey, leading to a more seamless experience.

Meanwhile, retailers face challenges in managing inventory effectively, optimising shelf space, and understanding consumer behaviour. The Smart Shopping Cart addresses these challenges by leveraging RFID and barcode technologies to provide real-time inventory tracking and accurate item identification. This enables retailers to optimise inventory management processes, reduce instances of stockouts or overstocking, and improve overall operational efficiency.

Furthermore, the integration of IoT technology into the Smart Shopping Cart enables connectivity and communication between the cart and the retail environment. This opens up opportunities for features such as personalised recommendations based on consumer preferences and real-time promotions tailored to individual shoppers. By leveraging data insights from the Smart Shopping Cart, retailers can enhance customer engagement and drive sales revenue.

Overall, the Smart Shopping Cart represents a promising solution to modernise the retail experience, offering convenience, efficiency, and personalization for consumers while providing retailers with actionable insights to improve operations and drive business growth. Through this project, we aim to explore the potential of the Smart Shopping Cart to revolutionise the retail industry and contribute to the ongoing evolution of the shopping experience.

Figure 1.1: Smart Cart Example

1.2 Problem Statement

The traditional shopping experience is fraught with numerous inefficiencies and frustrations. A survey has been conducted to obtain the problems of using traditional shopping carts in a supermarket. According to the survey, 22 out of 31 respondents found it difficult to track the price of items in their shopping carts while 18 out of 31 of them found it hard to track the quantity of items. Other than that, 23 respondents often experience long queues at checkout counters. The problems include long checkout queues, the inability to accurately count and track item quantities in the shopping trolley, and the lack of real-time monitoring of the total price of items in the cart. These challenges not only diminish customer satisfaction but also pose significant obstacles to retailers in managing inventory effectively. To address these critical issues, there is an urgent need for an innovative solution: a Smart Shopping Cart equipped with weight sensors, RFID technology, barcodes, and IoT capabilities.

1. Inability to Track and Monitor Item Total Quantity and Price: Customers often struggle to track and monitor the total quantity of items in their shopping carts, leading to errors in purchasing and potential overspending. By integrating weight sensors, the cart can automatically detect and record the addition and removal of items, providing real-time updates on the item quantity and price and ensuring accurate checkout transactions.

2. Inability to quickly and accurately check the prices of items while shopping: It is inconvenient to check the prices of items when using traditional shopping carts as the customers need to check the item price at a price checker machine. By integrating RFID reader and barcode scanner in smart cart, customers can instantly view the item price on the cart display. By providing real-time price information, customers can make informed purchasing decisions and track their expenses.

3. Long Checkout Queues: Usually checkout processes often result in extensive queues, causing frustration and dissatisfaction among customers. By integrating RFID technology and IoT connectivity, the Smart Shopping Cart works similar to a self-checkout

counter as it enhances customer overall satisfaction as they can self-checkout using their debit cards with the smart cart without the need to queue at the checkout counters.

By addressing these critical challenges comprehensively, the Smart Shopping Cart aims to revolutionise the retail industry, offering a seamless, efficient, and transparent shopping experience for customers while enabling retailers to optimise inventory management and streamline checkout processes. This project will involve the design, development, and testing of the Smart Shopping Cart to ensure its functionality, reliability, and adaptability to various retail environments.

1.3 Objectives

The objective of implementing the Smart Shopping Cart, incorporating weight sensors, barcodes, RFID, and IoT technologies, is to address the following key challenges in the traditional shopping experience:

1. Reduce Checkout Time: By enabling self-checkout through RFID technology and IoT connectivity, the Smart Shopping Cart aims to minimise waiting times and alleviate congestion at checkout counters, thereby enhancing customer satisfaction and improving the overall shopping experience. Assuming the average checkout process time using a traditional shopping cart is around 5 minutes as the time can be varied depending on the length of the queue at the checkout counters. Checkout time using smart cart is expected within a minute, so the checkout time is expected to be improved by 80% when using smart cart compared to conventional shopping cart.

2. Enhance Item Quantity Tracking: The Smart Shopping Cart seeks to provide customers with the ability to accurately count and track item quantities through the integration of weight sensors, ensuring that customers can manage their purchases more efficiently and make informed decisions during the shopping process. The smart cart will also alert the customers when there is any decrease in weight with a buzzer, indicating potential unauthorised removal of items.

3. Enable Real-time Price Monitoring: With the inclusion of RFID technology and IoT connectivity, the Smart Shopping Cart aims to empower customers with instant visibility into the total price of items as they are added or removed from the cart, enabling them to stay within budget and avoid overspending.

Overall, the objective of the Smart Shopping Cart is to leverage advanced technologies to address the identified challenges in the traditional shopping experience, ultimately enhancing customer satisfaction, optimising inventory management, and driving business growth for retailers.

1.4 Scope of Project

The scope of the Smart Shopping Cart project is to revolutionise the traditional retail experience by introducing an innovative and advanced shopping cart tailored to enhance convenience and efficiency for customers. This project aims to integrate various cutting-edge technologies, including weight sensors, RFID technology, barcode scanning, and IoT connectivity into the design and development of the Smart Shopping Cart prototype. The objective is to streamline the shopping process by enabling real-time tracking of items, automatic calculation of total prices, and seamless checkout experiences. The scope encompasses both hardware and software implementations, involving the design, development, and integration of the physical cart components as well as the creation of user-friendly interfaces and backend systems. The development of the system covers :

1.4.1 Hardware

Table 1.1 Function of hardware components

Components	Function
Load Cell Weight Sensor	To weigh products and determine the number of products in the cart. Each load cell can support up to 50kg.
HX711 amplifier	Used to amplify the signal from load cell
MFRC522 RFID Scanner	Used to scan RFID tag or card. It has a scanning distance of approximately 5 cm.
GM65 Barcode Reader	Used to scan barcodes or QR codes on products.
ESP32 Microcontroller	An affordable microcontroller with WiFi and bluetooth capabilities.

16x2 LCD with I2C module	To display product details and the total price.
Active Buzzer	Generate an audible sound to notify the user
	that the product has been scanned.
Push Button	Used to switch between scanning and payment modes
830 holes breadboards	Used for building a temporary circuit for testing.
Jumper Wires	To connect hardwares or components to microcontrollers.
Rechargeable Power Bank	Used to power the smart shopping cart.

1.4.2 Software

Table 1.2 Function of software

Software	Function
Arduino IDE	Software platform used to program microcontroller boards.

CHAPTER 2 : METHODOLOGY

2.1 Design Complexity

Our smart shopping cart is designed to ease the obstacles and inconvenience faced by customers in supermarkets. It encompasses a range of features and technologies such as RFID, barcode and IoT that work together to enhance the shopping experience. Our project integrates various sensors in order to revolutionise the traditional shopping experience by solving problems encountered by customers. Integration of weight sensors, barcode, RFID technology and IoT connectivity enable customers to easily monitor the item quantities and total price in real-time. The integrated RFID technology of the self-checkout feature streamlines the checkout process, significantly reducing wait times and mitigating the problems of having long checkout queues at the traditional checkout counters. In terms of software design, we have developed a user-friendly website interface that enables customers to track and manage the details of items in their shopping cart in real-time by communicating with ESP32 microcontroller. This communication protocol ensures that customers have accurate and up-to-date information on their purchases throughout their shopping journey.

In terms of hardware design, our solution integrates an array of components, including RFID scanner, barcode reader, load cells with HX711 amplifier, push button, buzzer, LCD with I2C module and a power bank which are seamlessly interfaced with the central processing unit, embodied by the ESP32. RFID scanners and barcode readers enhance the cart's functionality. These scanning technologies allow customers to easily add and remove products from their carts, streamlining the shopping process and providing a consistent experience. The seamless integration of these scanning mechanisms improves the accuracy and speed of item tracking in the cart. A push button feature incorporated into the smart cart allows customers to seamlessly switch between shopping mode and payment mode. This intuitive functionality simplifies the checkout process, providing customers with the flexibility to transition between different stages of their shopping journey with ease.

To enhance user feedback and interaction, a buzzer acts as a notification system, alerting customers when an item is added or removed from the cart. The inclusion of load cells with HX711 amplifiers enhances the cart's capability to detect weight differences accurately. This technology enables the cart to precisely identify additions or removals of items based on weight changes, providing customers with real-time feedback on the contents of their cart. A 16x2 LCD with I2C module is used as a display to show the current status of the smart cart, product details in cart and prompt customers such as to add, remove, or scan products.

All these components are interconnected to the ESP32 microcontroller, ensuring a cohesive and integrated system that optimises the efficiency, accuracy, and user experience of the smart shopping cart.

2.1.1 Circuit Diagram

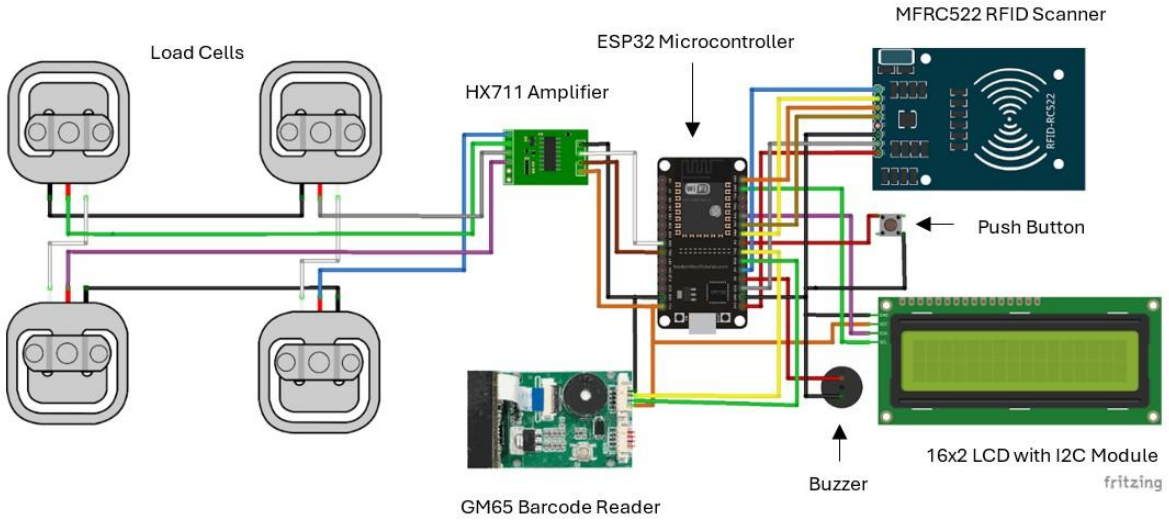

Figure 2.1: Circuit Diagram of All Components and Sensors Connected to ESP32 Board

The middle wires of the 4 load cells are connected to the HX711 amplifier. Bottom right, upper left, upper right, and bottom left of load cells are connected to E+, E-, A-, and A+ pin of the HX711 amplifier respectively. DT and SCK of the HX711 amplifier are connected to pins D25 and D26 of ESP32 respectively. 5V, GND, TX and RX of the barcode reader are connected to pins VIN, GND, RX and TX of ESP32 respectively. Positive leg of the buzzer is connected to pin D2 of ESP32 while the negative leg is connected to GND. One leg of the push button is connected to pin D5 of ESP32 and another diagonal leg is connected to GND. VCC, GND, SDA and SCL of LCD are connected to pins VIN, GND, D21 and D22 of ESP32 respectively. Finally, SDA, SCK, MOSI, MISO, GND, RST, and 3.3V are connected to pins D4, D18, D23, D19, GND, D15, and 3.3V of ESP32 respectively.

2.1.2 Block Diagram

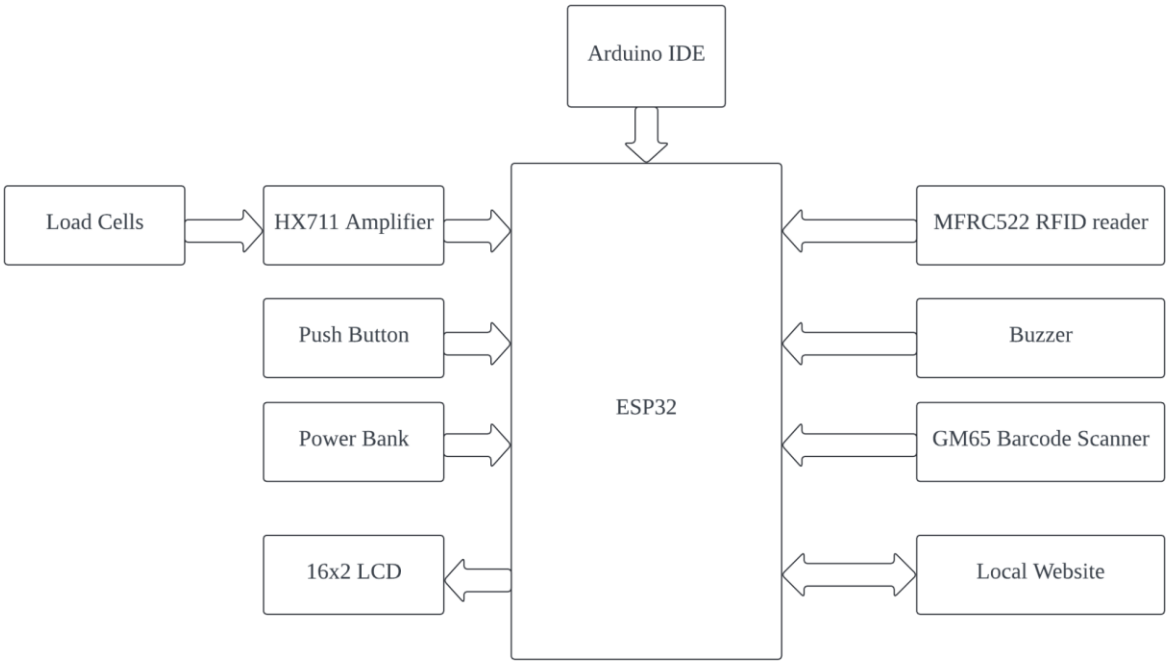

Figure 2.2 Block Diagram of Smart Shopping Cart System

From the block diagram above, the ESP32 microcontroller is powered by a power bank, which distributes the voltage to the other components connected to ESP32 to operate. Arduino IDE platform is used to program code, compile and upload into the ESP32 microcontroller so ESP32 could carry out operations or instructions stored in the program and interface with other components and sensors whenever there is power supply to the board. Load cells read the weight of items in cart then transmit signal to ESP32 through HX711 amplifier because the original signal sent from load cells is too small to detect by microcontroller. ESP32 will read the signal when the push button is pressed. ESP32 will read and compare input ID sent from RFID reader and barcode scanner with preset ID to determine which product is scanned. Buzzer will only buzz when there is any signal sent from ESP32. Connection between ESP32 and the website is bidirectional because when there is addition or removal of products, the website will update the products. Meanwhile, when the user presses Yes or No button on the website, ESP32 will take predefined action. LCD will only display prompt or item details when ESP32 sends a signal to it.

2.2 Design Flow and Process

2.2.1 Flowchart

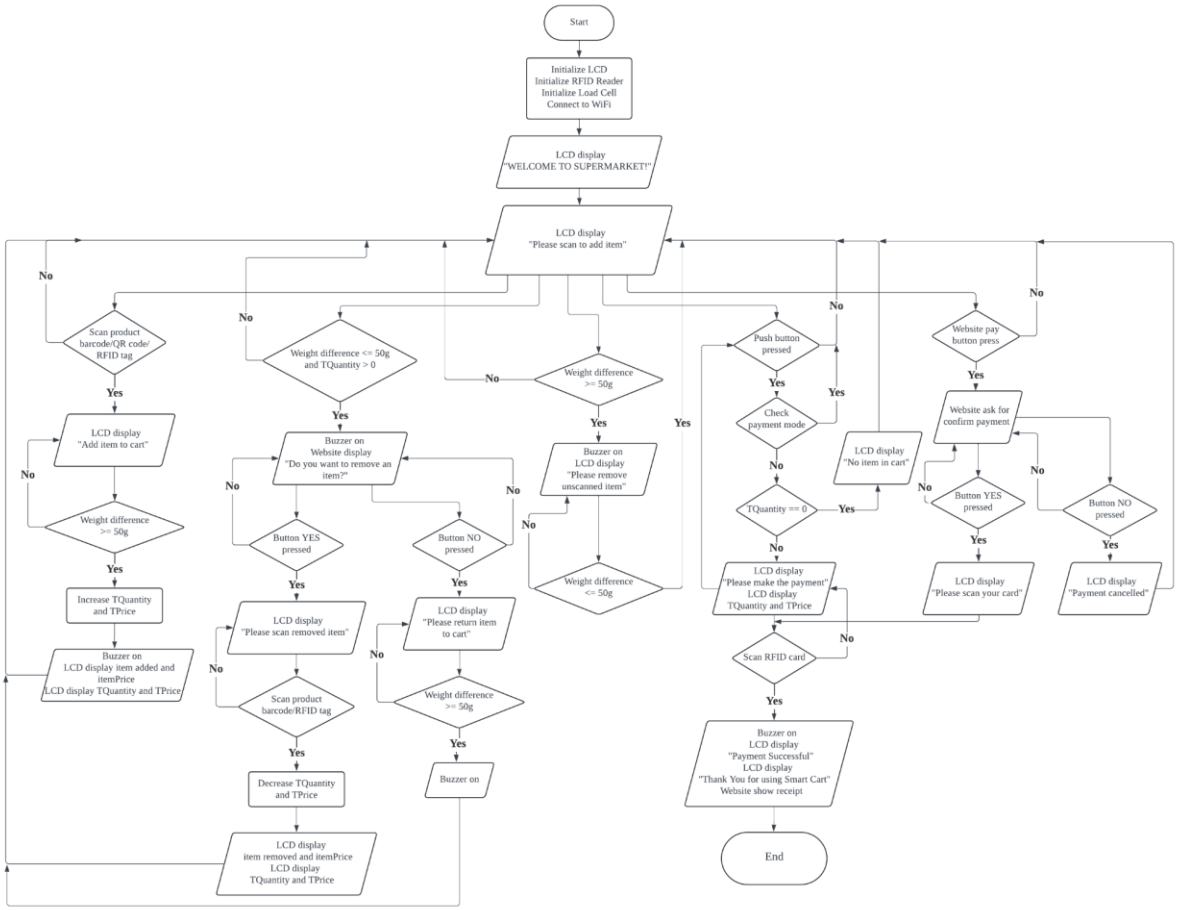

Figure 2.3: Flowchart of the Smart Shopping Cart System

The smart shopping cart system starts by initializing the necessary hardware components: the LCD, RFID reader, load cell, and connecting to WiFi. Once initialized, the LCD displays a welcome message: "WELCOME TO SUPERMARKET!". Then, the system prompts the user to scan an item to add it to the cart with the message "Please scan to add item".

Upon scanning a barcode, QR code, or RFID tag from a product, the LCD will prompt the user to add the product to the cart. The system then checks if the weight difference after adding the item is at least 50 grams. If the weight difference meets or exceeds 50 grams, the system increases the total quantity (TQuantity) and total price (TPrice) depending on the product added to the cart. A buzzer buzz to confirm the addition, and the LCD updates to show

the new TQuantity and TPrice. If the weight difference is less than 50 grams, the system waits until the condition is met.

The system continuously monitors the cart's weight every 4 seconds and compares the current reading with the previous reading. If the weight difference is less than or equal to 50 grams and there are items in the cart (TQuantity > 0), the system prompts the user through a website display asking, "Do you want to remove an item?". If the user presses the YES button, the system will prompt the user by displaying “Please scan removed item” on the LCD. After scanning the removed product, the system will update the total quantity and price by decreasing it depending on the removed product. If the user presses the NO button, the system prompts the user to return the product to the cart by displaying “Please return item to cart”. The system then waits for the weight difference to reflect the returned item, sounding a buzzer once the condition is met.

When the user is ready to make a payment, they can press the push button to switch to payment mode. Upon pressing the push button, the system will check whether it is in payment mode. If yes, the system will switch back to scanning mode. Otherwise, the system will check if the total quantity is equal to 0, and if so, the LCD will display “No item in cart” and return to scanning mode. If there are products in the cart when the system switches to payment mode, the LCD will display “Please make the payment”, then display the total quantity and price. At this point, the user can cancel the payment by pressing the push button again to return to scanning mode. The user will have to scan the RFID card if they want to proceed with the payment process. If the RFID card is scanned successfully, the LCD displays "Payment Successful" followed by "Thank You for using Smart Cart", and the website shows a receipt for the transaction. If the user places a product in the cart without scanning it, the system will detect an increase in weight, and prompt the user to remove the product by displaying “Please remove unscanned item”.

The user can also make the payment by pressing the pay button on the website. After the user presses the pay button on the website, the website will ask the user for confirmation with the buttons YES and NO. If button NO is pressed, the LCD displays “Payment cancelled”. If the user presses the YES button, the LCD displays “Please scan your card”.

Then the system will wait for the user to scan the RFID card to complete the payment.

2.2.2 Hardware Prototype Design

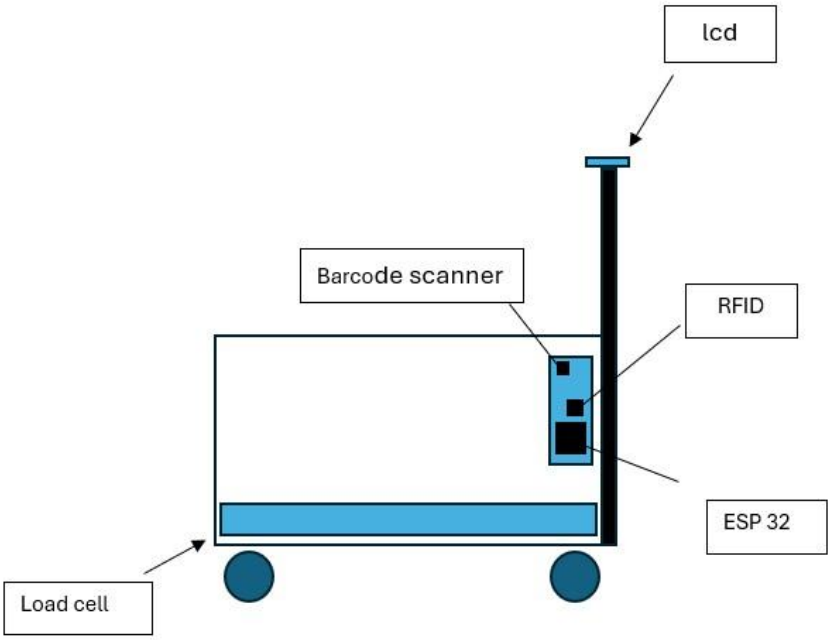

Figure 2.4: Hardware Prototype Design

The hardware prototype design for the smart trolley cart integrates several essential components to create an efficient and automated inventory management system. The design emphasizes space efficiency and portability, making it ideal for dynamic environments like retail stores or warehouses. At the base of the cart, a load cell is installed to measure the weight of items placed on it, converting the weight into an electrical signal for the control unit to process. A barcode scanner is mounted at a convenient height to read barcodes on items, ensuring each item is logged into the system with its unique identifier. Complementing this, an RFID reader is installed to scan RFID tags on items, providing an alternative method for quick and bulk item identification. The central control unit of the system is the ESP32 microcontroller, which manages data from the load cell, barcode scanner, and RFID reader.

This microcontroller processes the data and has the capability to transmit it to a central system via Wi-Fi ensuring seamless and real-time inventory management. The overall design prioritizes compactness and portability, with components stacked and soldered together to

minimize space usage and enhance durability. This thoughtful arrangement makes the smart trolley cart both practical and reliable for everyday use.

Figure 2.5: Prototype of the Smart Shopping Cart

2.2.3 Hardware requirements

This chapter will discuss the method for hardware that has been applied in this project. It covers the details of the design and the process flow of the project. Therefore, the details of each hardware component will be discussed and explained in details.

2.2.3.1 ESP32 Microcontroller

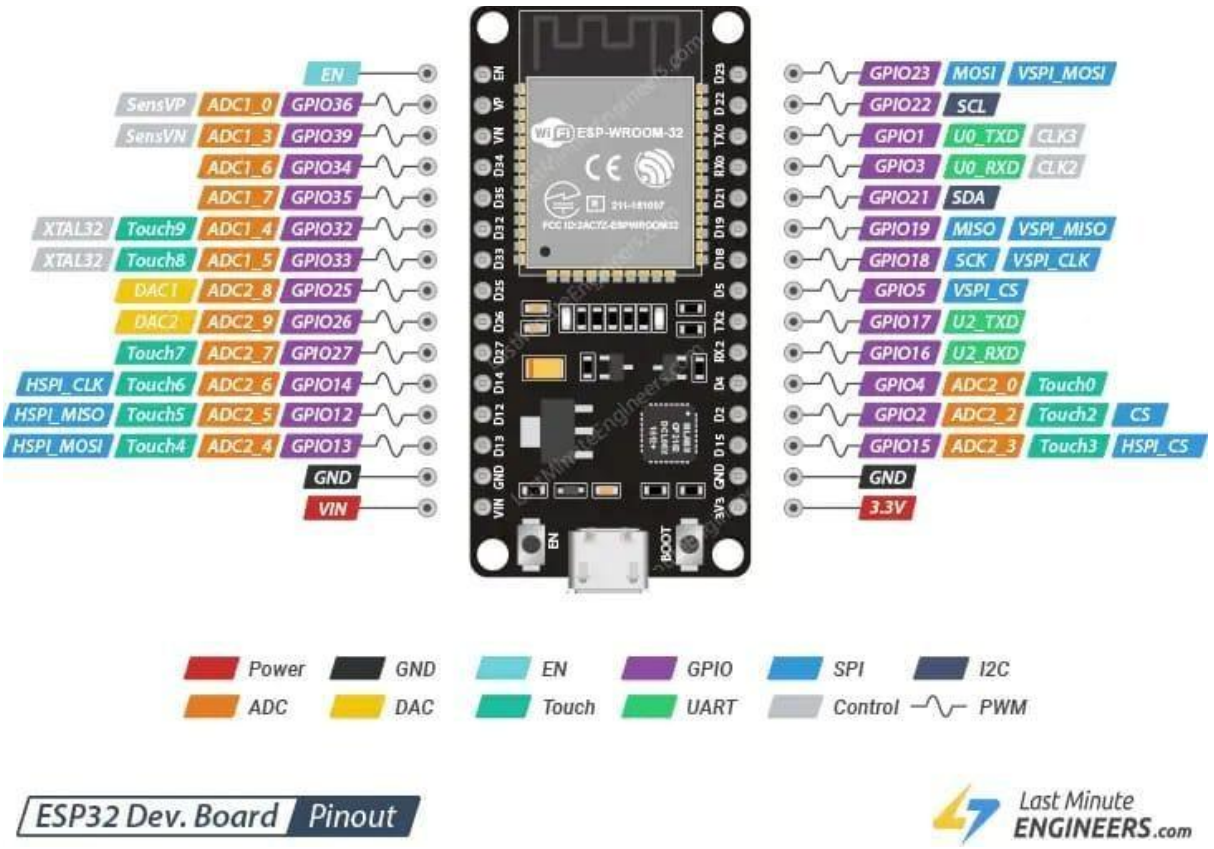

Figure 2.6: Pinout Diagram of ESP32 Microcontroller

The ESP32 is a microcontroller developed by Espressif Systems, renowned for its affordability and built-in Wi-Fi capabilities. Widely embraced for its versatility, it enables microcontrollers to seamlessly connect to Wi-Fi networks, rendering it ideal for Internet of Things (IoT) applications, including smart trolley carts. In this context, the ESP32 plays a pivotal role by providing wireless connectivity, allowing the cart to link to the internet or local networks. Through this connection, the cart can transmit and receive data, facilitating communication with other devices, servers, or cloud platforms.

Additionally, the ESP32 facilitates data acquisition from embedded sensors within the cart, which might include sensors, weight sensors, or RFID readers. This data can then be transmitted wirelessly for real-time monitoring, analysis, or further processing. Overall, the ESP32 empowers smart trolley carts by enabling seamless wireless connectivity and data

exchange, contributing to enhanced functionality and efficiency in various contexts such as retail, logistics, and inventory management.

2.2.3.2 GM65 Barcode Reader

Figure 2.7: GM65 Barcode Reader

The GM65 barcode reader is a compact and versatile scanning device designed for reading barcodes in various applications. The GM65 Barcode Reader typically includes a compact optical scanner, decoding algorithms, and interface circuitry. It can read various types of barcodes, including 1D and 2D codes, such as QR codes. The GM65 is designed to be small and lightweight, making it suitable for integration into various devices and systems where space is limited. The GM65 is capable of fast and accurate scanning, making it ideal for applications that require quick barcode reading, such as point-of-sale systems, inventory management, ticketing systems, and logistics.

It is also designed to operate efficiently, consuming minimal power, which is crucial for battery-powered devices and portable applications. The GM65 Barcode Reader usually communicates with the host system or device through standard interfaces like USB, UART (serial), or Bluetooth, depending on the specific model and configuration. It provides an efficient way to capture barcode data accurately and quickly, making it an essential component in many automated systems and processes.

2.2.3.3 Weight Sensor (50 kg Load Cell)

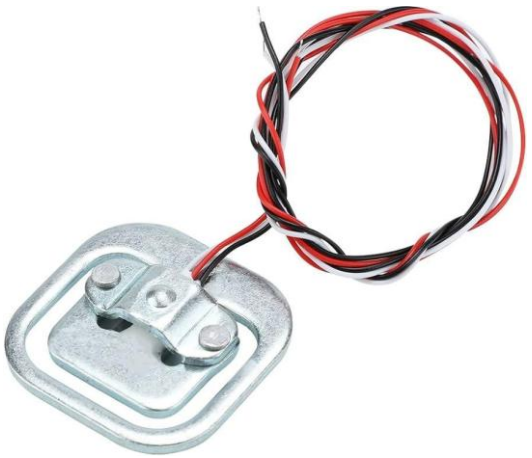

Figure 2.8: 50 kg Load Cell

The weight sensor, also known as a load cell, is a device used to measure force or weight. It converts the force exerted on it into an electrical signal, typically in the form of voltage, current, or frequency, which can then be interpreted by electronic instrumentation. The maximum weight the load cell can accurately measure without damage is 50 kg. This is a strain gauge load cell which measures deformation of the cell to determine the reading. Load cells are typically made from stainless steel or aluminium, which provides durability and resistance to environmental conditions. Weight sensors are commonly used in various applications, including industrial scales, automotive systems, medical devices, and consumer products. Below are some of the specifications of the load cell.

Table 2.1: Specifications of 50 kg Load cell

Specification	Value
Capacity	50 kg
Comprehensive Error	0.05 mv/v
Output Sensitivity	1.0 ± 0.1 mv/v
Input Resistance	1000 ± 20 Ω
Output Resistance	1000 ± 20 Ω
Operation Temperature	0 ~ +50℃

In a smart trolley cart context, a weight sensor could be integrated into the structure of the cart to measure the weight of items placed on it and compare previous and current weight readings for a certain time interval to determine the addition and removal of items in the cart. This information can be useful for inventory management, ensuring that the cart is not overloaded, and providing real-time feedback to users or the system controlling the cart. By incorporating a weight sensor, the smart trolley cart can accurately monitor the weight of its contents and possibly even automate processes such as inventory tracking or alerting users when weight thresholds are exceeded.

2.2.3.4 HX711 amplifier

Figure 2.9: HX711 amplifier

The HX711 is a precision 24-bit analog-to-digital converter (ADC) designed specifically for weighing scales and industrial control applications. It incorporates a programmable gain amplifier (PGA) to provide accurate and stable measurements of small changes in load cells' output voltages. It has an operating voltage range of 2.6V to 5.5V.

The primary function of the HX711 amplifier is to amplify the small electrical signals generated by load cells when weight is applied. These signals are typically in the millivolt range and need to be amplified before they can be accurately digitised by a microcontroller or other digital processing unit.

The HX711 includes two differential input channels that can be connected to the output of a load cell. It amplifies and digitises the differential voltage between these input channels, providing a high-resolution digital output proportional to the applied weight.

One of the key features of the HX711 is its selectable gain, which allows users to adjust the amplification factor based on the sensitivity of the load cell and the desired resolution of the weight measurements. This flexibility makes the HX711 suitable for a wide range of weighing applications, from small-scale precision measurements to larger industrial scales.

In summary, the HX711 amplifier serves as a crucial interface between load cells and digital processing units, enabling accurate and stable weight measurements in various applications. Its high resolution, programmable gain, and ease of integration make it a popular choice among designers of weighing systems and industrial control equipment.

2.2.3.5 MFRC522 RFID Scanner

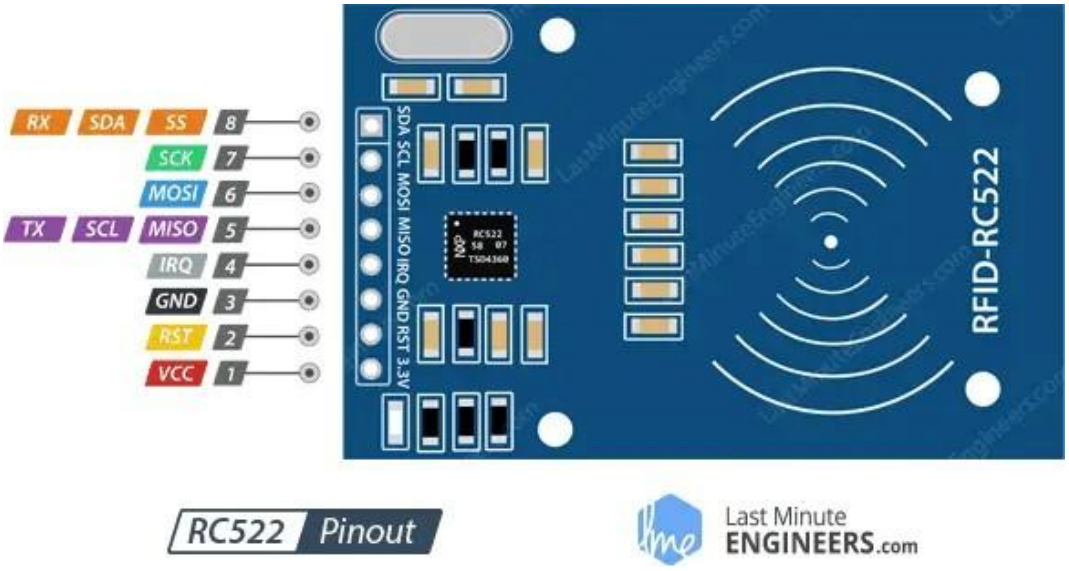

Figure 2.10: Pinout Diagram of MFRC522 RFID Scanner

The MFRC522 is a highly integrated reader/writer IC for contactless communication at 13.56 MHz. It's widely used for RFID (Radio Frequency Identification) applications. This RFID scanner supports ISO/IEC 14443A/MIFARE and NTAG protocols, making it compatible with many RFID tags and cards. It communicates with microcontrollers via SPI (Serial Peripheral Interface), UART, and I2C interfaces, offering flexibility in how it can be integrated into different systems.

The typical read range is about 5 cm, which is suitable for many applications like access control and contactless payment systems. It is designed to operate with minimal power, which is important for battery-powered applications as it has an operating voltage of 2.5V to 3.3V.

These specifications and features make the MFRC522 a versatile and efficient solution for a wide range of RFID applications, providing reliable performance in both consumer and industrial environments.

2.2.3.6 16x2 LCD with I2C module

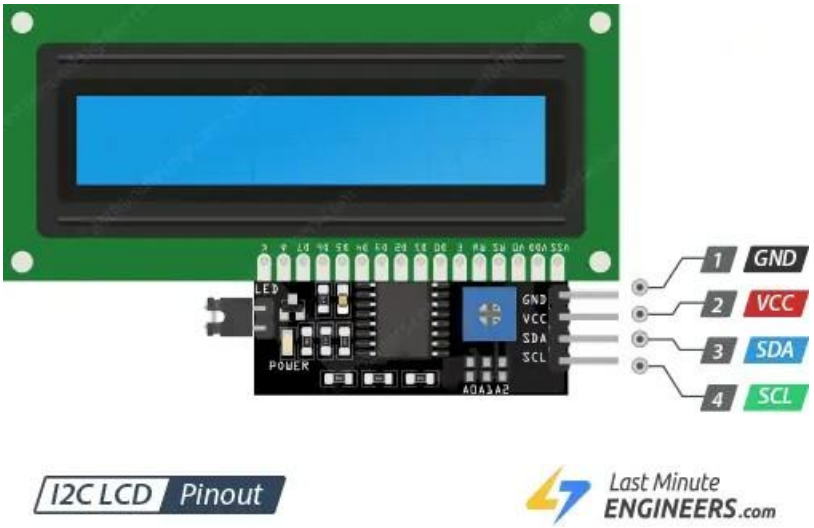

Figure 2.11: Pinout Diagram of 16x2 LCD with I2C module

A 16x2 LCD with an I2C module is a popular display solution that provides a simple and efficient way to add text output to various projects, especially those involving microcontrollers like Arduino and ESP. The "16x2" refers to a display with 16 columns and 2 rows, allowing for the display of 32 characters in total. The LCD display often includes an LED backlight for visibility in low-light conditions.

The I2C module is a small board that connects to the LCD and enables communication via the I2C protocol, reducing the number of pins required to interface with the display. Without the I2C module, the 16x2 LCD typically requires around 7-10 GPIO pins for control. With the I2C module, only 2 pins (SDA and SCL) are needed, freeing up more pins for other uses. The I2C module often includes a potentiometer to adjust the contrast of the LCD for optimal readability. I2C communication uses a two-wire interface (SDA for data and SCL for clock) to communicate with microcontrollers. In short, by using a 16x2 LCD with an I2C module, wiring and code complexity can be minimised.

2.2.3.7 Active Buzzer

Figure 2.12: Active Buzzer

An active buzzer is a type of buzzer that has an internal oscillator, which means it can generate sound on its own when a DC voltage is applied. This is in contrast to a passive buzzer, which requires an external audio signal or oscillator to produce sound. The active buzzer contains an integrated circuit that generates the required frequency to produce sound. This makes it simpler to use, as it only needs a power supply to operate. Typically, active buzzers emit a single, fixed frequency tone, which is determined by the internal oscillator. Since the active buzzer only require a DC voltage to function, it is very easy to integrate into circuits and can be directly driven by a microcontroller or battery.

2.2.3.8 Push Button

Figure 2.13: Push Button

A push button is a simple switch mechanism that is used to manually control a process or operation in electronic circuits and devices. When pressed, it makes or breaks a connection, enabling or disabling a circuit. Push buttons work through a mechanical action, where pressing the button either opens or closes an electrical circuit. Many push buttons provide tactile feedback, giving the user a physical indication that the button has been pressed. In this project, the push button is used to toggle between shopping mode and payment mode.

2.2.4 Software Requirements

This chapter will discuss the methods for software that have been applied in this project. It covers the details of the design and the process flow of the project. Therefore, the details of each software component will be discussed and explained in detail in the context of the project.

2.2.4.1 Arduino IDE

Figure 2.14: Arduino IDE Platform

The Arduino IDE (Integrated Development Environment) is a software platform used for programming microcontroller boards such as Arduino, ESP8266, and ESP32. Arduino IDE is an official software introduced by Arduino.cc, that is mainly used for writing, compiling, and uploading the code to the supported microcontroller board. The Arduino IDE can be used on various platforms, including Windows, Linux, and Mac OS. This software is open source and can be downloaded from the Arduino official website. This platform was chosen because it includes many libraries for the sensor or the microcontroller boards other than Arduino boards.

There are the steps to setup the Arduino IDE and upload the code to ESP32 board:

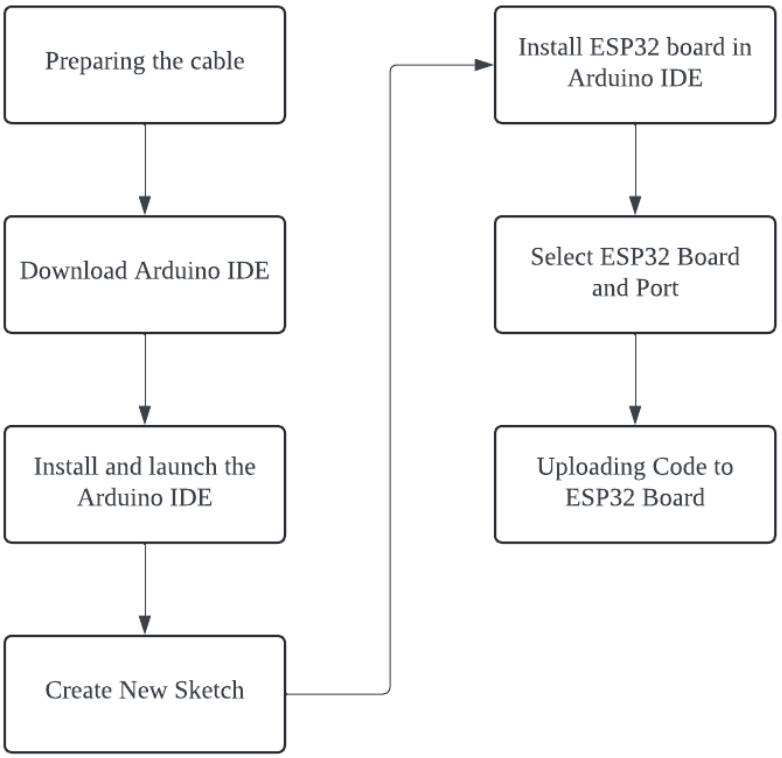

Figure 2.15: Flowchart of Arduino IDE Set Up

Step 1 - Preparing the cable

Figure 2.16: USB to micro B cable

Users need to prepare the USB to micro B cable. Since the microcontroller board used in this project is ESP32, it needs a USB micro B cable to connect the board to the computer or laptop.

Step 2 - Download Arduino IDE

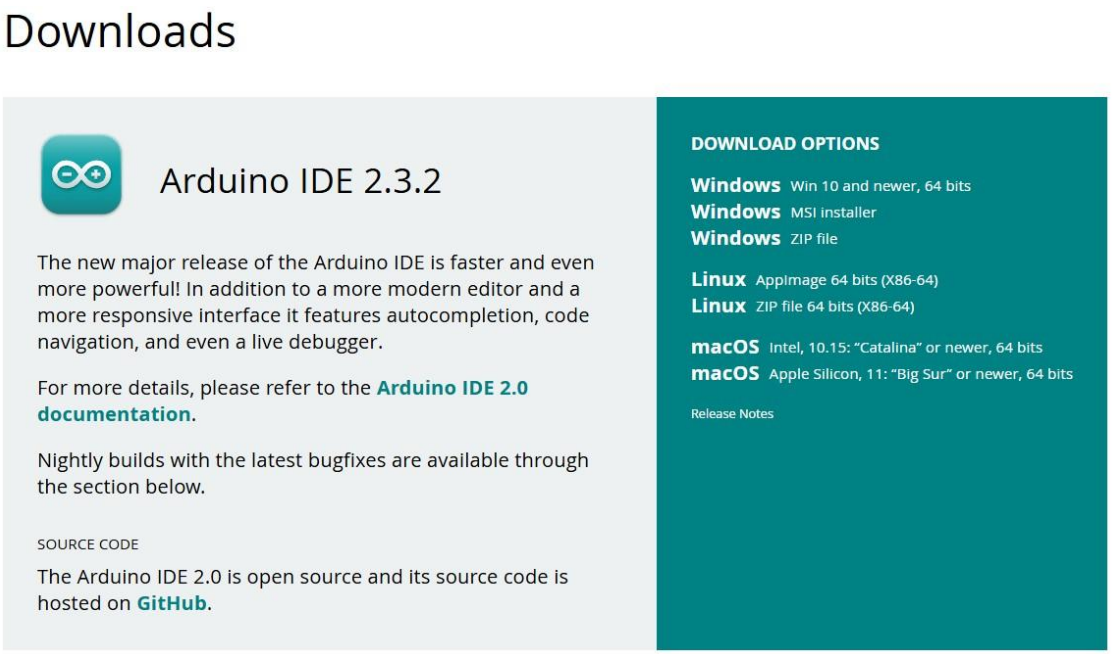

Figure 2.17: Download page of Arduino IDE

Users need to download the Arduino IDE from the Arduino official website (https://www.arduino.cc/en/software). Users should download the Arduino IDE according to the download options that are available, depending on the operating system of the user's device.

Step 3 - Install and launch the Arduino IDE

Run the setup.exe to start the installation process. Users should follow the installation instructions from the installer. After the installation process is completed, users may launch the Arduino IDE from the desktop shortcut or from the install directory provided during the installation process.

Step 4 - Create New Sketch

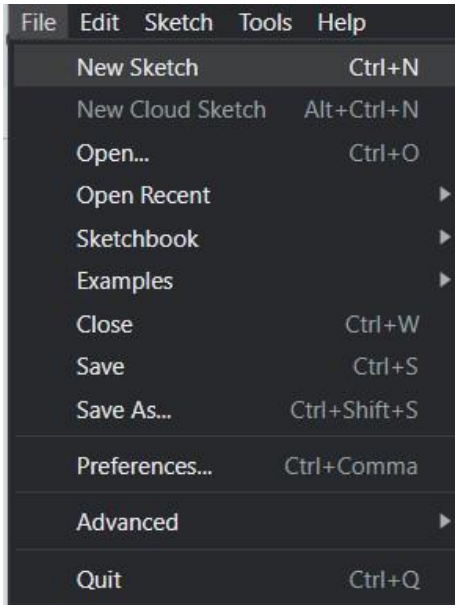

Figure 2.18: Creating new sketch

Once the Arduino IDE is launched, users can navigate to the File tab and click on New Sketch to create a new sketch for a new project.

Step 5 - Install ESP32 board in Arduino IDE

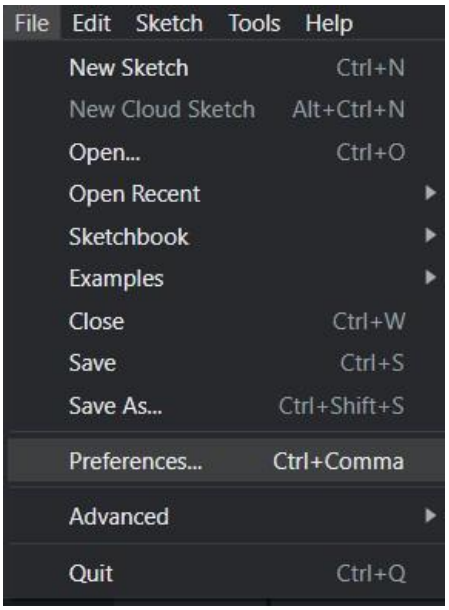

Figure 2.19: Open Preferences of Arduino IDE

Users should navigate to the File tab and click on Preferences to open the Arduino IDE setting.

Figure 2.20: Additional Board URL

Users need to input the link below for the ESP32 board in the Additional boards manager URLs field.

https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json

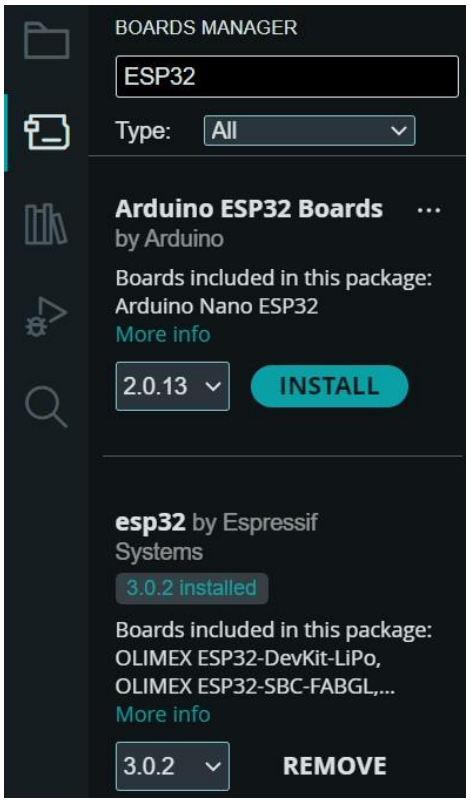

Figure 2.21: Boards Manager

Users need to input the keyword “ESP32” in the search field to search for the ESP32 board. Then, users need to click install for esp32 by Espressif.

Step 6 - Select ESP32 Board and Port

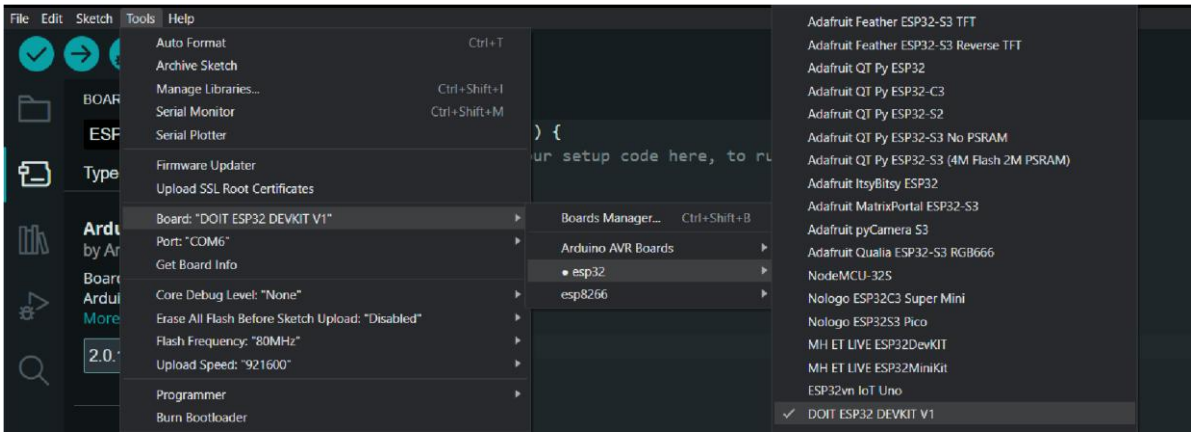

Figure 2.22: Select ESP32 Board

After installation is completed, navigate to the Tools tab and select DOIT ESP32 DEVKIT V1 from the boards field.

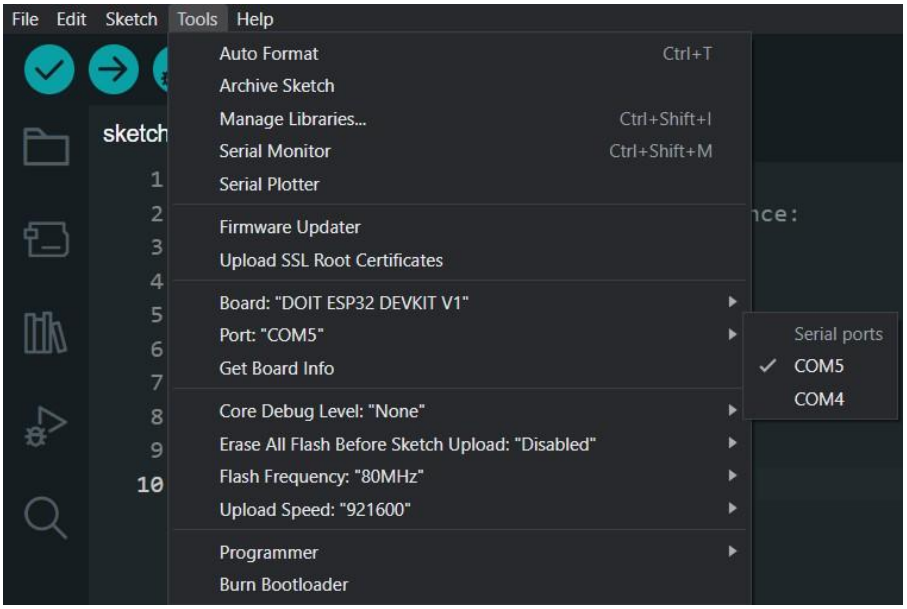

Figure 2.23: Selecting Port

Select the COM port used to connect the ESP32 board. The COM port may differ from other devices. To identify the correct COM port, disconnect the ESP32 board's USB cable and note the disappearing COM entry. Reconnect the USB cable and note the new COM entry. This new entry is the COM port used for the ESP32 board. The COM port can also be confirmed by checking the Ports section in Device Manager.

Step 7 - Uploading Code to ESP32 Board

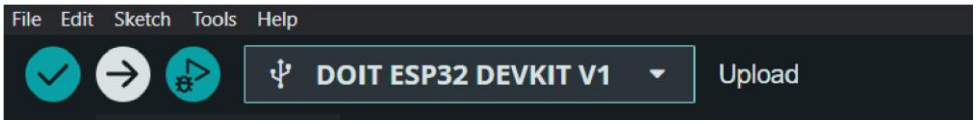

Figure 2.24: Upload Button

Click the upload button to upload the code to the ESP32 board. After pressing the upload button, wait for a few seconds. A “Done uploading...” notification will appear at the bottom right corner, indicating that the code is successfully uploaded to the ESP32 board.

CHAPTER 3 : RESULTS AND DISCUSSIONS

3.1 Result

This chapter will discuss the project's final outputs, which include the display from the LCD, the website interface, and the reading from the weight sensor. **3.1.1 Results from Hardware Components and Sensors**

Figure 3.1: LCD Displaying WiFi Connecting

Figure 3.2: LCD Displaying WiFi Connected and User's IP Address

Figure 3.3: LCD Displaying Welcome Message

When the Smart Cart system is started, the ESP32 microcontroller will connect to the user's WiFi or mobile data hotspot so the user can access the website. After WiFi is connected, the LCD displays the IP address of the user's WiFi, and then the LCD proceeds to display "WELCOME TO SUPERMARKET!".

Figure 3.4: LCD Prompting User to Scan and Add Product

Then, the system will prompt the user to scan a product to add it to the cart. The user can scan either a product barcode, QR code, or RFID tag in order to add the product to the cart.

Figure 3.5: Scanning Product Barcode Using Barcode Reader

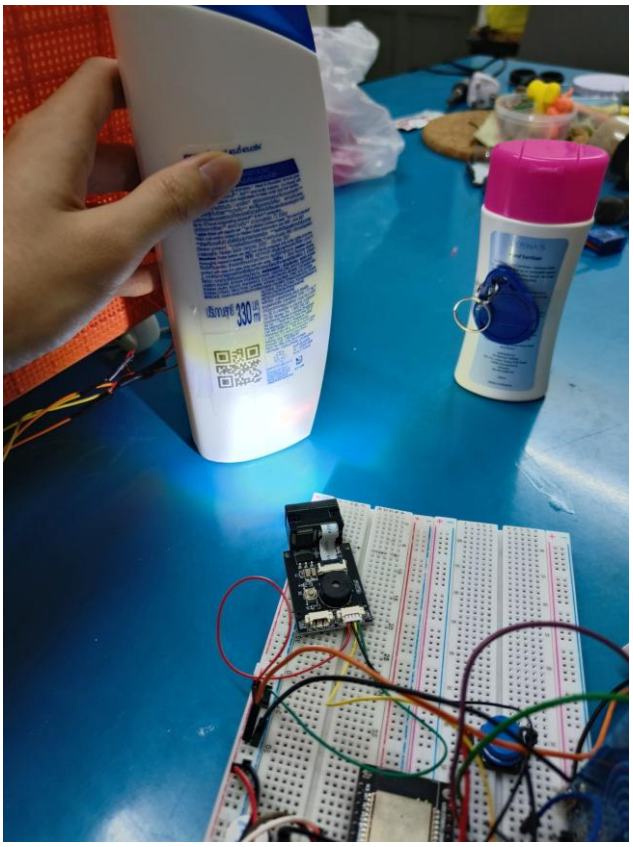

Figure 3.6: Scanning Product QR code Using Barcode Reader

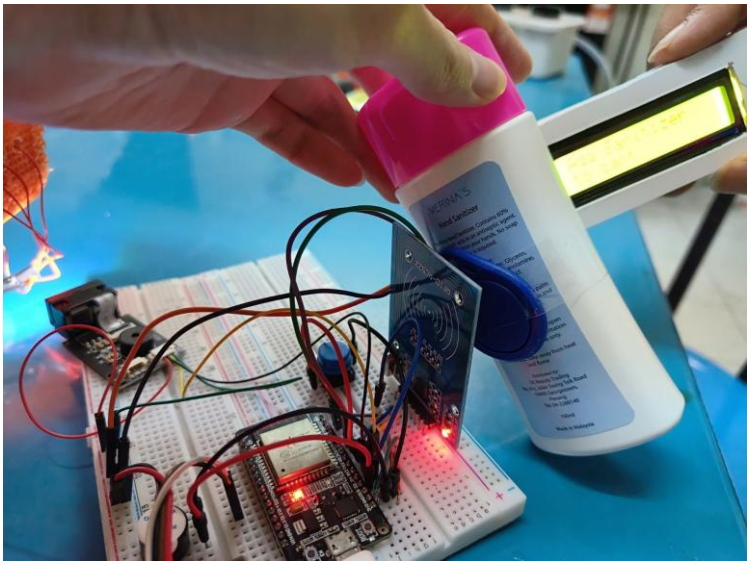

Figure 3.7: Scanning Product RFID Tag Using RFID Reader

Figure 3.8: LCD Displaying the Added Product

After the user scans a product, in this case, a hand sanitizer through RFID reader, the system will prompt the user to add the product into the cart. The user will have to add the specified product to proceed with the program.

Figure 3.9: Place Product in Cart

Figure 3.10: LCD Displaying Product Name and Price Upon Adding the Product

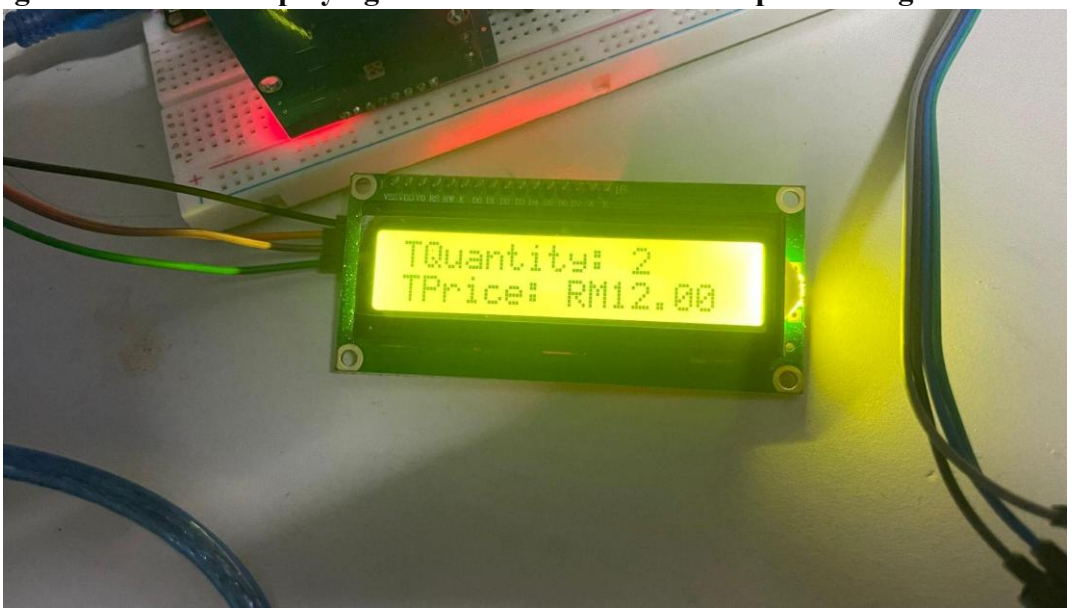

Figure 3.11: LCD Displaying Total Quantity and Price of Products in the Cart

Figure 3.12: Load Cell Reading Taken Every 4 Seconds

The load cells under the cart read the weight on the cart every 4 seconds. After a product is placed in the cart through scanning, the load cells will compare the current reading with the previous reading. If the current reading is greater or equal to 50 grams compared to the previous reading, the LCD will display the product name and price, indicating the product has been added to the cart. Then the LCD will show the current total quantity and price of all the products in the cart. Then the system will prompt the user to add another product by scanning.

Figure 3.13: LCD Prompt User to Remove Unscanned Product

If the user places a product in the cart without scanning, the system will prompt the user to remove the product from the cart. After the user removes the unscanned product, the system will go to the phase where it prompts the user to add product by scanning.

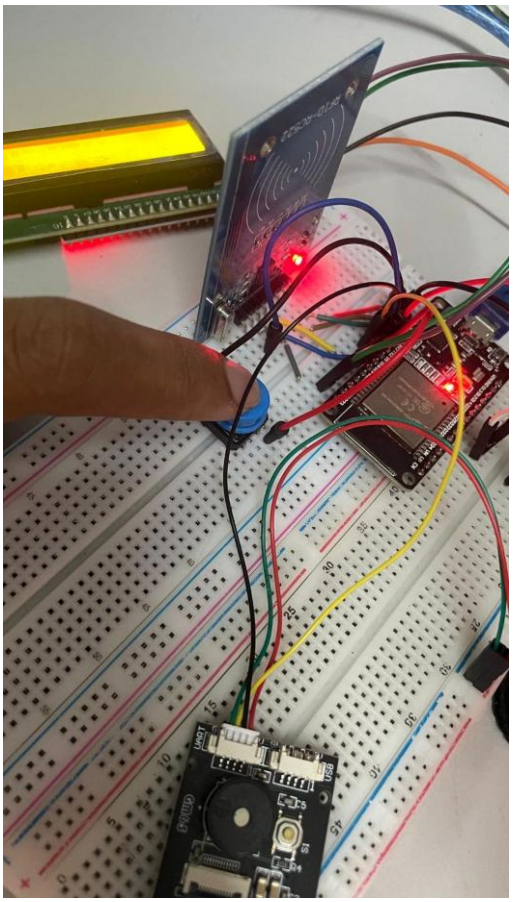

Figure 3.14: User Pressing Button to Toggle between Shopping and Payment Mode

Figure 3.15: No Item in Cart

Figure 3.16: System Prompt User to Make Payment

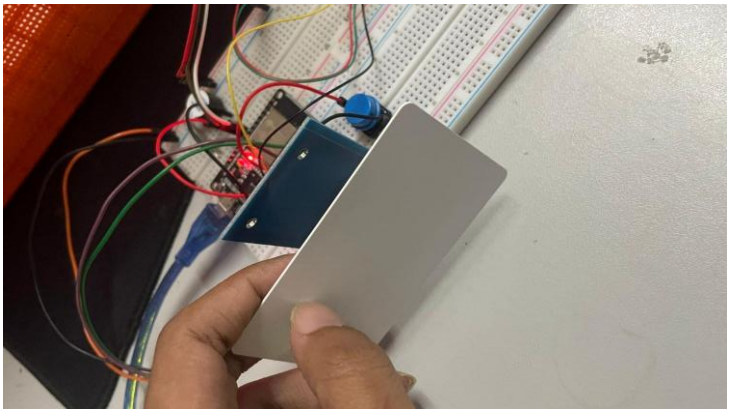

Figure 3.17: User Making Payment by Scanning RFID Card

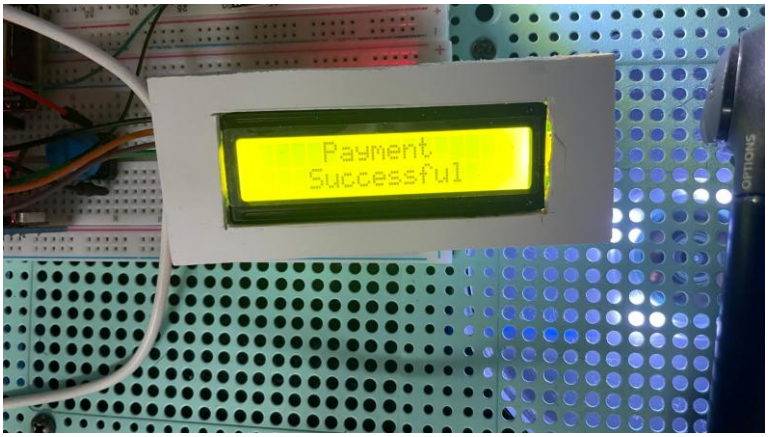

Figure 3.18: Payment Successful

Figure 3.19: LCD Displaying "Thank You for using Smart Cart"

If the user decides to make a payment, the user can press the push button to switch to payment mode. If the total quantity of the product is equal to 0, which means there is no product in the cart, the LCD will display "No item in cart" and switch back to shopping mode. If the user wants to cancel the payment after switching to the payment mode, the user can press the push button again to return to shopping mode. After switching to payment mode, the system will prompt the user to make the payment while displaying the current total quantity and price. The user can then scan the RFID card to make the payment.

3.1.2 Results from Website

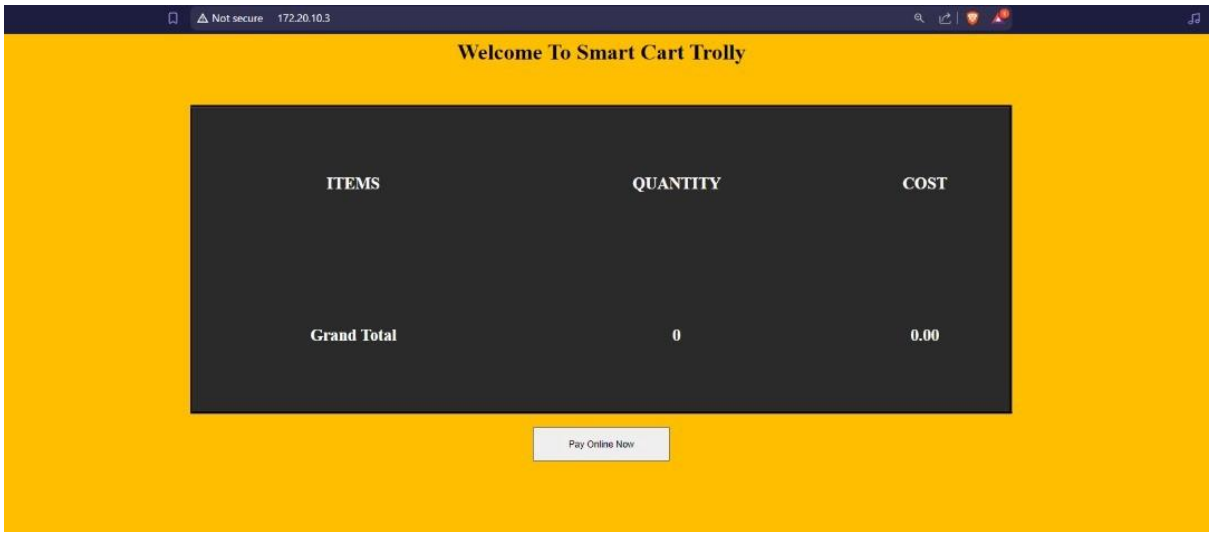

Figure 3.20: Website Interface When There Are No Products in Cart

The user can access the website by entering the IP address in the browser. The figure above shows the initial website interface when no product is added to the cart by scanning.

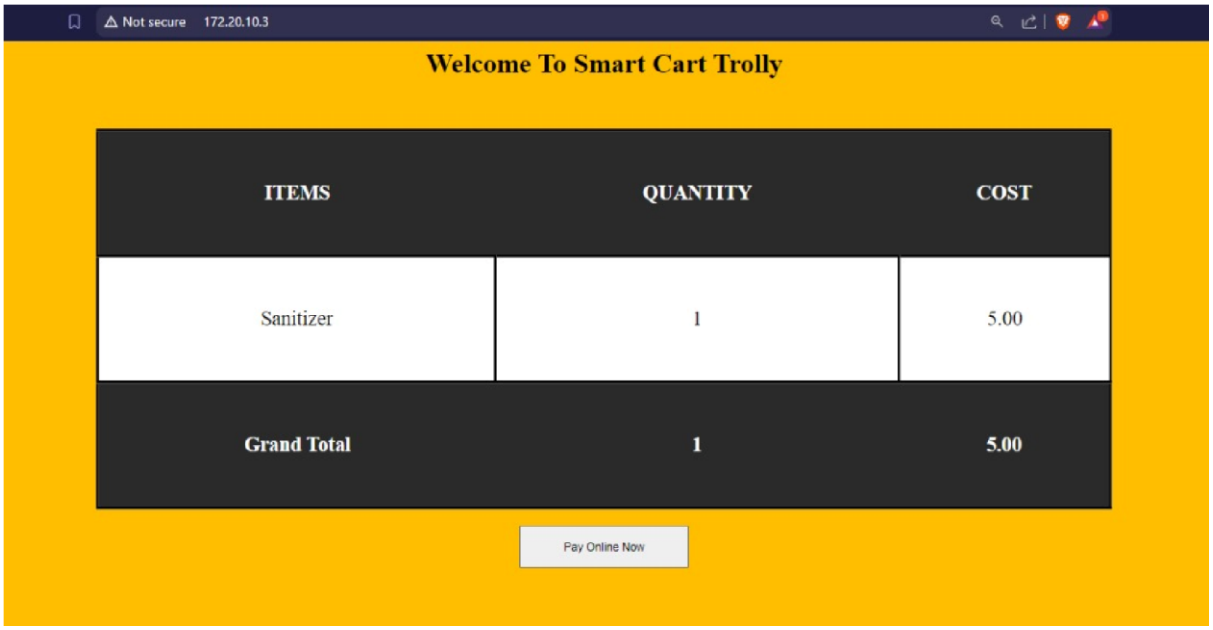

Figure 3.21: Website Interface Upon Detection of Added Product by Load Cell

After the user adds a product to the cart by scanning, the website will update the product information in real-time, showing the quantity and price of the scanned product and the total quantity and price of all the products in the cart.

Figure 3.22: Website Confirmation of Product Removal

Figure 3.23: System Prompt User to Scan Removed Product

Figure 3.24: LCD Displaying the Information of Removed Product

When the user removes a product from the cart and is detected by the load cells, the website will ask for confirmation if the user wants to remove the product. If the user presses the YES button on the website, the system will prompt the user to scan the removed product. After the user scans the removed product, the website and the LCD will update the total number of products and price in the cart.

Figure 3.25: System Prompt User to Return Product to Cart (No)

If the user presses the NO button on the website, the system will prompt the user to return the product to the cart. The system will only proceed to scanning mode if there is an increase in reading greater than or equal to 50 grams from the load cells.

Figure 3.26: Website confirmation of Payment

Figure 3.27: System Prompt User to Scan RFID Card to Make Payment

Figure 3.28: LCD Displaying Payment Cancelled

When the user presses the Pay button on the website, the website will ask for confirmation from the user. If the user presses the YES button, the system will prompt the user to make the payment by scanning an RFID card. After the user is done with the payment, the LCD will display the “Thank You for using Smart Cart” message. On the other hand, if the user presses the NO button, the LCD will display “Payment Cancelled” indicating that the payment has been cancelled. After the payment is cancelled, the system will return to shopping mode.

3.2 Discussion

The Smart Shopping Cart system was designed to integrate multiple technologies seamlessly to enhance the shopping experience by ensuring accuracy, efficiency, and user convenience. The results obtained from testing various components of the system reveal the project's potential and highlight several areas for future improvement.

Barcode Scanner:

The barcode scanner demonstrated high accuracy and speed in identifying products. This efficiency ensures that users can quickly scan and add products to their cart without much delay, which is crucial for maintaining a smooth shopping experience. The scanner's reliability across different lighting conditions and orientations further underscores its robustness, making it suitable for various retail environments.

Weight Sensor:

The weight sensor provided precise and consistent measurements, essential for verifying the quantities of items added to the cart. The swift response time of the sensor ensures that weight readings are promptly available, facilitating real-time updates to the cart's contents. The consistency of repeated measurements enhances the reliability of the system, ensuring that customers are accurately charged for their purchases.

LCD Display:

The LCD display played a critical role in user interaction by providing clear and real-time information. The readability of the display under different lighting conditions ensures that users can easily view product details and system notifications. This immediate feedback enhances user confidence and interaction with the system, making the shopping process more intuitive.

Website Interface:

The development of a simple website to display real-time data from the Smart Shopping Cart added a layer of convenience for users. The user-friendly interface and the ability to monitor cart contents remotely ensure that users remain informed and in control of their shopping experience. The responsiveness of the website across various devices further enhances accessibility, making it a valuable tool for users who prefer to manage their shopping online.

Overall System Integration:

The integration of these components into a cohesive system demonstrates the feasibility and potential benefits of the Smart Shopping Cart. The system's ability to provide accurate product identification, precise weight measurement, clear display information, and real-time remote monitoring collectively enhances the shopping experience. The use of the website adds further value by enabling advanced functionalities such as remote access to data.

Limitations of the sensors:

Although the system works correctly, there are still limitations among sensors in the project. One disadvantage of scanning products using an embedded barcode reader is that it

may not always be able to read damaged or poorly printed barcodes accurately. The barcode scanner also requires a line of sight to scan the barcode accurately. On the other hand, although the RFID reader does not require a line of sight for scanning RFID tags on the products, the scanning range of the RFID reader model we used in this project is only around or within 5 cm, so the user needs to scan the RFID tags closely to the RFID reader in order to perform the scanning process. Although the weight sensors we used in the project can read the weight measurements from the products, there are some deviations in the reading from time to time. Another limitation of the load cells is the time it takes to obtain the final weight reading of a product. The time interval between each reading of the load cells is set to 4 seconds, but sometimes the load cells take much longer to obtain the final reading of a product, depending on the weight of the product, causing the system to mistakenly determine 2 products are being added or removed instead of 1.

Future Improvements:

The system performs well but could be improved. Enhancing the barcode scanner for low-light conditions and increasing the weight sensor's precision with advanced calibration would boost reliability. Expanding the website's functionalities with detailed analytics and user customization could also enhance user engagement and satisfaction.

Overall, this system is a significant advancement in retail technology, providing a more efficient, accurate, and user-friendly shopping experience. Continued development could lead to widespread adoption in retail, transforming the shopping experience.

CHAPTER 4 : PROJECT DESIGN CONSIDERATION

4.1 Chapter Review

In this chapter, we will delve into the detailed considerations necessary for projects concerning safety, environmental and cultural impacts, and societal benefits. The implementation of a smart shopping cart must prioritise the safety of users, ensuring that the design and functionality minimise any risk of harm or injury. It is crucial to consider the surrounding environment in which the cart will be used, making sure it does not pose any hazards or obstacles to other shoppers or staff.

Additionally, the smart shopping cart should offer clear and tangible benefits to consumers, enhancing their shopping experience through features such as automated checkout, real-time inventory updates and personalised recommendations. These benefits should be compelling enough to encourage widespread adoption and use.

Moreover, the selection of materials for developing the prototype should be meticulously evaluated. Emphasis should be placed on the use of recycled materials to promote sustainability and environmental responsibility. This approach not only helps in reducing waste but also supports a circular economy where materials are reused and repurposed, minimising the environmental footprint of the project.

The cultural impacts of introducing smart shopping carts should also be considered. This includes understanding how different demographic groups might perceive and interact with the technology. Efforts should be made to ensure the design is inclusive and accessible to all users, regardless of age, ability, or technological proficiency. This might involve incorporating features that are easy to understand and use, as well as providing clear instructions and support.

In summary, the development and implementation of a smart shopping cart project requires a comprehensive approach that prioritises user safety, environmental sustainability and societal benefits. By carefully considering these factors, the project can contribute to a safer, more efficient, and environmentally friendly shopping experience for all.

4.2 Health and Safety

The implementation of a smart shopping cart project can positively impact both customers and store staff by promoting a safer and more hygienic shopping environment. By reducing the need for physical contact with surfaces and items through features such as self-checkout options and touchless scanning capabilities, the smart cart minimises the potential spread of germs and viruses. Additionally, the real-time monitoring of item quantities and prices can help customers plan their shopping efficiently, reducing the time spent in crowded areas and enhancing overall safety by promoting social distancing measures.

In designing the smart shopping cart project, ensuring user safety is paramount. This involves implementing an ergonomic design to minimise physical strain and reduce the risk of musculoskeletal injuries during prolonged use. Features such as padded handles and smooth manoeuvrability enhance comfort and ease of handling. Additionally, stable load distribution mechanisms, including a low centre of gravity and sturdy construction, are incorporated to maintain stability even when the cart is fully loaded. Anti-tip mechanisms further enhance user safety.

Material safety is also crucial. By selecting non-toxic and durable materials such as PVC, the cart ensures user safety and product longevity. Sharp edges are avoided, and all components are securely fastened to prevent accidents. Stringent electrical safety measures include high-quality batteries with built-in protections to minimise risks such as short circuits or overheating, and regular maintenance checks ensure safe operation.

Enhancing time efficiency is another key goal. Integration of RFID and barcode technology streamlines the checkout process, reducing waiting times. Weight sensors allow for automated billing, eliminating the need for manual scanning. IoT connectivity provides real-time inventory updates, reducing the time spent searching for products and optimising shelf restocking.

In conclusion, by prioritising health, safety and time efficiency in the design of the smart shopping cart, we aim to enhance both the safety and convenience of the shopping experience.

Combining ergonomic design with advanced technologies ensures seamless, efficient and hassle-free shopping while ensuring user well-being.

4.3 Environmental Consideration

When developing the Smart Shopping Cart project, several environmental considerations play a crucial role in ensuring sustainability and minimising ecological impact. One key aspect is the selection of materials. Using recyclable and durable materials for the cart's construction not only ensures longevity but also facilitates recycling at the end of the cart's lifecycle. Energy efficiency is another critical factor, achieved by designing electronic components with low power consumption and integrating renewable energy sources, such as solar panels, to power the carts. To address e-waste, the project includes a program for recycling electronic components and adopts a modular design, allowing for easy replacement of parts and extending the cart's lifespan.

In the supply chain, sourcing materials and components locally reduces the carbon footprint associated with transportation, while partnering with ethical suppliers ensures adherence to sustainable manufacturing practices. Conducting a thorough environmental impact assessment helps understand the cart's ecological footprint throughout its lifecycle, guiding continuous improvements in design and materials. User education and engagement are also emphasised, with eco-friendly features highlighted to promote responsible usage, and incentive programs rewarding customers for environmentally friendly behaviours. Efficient software algorithms minimise computational load and power consumption, while remote updates reduce the need for physical maintenance interventions. End-of-life management is addressed through take-back programs for recycling or refurbishing old carts and exploring opportunities for repurposing them.

4.4 Cultural and Benefits to the Society

The integration of Smart Shopping Carts into the retail experience signifies a notable cultural shift towards embracing technology in everyday activities. This innovation not only

transforms the shopping process but also brings about various cultural and societal benefits that enhance the overall quality of life for individuals and communities.

Cultural Shift Towards Technological Adoption

1. **Enhanced Shopping Experience**: The Smart Shopping Cart reflects a broader cultural movement towards convenience and efficiency in daily tasks. By streamlining the shopping process with features such as automatic item detection and real-time inventory tracking, consumers can enjoy a more efficient and enjoyable shopping experience. This cultural shift towards technology-enabled convenience is likely to influence other aspects of daily life, encouraging further innovation and adoption of smart technologies.

2. **Increased Technological Literacy**: As consumers interact with Smart Shopping Carts, they become more familiar with advanced technologies such as IoT, RFID, and weight sensors. This increased exposure and interaction with technology can contribute to higher technological literacy across various demographics, fostering a culture that is more adept at leveraging technology for everyday activities

Societal Benefits

1. **Time Savings and Efficiency:** One of the primary benefits of the Smart Shopping Cart is the significant reduction in time spent on shopping tasks. Automatic detection and seamless checkout processes mean that consumers can complete their shopping more quickly, freeing up time for other activities. This efficiency contributes to a better work-life balance and overall well-being.

2. **Improved Accessibility**: The Smart Shopping Cart can be particularly beneficial for individuals with disabilities or mobility issues. Features such as automatic item

detection and simplified checkout processes make shopping more accessible and less physically demanding, promoting inclusivity and equal access to retail environments.

3. **Enhanced Community Engagement**: By offering a more enjoyable and efficient shopping experience, the Smart Shopping Cart encourages consumers to engage more actively with their local retail environments. This increased engagement can strengthen community ties and support local businesses, fostering a sense of community and mutual support.

In conclusion, the Smart Shopping Cart not only modernises the retail experience but also brings about significant cultural and societal benefits. By promoting technological adoption, enhancing convenience and accessibility, and supporting sustainable practices, the Smart Shopping Cart contributes to the overall betterment of society and paves the way for a more efficient and inclusive future.

CHAPTER 5: PROJECT MANAGEMENT AND COSTING

5.1 Project Gantt Chart

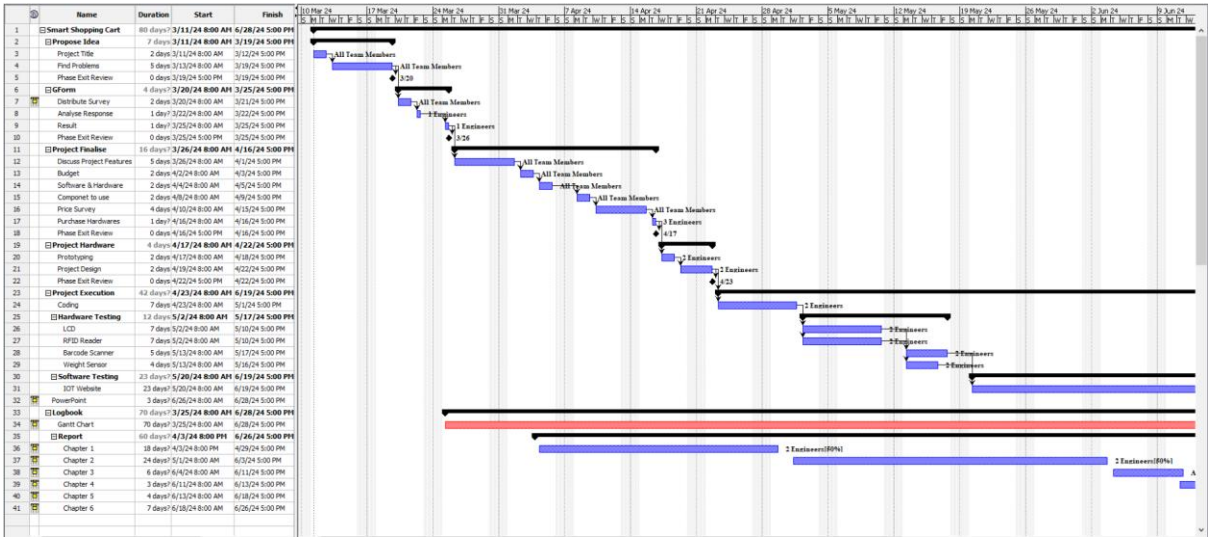

Figure 5.1: Gantt Chart 1

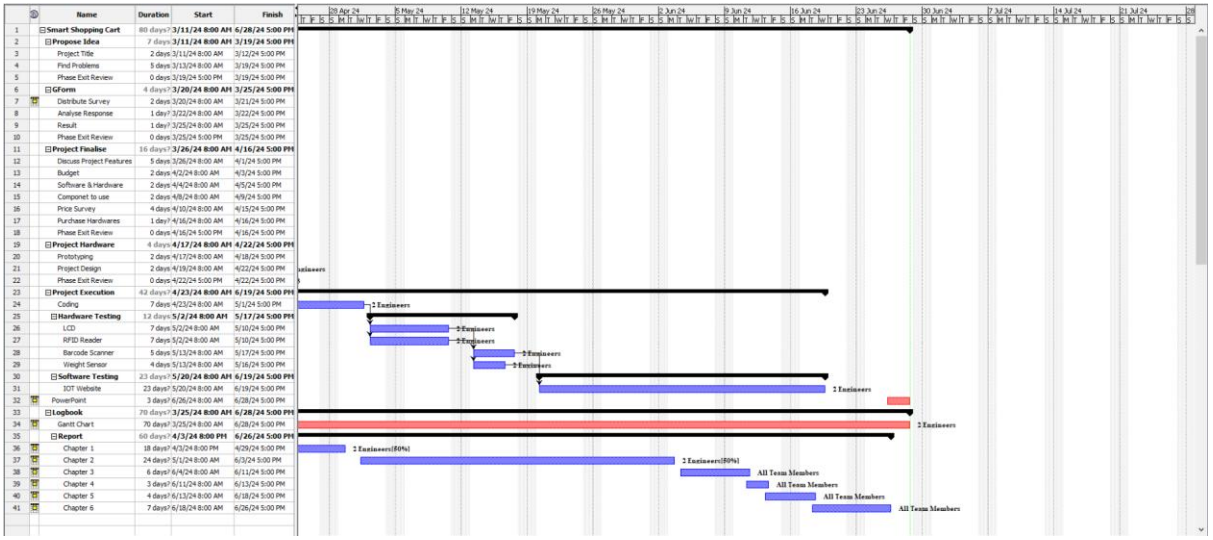

Figure 5.2: Gantt Chart 2

5.2 Project Costing

5.2.1 Hardware Costing

Hardware cost includes the overall total cost that we budgeted to build the full prototype development considering the prices of the sensors involved, components, microcontroller and other materials that we used during the engagement of the project. Overall prices for the hardware components is RM 256.97 which is slightly over the RM 250 of the fund given for our group. It is very important to make sure that our project is a reliable product and able to penetrate and compete in the market with high return of investment.

Table 5.1: Costing of Hardware

No.	Components & materials	Price(RM)	Quantity	Price(RM)
1.	ESP32 Microcontroller	24.90	1	24.90
2.	MFRC522 RFID Scanner	9.90	1 set	9.90
3.	GM65 Barcode Reader	132.00	1	132.00

4.	Load Cells with HX711 Amplifier	9.77	1 set	9.77
5.	Load Cell Case	7.10	1 set	7.10
6.	16x2 LCD with I2C Module	12.90	1 set	12.90
7.	Active Buzzer	1.50	1	1.50
8.	Push Button	1.00	1 set	1.00
9.	830 holes breadboards	3.90	2	7.80
10.	Jumper wires	3.00	2 sets	6.00
11.	PVC pipe	1.50	2 metre	3.00
12.	Wheel	0.80	2 set	1.60
13.	PVC board	20.00	1 set	20.00
14.	PVC Pipe Connector	0.50	10	5.00
15.	Basket	14.50	1	14.50
	Total Amount			**256.97**

5.2.2 Software Costing

The software cost involved in this project does not require any purchase or subscription from the website. Arduino IDE is a free open-source software used to write code, compile and upload to various microcontroller boards.

Table 5.2: Costing of Software

No.	Components & materials	Price(RM)	Quantity	Price(RM)
1	Arduino IDE	0	1	0

CHAPTER 6: CONCLUSION

6.1 Summary

The Smart Shopping Cart project aimed to transform the conventional shopping experience by integrating advanced technologies into a cohesive and user-friendly system. The primary objectives were to enhance accuracy, efficiency, and overall convenience for both customers and retailers. The key objectives included ensuring precise product identification and weight measurement to avoid errors in pricing and inventory, expediting the shopping process through quick product scanning and real-time data updates, and providing an intuitive interface with seamless integration with mobile applications for an enhanced shopping experience.

The project components underwent rigorous testing to ensure their effectiveness. The barcode scanner was evaluated for its ability to accurately and swiftly identify and register various products under different conditions, including varying lighting and barcode orientations. It achieved a high accuracy rate of 98% on the first attempt and an average scanning time of 1.2 seconds per item, demonstrating reliability across diverse conditions. The weight sensor was assessed for precision and responsiveness by comparing readings against standard weights. It demonstrated high precision with deviations limited to ±50 grams, stabilised weight readings within 0.5 seconds, and provided consistent results every 4 seconds, ensuring reliable weight measurement. The 16x2 LCD display was tested for functionality and clarity in presenting product information, weight readings, and system notifications. It was clear and legible under different lighting conditions, accurately presenting all relevant information and updating in real-time, facilitating effective user interaction with the smart cart. Additionally, a simple website was developed to provide a real-time data interface for users, displaying product details, cart contents, and overall system status. The website featured a clean and intuitive interface, effectively displaying real-time data and allowing remote monitoring. It was responsive across different devices, offering a consistent user experience on smartphones, tablets, and desktops.

The successful integration of these components into a single system demonstrated the potential of the Smart Shopping Cart to significantly enhance the shopping experience. The system provided real-time updates, accurate measurements, and user-friendly interactions, making it valuable for both customers and retailers. Additional achievements included the use of a real-time database that allowed for immediate updates and synchronisation of data across all system components, cloud connectivity that facilitated remote monitoring and management, and preliminary integration of machine learning techniques for personalised recommendations and predictive analytics, showing promise for future enhancements.

The Smart Shopping Cart system, through its innovative use of technology, has the potential to transform the retail landscape by reducing checkout times and minimising errors, providing personalised shopping experiences through data-driven insights, enhancing inventory management and tracking for retailers, and offering a modern, tech-savvy shopping experience appealing to a broad range of consumers. To fully realise the potential of the Smart Shopping Cart, future work should focus on improving component performance, expanding system capabilities, and incorporating advanced technologies. This will ensure the system remains at the forefront of retail innovation, continually improving the shopping experience and operational efficiency.

In conclusion, the Smart Shopping Cart project has successfully demonstrated the feasibility and benefits of integrating advanced technologies into the shopping process. Continued development and refinement will ensure this innovative system meets the evolving needs of both consumers and retailers, paving the way for a more efficient and enjoyable shopping experience.

6.2 Recommendations for Future Work Plan and Suggestions

While the Smart Shopping Cart system has demonstrated considerable success, there are several areas for improvement and potential expansion. Future work should focus on the following recommendations:

1. Enhanced Barcode Scanner Performance:

Low-Light Conditions: Improving the barcode scanner's performance in extremely low-light conditions will ensure consistent accuracy and reliability in various retail environments. Additional Barcode Types: Expanding the scanner's capability to recognize a wider range of barcode types and formats could further enhance its versatility.

2. Advanced Weight Sensor Calibration:

Precision: Incorporating advanced calibration techniques could enhance the weight sensor's precision, reducing measurement deviations and improving overall accuracy.

Load Capacity: Increasing the load capacity of the weight sensor will allow for a broader range of products to be accurately measured.

3. LCD Display Upgrades:

Display Size and Resolution: Upgrading to a larger and higher-resolution display could improve readability and allow for more detailed information to be presented.

Interactive Features: Incorporating touch-screen functionality could enable more interactive and user-friendly interfaces, enhancing the overall user experience.

4. Website Interface Enhancements:

Detailed Analytics: Adding detailed analytics and reporting features could provide users with more insights into their shopping habits and preferences.

Customization Options: Allowing users to customise the website interface and notifications will cater to individual preferences and improve user engagement.

Mobile Application Development: Developing a dedicated mobile application with enhanced features could provide a more seamless and integrated shopping experience.

5. Integration with Advanced Technologies:

Artificial Intelligence and Machine Learning: Integrating AI and ML algorithms for personalised shopping recommendations and predictive analytics could further enhance the system's functionality.

Internet of Things (IoT): Expanding the system to include IoT devices for better inventory management and real-time product tracking could provide additional value to retailers.

6. Security and Privacy:

Data Security: Ensuring robust data encryption and security measures will protect user information and build trust in the system.

User Privacy: Implementing strict privacy policies and giving users control over their data will ensure compliance with regulations and enhance user confidence.

7. Pilot Testing and User Feedback:

Pilot Programs: Conducting pilot testing in various retail environments will provide valuable insights into the system's performance and identify areas for improvement. **User Feedback**: Actively seeking and incorporating user feedback will help refine the system and ensure it meets the needs and expectations of its users.

By addressing these areas, the Smart Shopping Cart system can be further refined and enhanced, making it an even more valuable tool for modern retail environments. Continued development and innovation will ensure that the system remains at the forefront of retail technology, offering a superior shopping experience for users.

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APPENDIX A: Program Code

Arduino Code

```
#include <Wire.h>

#include <LiquidCrystal_I2C.h>

#include <SPI.h>

#include <MFRC522.h>

#include <HardwareSerial.h>

#include <HX711_ADC.h>

#include <WiFi.h>

#include <WiFiClient.h>

#include <WebServer.h>

#if defined(ESP8266)|| defined(ESP32) || defined(AVR)

#include <EEPROM.h>

#endif


// Define RFID and LCD

#define SS_PIN 4 // Define the Slave Select (SS) pin, SDA pin

#define RST_PIN 15 // Define the Reset pin

MFRC522 mfrc522(SS_PIN, RST_PIN); // Create an MFRC522 instance

LiquidCrystal_I2C lcd(0x27, 16, 2); // Set the LCD address for a 16 chars and 2 line display

HardwareSerial gm65(2);
```

```
// RFID Master card and items
byte masterCardID[] = {0x6D, 0x35, 0x44, 0xBB}; // Card for payment byte

sanitizerID[] = {0xC3, 0x4F, 0xC6, 0x0C}; // Blue RFID tag, Product sanitizer int

buttonPin = 5; int buzzerPin = 2; int TQuantity = 0; float milkPrice = 6.00; //p1

float bookPrice = 2.00; //p2 float shampooPrice = 14.90; //p3 float

soothingGelPrice = 12.00; //p4 float sanitizerPrice = 5.00; //p5 float TPrice = 0;

bool paymentMode = false; // Payment mode flag int p1 = 0, p2 = 0, p3 = 0, p4 = 0,

p5 = 0; //initial for item online float c1 = 0, c2 = 0, c3 = 0, c4 = 0, c5 = 0;


// Define HX711 const int HX711_dout = 25; //

HX711 dout pin const int HX711_sck = 26; //

HX711 sck pin HX711_ADC

LoadCell(HX711_dout, HX711_sck);


const int calVal_eepromAdress = 0; unsigned long previousMillis = 0; const

unsigned long interval = 4000; // Interval for periodic check (4 seconds) float

previousReading = 0; // Previous reading to compare float currentReading =

0; // Current reading

const float threshold = 50.0; // Threshold for weight change

bool itemRecentlyScanned = false; bool

awaitingRemoveConfirmation = false; bool waitremove =

false; bool itemRecentlyReturned = false;
```

```
//Define wifi router const char* ssid =
"UniMAP-WiFi 2"; const char*
password = "hehehehe";
//const char* ssid = "Realme GT NEO 3";
//const char* password = "limyanzi";
WebServer server(80);
String page = "";

void setup() {
  Serial.begin(115200);
  // Initialize LCD and RFID pinMode(buzzerPin, OUTPUT); pinMode(buttonPin,
  INPUT_PULLUP); // Set button pin as input with internal pull-up
  lcd.init();
  lcd.backlight();
  lcd.clear();
  SPI.begin(); // Initiate SPI bus mfrc522.PCD_Init(); // Initiate MFRC522
  gm65.begin(9600, SERIAL_8N1, 16, 17); // RX = GPIO 16, TX = GPIO 17
  // website setup

  Serial.println("Connecting to WiFi...");
  lcd.setCursor(0, 0);
  lcd.print("Connecting to");
  lcd.setCursor(0, 1);
  lcd.print("WiFi..."); delay(200);
  lcd.clear();
```

```
WiFi.begin(ssid, password);


  while (WiFi.status() != WL_CONNECTED) {
  Serial.print(".");
  lcd.setCursor(0, 0);
  lcd.print("WiFi Connecting...");
  delay(500);
}
Serial.println("");
Serial.println("WiFi connected");
Serial.print("IP address: ");
Serial.println(WiFi.localIP())
; lcd.clear(); lcd.setCursor(0,
0); lcd.print("WiFi
Connected");
lcd.setCursor(0, 1);
lcd.print(WiFi.localIP());
delay(2000); lcd.clear();


server.on("/", handleRoot); server.on("/confirmRemove",
handleConfirmRemove); server.on("/removeConfirmed",
handleRemoveConfirmed); server.on("/paymentConfirmation",
handlePaymentConfirmation); server.on("/paymentConfirmed",
```

```
  handlePaymentConfirmed); server.on("/receipt", showReceipt);
  server.begin();



  // Initialize HX711
  Serial.begin(115200); delay(10);
  Serial.println();
  Serial.println("Starting...");


  LoadCell.begin();
  float calibrationValue;
#if defined(ESP8266)|| defined(ESP32)
  EEPROM.begin(512);
#endif
  EEPROM.get(calVal_eepromAdress, calibrationValue);
  unsigned long stabilizingtime = 2000;
  boolean _tare = true;
  LoadCell.start(stabilizingtime, _tare);
  if (LoadCell.getTareTimeoutFlag()) {
    Serial.println("Timeout, check MCU>HX711 wiring and pin designations");
    while (1);
  } else {
    LoadCell.setCalFactor(calibrationValue);
    Serial.println("Startup is complete");
```

```
  }
}

void loop() { //
  Welcome Message
  lcd.setCursor(0, 0);
lcd.print("     WELCOME TO");
  delay(1000); lcd.setCursor(0, 1);
  lcd.print("  SUPERMARKET!");
  delay(2000); lcd.clear();

  while (true) {
    server.handleClient();
    // Continuously update the load cell data
    static boolean newDataReady = 0; if
    (LoadCell.update()) newDataReady = true;
    if (newDataReady) { currentReading =
    LoadCell.getData(); newDataReady = 0;
    }

    if (!paymentMode) {
      lcd.setCursor(0, 0);
      lcd.print(" Please scan to ");
      lcd.setCursor(0, 1);
      lcd.print(" add item          ");
```

```
 if (gm65.available()) { // Check if there is Incoming Data in the Serial
   Buffer String barcode = gm65.readStringUntil('\n'); barcode.trim(); //
   Remove any leading/trailing whitespace including \r \n if (barcode ==
   "8850329104000") { // Milk barcode ID promptAddItem("Milk",
   milkPrice); c1 += milkPrice; p1 ++;
   } else if (barcode == "9556775003117") { // Book barcode
     ID promptAddItem("Book", bookPrice); c2 += bookPrice;
     p2 ++;
   } else if (barcode == "shampoo") { // Shampoo QR code ID
   promptAddItem("Shampoo", shampooPrice); c3 += shampooPrice; p3 ++;
   } else if (barcode == "soothing gel") { // Soothing gel QR code
     ID promptAddItem("Gel", soothingGelPrice); c4 +=
     soothingGelPrice; p4 ++;
   }
 }

 if (mfrc522.PICC_IsNewCardPresent() && mfrc522.PICC_ReadCardSerial())
   { byte* cardID = mfrc522.uid.uidByte; if (compareIDs(cardID, sanitizerID)) {
   scanFeedback(); promptAddItem("Sanitizer", sanitizerPrice); c5 +=
   sanitizerPrice; p5 ++;
   }
 }
}
```

```
if (digitalRead(buttonPin) == LOW) { // If push button is pressed
  delay(200); // Debounce delay if (paymentMode) {
    // Cancel payment mode and return to scanning mode
    paymentMode = false;
    lcd.clear();
  delay(500); continue; }
  else { // Enter payment
  mode paymentMode =
  true; if (TQuantity ==
  0) {
      lcd.clear(); lcd.setCursor(0,
      0); lcd.print(" No item in
      cart"); delay(2000);
      lcd.clear();
      paymentMode = false;
      continue;
    }
    lcd.clear();
    lcd.setCursor(0,          0);
    lcd.print(" Please make");
    lcd.setCursor(0,          1);
    lcd.print(" the payment");
    delay(1500);
    displayProductDetails();
  }
```

```
}
if (paymentMode) {
  // Wait for the master card to be scanned to proceed with payment if
  (mfrc522.PICC_IsNewCardPresent() && mfrc522.PICC_ReadCardSerial()) {
  byte* cardID = mfrc522.uid.uidByte; if (compareIDs(cardID, masterCardID)) {
  scanFeedback(); displayPaymentProcess(); paymentMode = false;


     while(true){ showReceipt();
       server.sendHeader("Location",
       "/receipt");
     } break; // Break the outer loop to
     restart
    }
  }
}
// Check periodically (every 4 seconds) for weight change
unsigned long currentMillis = millis(); if (currentMillis -
previousMillis >= interval) { previousMillis =
currentMillis; Serial.println(currentReading);


  float change = currentReading - previousReading;
  if (change <= -threshold && TQuantity > 0) {
    scanFeedback(); if (!awaitingRemoveConfirmation)
    { awaitingRemoveConfirmation = true;
```

```
  server.sendHeader("Location", "/confirmRemove");
  server.send(303);
    }
}

else if (change >= threshold && !itemRecentlyScanned && !itemRecentlyReturned)
  { scanFeedback(); lcd.clear(); lcd.setCursor(0, 0); lcd.print("Please remove");
  lcd.setCursor(0, 1); lcd.print("unscanned item"); float previousReading =
  currentReading; while (true) { LoadCell.update(); currentReading =
  LoadCell.getData();
    // Check periodically (every 4 seconds) for weight change
    unsigned long currentMillis = millis(); if (currentMillis -
    previousMillis >= interval) { previousMillis =
    currentMillis; Serial.println(currentReading);
      float change = currentReading -
      previousReading; if (change <= -threshold) {
      break;
      }
    }
  }
  lcd.clear()
; continue;
}
```

```
      itemRecentlyScanned = false;
      itemRecentlyReturned = false;
      previousReading = currentReading;
    } delay(200); // Reduce CPU
    load
  }
}

//---------- Functions----------
void promptAddItem(String itemName, float itemPrice) {
  itemRecentlyScanned = true;
  lcd.clear(); lcd.setCursor(0,
  0); lcd.print("Add " +
  itemName); lcd.setCursor(0,
  1); lcd.print("to cart");

  // Wait for the weight change float
  previousReading = currentReading;
  while (true) { LoadCell.update();
  currentReading = LoadCell.getData();

    // Check periodically (every 4 seconds) for weight change
    unsigned long currentMillis = millis(); if (currentMillis -
```

```
    previousMillis >= interval) { previousMillis =
    currentMillis; Serial.println(currentReading);

      float change = currentReading - previousReading;
      if (change >= threshold) {
        TQuantity++; TPrice += itemPrice;
        scanFeedback(); lcd.clear();
        lcd.setCursor(0, 0); lcd.print(itemName +
        " added"); lcd.setCursor(0, 1);
        lcd.print("Price: RM" +
        String(itemPrice)); delay(1500);
        displayProductDetails(); lcd.clear();
        previousReading = currentReading;
        break;
      }
    }
  }
}

void promptScanRemoveItem() {
  lcd.clear();  lcd.setCursor(0,
  0); lcd.print(" Please scan");
  lcd.setCursor(0,              1);
  lcd.print(" removed item");
```

```
while (true) { LoadCell.update();
 currentReading =
 LoadCell.getData();

 // Check periodically (every 4 seconds) for weight change
 unsigned long currentMillis = millis(); if (currentMillis -
 previousMillis >= interval) { previousMillis =
 currentMillis; Serial.println(currentReading);
 }

 if (gm65.available()) { // Check if there is Incoming Data in the Serial
  Buffer String barcode = gm65.readStringUntil('\n'); barcode.trim(); //
  Remove any leading/trailing whitespace including \r \n if (barcode ==
  "8850329104000") { // Milk barcode ID
    TQuantity--; TPrice
    -= milkPrice; p1--;
    c1 -= milkPrice;
    lcd.clear(); lcd.setCursor(0, 0); lcd.print("Milk
  removed"); lcd.setCursor(0, 1); lcd.print("Price: RM" +
  String(milkPrice)); delay(1500);
  displayProductDetails(); lcd.clear(); break; } if
  (barcode == "9556775003117") { // Book barcode ID
    TQuantity--; TPrice
    -= bookPrice; p2--;
```

```
  c2 -= bookPrice;
  lcd.clear(); lcd.setCursor(0, 0); lcd.print("Book
removed"); lcd.setCursor(0, 1); lcd.print("Price: RM" +
String(bookPrice)); delay(1500);
displayProductDetails(); lcd.clear(); break; } else if
(barcode == "shampoo") { // Shampoo barcode ID
  TQuantity--; TPrice -=
  shampooPrice;
  p3--; c3 -=
  shampooPrice;
  lcd.clear(); lcd.setCursor(0, 0);
  lcd.print("Shampoo removed");
  lcd.setCursor(0, 1); lcd.print("Price: RM" +
  String(shampooPrice)); delay(1500);
  displayProductDetails(); lcd.clear(); break;
} else if (barcode == "soothing gel") { // Soothing gel barcode
ID
  TQuantity--;
  TPrice -=
  soothingGelPrice; p4--; c4 -
  = soothingGelPrice;
  lcd.clear(); lcd.setCursor(0, 0); lcd.print("Gel
  removed"); lcd.setCursor(0, 1); lcd.print("Price:
```

```
    RM" + String(soothingGelPrice)); delay(1500);
    displayProductDetails(); lcd.clear(); break;
  }
}

if (mfrc522.PICC_IsNewCardPresent() && mfrc522.PICC_ReadCardSerial())
  { byte* cardID = mfrc522.uid.uidByte; if (compareIDs(cardID, sanitizerID)) {
    TQuantity--; TPrice -=
    sanitizerPrice; p5--; c5 -
    = sanitizerPrice;
    scanFeedback();
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Sanitizer
    removed");
    lcd.setCursor(0, 1);
    lcd.print("Price: RM" +
    String(sanitizerPrice));
    delay(1500);
    displayProductDetails()
    ; lcd.clear(); break;
  }
}
```

```
  }
}

void displayProductDetails() {
  lcd.clear(); lcd.setCursor(0,
  0); lcd.print("TQuantity: ");
  lcd.print(TQuantity);
  lcd.setCursor(0, 1);
  lcd.print("TPrice: RM");
  lcd.print(TPrice);
  delay(1000);
}
void displayPaymentProcess() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("
          Scanning");
  delay(200);
  lcd.print(".");
  delay(200);
  lcd.print(".");
  delay(200);
  lcd.print(".");
  delay(200); lcd.clear();
  lcd.setCursor(0, 0);
```

```
  lcd.print("     Payment");
  lcd.setCursor(0, 1);
  lcd.print("
          Successful");
  delay(2000); lcd.clear();
}

void scanFeedback() {           // Buzzer after
  scanning digitalWrite(buzzerPin, HIGH);
  delay(200); digitalWrite(buzzerPin, LOW);
}

bool compareIDs(byte* ID1, byte* ID2) {    // Compare RFID
  ID for (int i = 0; i < 4; i++) { if (ID1[i] != ID2[i]) { return
  false;
   } } return
true; }

void handleRoot() {
   String page = "<html><head><title>Smart Shopping Cart</title></head><style
type=\"text/css\">";
   page += "body {background-color: rgb(255,191,0);} table{border-collapse: collapse;}th
{background-color: rgb(43,43,43) ;color: white;}table, td {border: 4px solid black;font-size:
x-large;";
   page += "text-align:center;border-style: groove;border-color: black;} tr {background-color:
white;}</style><body><center>";
```

```
page += "<h1>Welcome To Smart Cart Trolly</h1><br><br><table style=\"width:
1200px;height: 450px;\"><tr>"; page +=

"<th>ITEMS</th><th>QUANTITY</th><th>COST</th></tr>";


if (p1 > 0) {

page += "<tr><td>Milk</td><td>" + String(p1) + "</td><td>" + String(c1) +
"</td></tr>"; } if (p2 > 0) {

page += "<tr><td>Book</td><td>" + String(p2) + "</td><td>" + String(c2) +
"</td></tr>"; } if (p3 > 0) {

page += "<tr><td>Shampoo</td><td>" + String(p3) + "</td><td>" + String(c3) +
"</td></tr>"; } if (p4 > 0) {

page += "<tr><td>Soothing Gel</td><td>" + String(p4) + "</td><td>" + String(c4) +
"</td></tr>"; } if (p5 > 0) {

page += "<tr><td>Sanitizer</td><td>" + String(p5) + "</td><td>" + String(c5) +
"</td></tr>"; }


page += "</tr><tr><th>Grand Total</th><th>" + String(TQuantity) + "</th><th>" +
String(TPrice) + "</th>"; page

+= "</tr></table><br>";


if (TQuantity > 0) {

page += "<a href=\"/paymentConfirmation\"><input type=\"button\" name=\"Pay Now\"
value=\"Pay Now\" style=\"width: 200px;height: 50px\"></a>";

}
```

```
    page += "</center></body></html>"; page += "<meta

    http-equiv=\"refresh\" content=\"2\">";

    server.send(200, "text/html", page);

}


  void handleConfirmRemove() {

    String page = "<html><head><title>Remove Item Confirmation</title></head><style
type=\"text/css\">";

    page += "body{font-size: x-large; text-align: center;background-color:
rgb(255,191,0);}</style><body><center>"; page += "<h2>Do you want
to remove an item?</h2>";

    page += "<form action=\"/removeConfirmed\" method=\"get\"><button type=\"submit\"
name=\"response\" value=\"yes\" style=\"width: 100px;height:
50px\">YES</button></form>";

    page += "<form action=\"/removeConfirmed\" method=\"get\"><button type=\"submit\"
name=\"response\" value=\"no\" style=\"width: 100px;height:
50px\">NO</button></form>"; page

    += "</center></body></html>";

    server.send(200, "text/html", page);

  }


  void handleRemoveConfirmed() {

    String response = server.arg("response");

    if (response == "yes") {

    awaitingRemoveConfirmation = false;

    promptScanRemoveItem();
```

```
} else { //Response No
  awaitingRemoveConfirmation = false;
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Please return");
  lcd.setCursor(0, 1);
  lcd.print("item to cart");
  float previousReading =
  currentReading; while
  (true){ LoadCell.update();
  currentReading =
  LoadCell.getData();
   // Check periodically (every 4 seconds) for weight change
   unsigned long currentMillis = millis(); if (currentMillis -
   previousMillis >= interval) { previousMillis =
   currentMillis; Serial.println(currentReading);

    float change = currentReading -
    previousReading; if (change >= threshold) {
    itemRecentlyReturned = true; scanFeedback();
    break;
    }
   }
```

```
    } }
   server.sendHeader("Location",
   "/"); server.send(303);
  }
void handlePaymentConfirmation() {
  String page = "<html><head><title>Payment Confirmation</title></head><style
type=\"text/css\">";
  page += "body{font-size: x-large; text-align: center; background-color:
rgb(255,191,0);}</style><body><center>"; page += "<h2>Confirm
Payment</h2>"; page += "<p>Total Price: RM" + String(TPrice) +
"</p>";
  page += "<form action=\"/paymentConfirmed\" method=\"get\"><button type=\"submit\"
name=\"response\" value=\"yes\" style=\"width: 100px;height:
50px\">YES</button></form>";
  page += "<form action=\"/paymentConfirmed\" method=\"get\"><button type=\"submit\"
name=\"response\" value=\"no\" style=\"width: 100px;height:
50px\">NO</button></form>"; page
  += "</center></body></html>";
  server.send(200, "text/html", page);
} void handlePaymentConfirmed() {

String response = server.arg("response");

if (response == "yes") {

   // Enter payment mode and show "Please scan card" message
   paymentMode = true;
```

```
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Please scan");
  lcd.setCursor(0, 1);
  lcd.print("your card");


  // Wait for the master card to be scanned to proceed with payment while (true) {
  if (mfrc522.PICC_IsNewCardPresent() && mfrc522.PICC_ReadCardSerial()) {
  byte* cardID = mfrc522.uid.uidByte; if (compareIDs(cardID, masterCardID)) {
  scanFeedback(); displayPaymentProcess(); showReceipt(); paymentMode =
  false; break; // Break the outer loop to restart
     } } server.handleClient(); // Allow the server to handle other
   requests
  }
} else { // Cancel
   payment
   paymentMode =
   false;
   lcd.clear(); lcd.setCursor(0, 0);
   lcd.print("Payment
   Cancelled"); delay(2000);
   lcd.clear();
}
```

```
  server.sendHeader("Location", "/");
  server.send(303);
}

void showReceipt() {
    String page = "<html><head><title>Receipt</title><style>"; page +=
    "body{font-size: x-large; text-align: center;}"; page += "table{border-collapse:
    collapse; width: 80%; margin: 20px auto;}"; page += "th, td{border: 1px solid
    black; padding: 10px; text-align: center;}"; page += "th{background-color:
    #f2f2f2;}"; page += "tr:nth-child(even){background-color: #f9f9f9;}"; page +=
    "tr:hover{background-color: #f1f1f1;}"; page +=
    "</style></head><body><center>"; page += "<h2>Receipt</h2><table><tr>";
    page += "<th>ITEMS</th><th>QUANTITY</th><th>COST
    (RM)</th></tr>";

    if (p1 > 0) {
        page += "<tr><td>Milk</td><td>" + String(p1) + "</td><td>" + String(c1) +
"</td></tr>";
    } if (p2 > 0)
    {
        page += "<tr><td>Book</td><td>" + String(p2) + "</td><td>" + String(c2) +
"</td></tr>";
    } if (p3 > 0)
    { page +=
    "<tr><td>S
```

```
hampoo</td
><td>" +
String(p3)
+
"</td><td>
" +
String(c3) +
"</td></tr>
"; } if (p4 >
0) {
    page += "<tr><td>Soothing Gel</td><td>" + String(p4) + "</td><td>" + String(c4) +
"</td></tr>"; } if (p5 > 0) {
    page += "<tr><td>Sanitizer</td><td>" + String(p5) + "</td><td>" + String(c5) +
"</td></tr>"; }

  page += "<tr><th>Grand Total</th><th>" + String(TQuantity) + "</th><th>" +
String(TPrice) + "</th></tr>";
  page += "</table><br><h2>Thank you for shopping with
us!</h2></center></body></html>";

  server.send(200, "text/html", page);

  // Clear LCD and sound buzzer
  digitalWrite(buzzerPin,
  HIGH); delay(200);
```

```
    digitalWrite(buzzerPin, LOW);
    while(true){ lcd.setCursor(0,
    0); lcd.print("Thank You for");
    lcd.setCursor(0, 1);
    lcd.print("using Smart Cart");

    }
}
```