Kit Hub: Smart School Supplies Dispenser

by

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A Project Design Proposal Presented in Partial Fulfillment
of the Requirements for the Degree

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CEBU INSTITUTE OF TECHNOLOGY UNIVERSITY

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has been approved

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ABSTRACT

The current system for purchasing essential school supplies at the school canteen presents several challenges, particularly during peak hours when students often face long queues, leading to congestion, wasted time, frustration, and disruptions to their academic schedules. This inefficiency negatively impacts their overall school experience. To address these issues, the "Kit Hub" vending machine offers an innovative solution by providing an automated dispenser for essential school items such as pens, pencils, correction tapes and other consumables. This project uses a Raspberry Pi as its processing core, featuring a touch LCD interface paired with interactive software that ensures smooth navigation and easy item selection for each transaction. Integrated with RFID-enabled tap ID payment system, where students can use their school ID, which can be preloaded with credits for transactions. Alternatively, they can opt to defer payment and add the charges to their tuition fees if they lack sufficient funds at the time of purchase.

The implementation of Kit Hub offers several advantages. By strategically placing the machines around the campus, it reduces congestion in the school canteen and provides students with instant access to essential supplies, eliminating the need to go all the way to the canteen or leave campus, reducing student stress and enhances their overall school experience. The flexibility of the payment options also ensures inclusivity for students with varying financial situations. Additionally, the use of modern technology promotes financial literacy and supports the transition to cashless transactions.

ACKNOWLEDGMENTS

This is the section where you will express your gratitude to the people who in one way or another extended their support in your project. You are allowed to use personal pronouns here like I, we, you, etc. You are free to express your feelings here ☺

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CHAPTER 1

INTRODUCTION

1.1 PROBLEM BACKGROUND

One long standing challenge for academic institutions are successfully managing and administering essential school supplies for students and staff. The problem is that students often require quick access to items such as pens, pencils, correction tape, foot mops, id laces, markers, highlighters, and other such supplies. These items may or may not be available through the school canteen, which sometimes experiences congestion, waiting for long periods during peak times. This congestion negatively impacts the overall user experience, not only for those purchasing school supplies but also for other canteen customers. It also takes away valuable time that could otherwise be devoted to academic or professional responsibilities.

In addition, there is a lack of automated systems for users to be able to obtain items automatically, when required. Manual distribution also is putting a strain on administrative staff who can entertain limited number of customers. There are currently systems that as such, which integrates digital payments but takes days to confirm and need a physical receipt for claiming the item others which do not integrate with digital payments, making users additional inconvenienced and slowed down as they must travel to an office to pick their supplies and settle payments physically.

The proposed solution of the researchers is to develop a vending machine that dispenses on-demand school supplies and uses school-issued ID cards for payment integration. The primary goal of this project is to simplify the process of acquiring necessary supplies. The prototype utilizes RFID technology using a Raspberry Pi single-board computer that consists of hardware and software capabilities for the success of developing this project.

This innovation aligns with the ongoing global shift towards digital payments. With the rise of cashless transactions, driven by the need for efficiency, and convenience, consumers are increasingly relying on online payment systems. The integration of such technologies in everyday environments, like schools, reflects a broader movement towards more sustainable, secure, and efficient financial systems. By making use of these advancements, the proposed vending machine would not only simplify access to school supplies but also contribute to a more modern and efficient school environment.

1.2 PROJECT GOAL AND OBJECTIVES

Project Goal:

The primary objective of this project is to develop a vending machine that offers students quick and convenient access to essential school supplies. By implementing an automated, self-service dispensing system, the solution aims to reduce stress in purchasing process, promote financial literacy, and improve operational efficiency within educational institutions.

Objectives:

1. Automate Supply: Supply a flawless, efficient dispenser system for dispensing school items/supplies.
2. Reduce Congestion and Waiting Times: Reduce queues in the school canteen and enable faster transactions, reducing the time students spend waiting for supplies and allowing them to return to academic activities.
3. Payment Flexibility: Allow users to pay via cards with pre-loaded balances or defer charges to their tuition accounts, offering financial flexibility.
4. Improve Student Satisfaction and Overall School Experience: Reduce student stress and frustration by providing a more convenient and accessible way to obtain necessary supplies.

1.3 SIGNIFICANCE OF THE STUDY

This study will be beneficial to the following recipients:

1.3.1 The Students

This project provides enhanced convenience and saves time for students. By eliminating the need to stand in long lines to acquire school essentials, the Kit Hub allows students to quickly access supplies during busy periods. This time-saving feature enables students to focus on more important academic tasks, creating a more efficient and less disruptive school environment. Additionally, the project supports financial transparency and simplicity. The proposed digital payment system, which allows users to make purchases using pre-loaded school-issued ID cards or defer charges to tuition accounts, offers flexibility to students regardless of their financial situation.

1.3.2 The School Administration

For the school administration, this would give them an efficient and streamlined solution for managing student purchase transactions. By incorporating a digital payment system, it minimizes administrative tasks related to tracking and processing purchases. Additionally, it raises awareness of digital payment systems and enhances the overall student experience, reflecting positively on the school's dedication to innovation and student well-being.

1.3.3 The Future Researchers

The future researchers would use this project as a steppingstone into the cashless vending machines and would like to contribute the information gathered in this project for the possible innovation and development of more advance vending machines and more ways to make the machine scalable. This study will be a helpful resource and a guideline for researchers who plan to conduct any relevant study involving the variables used and considered in this study.

1.4 THEORETICAL BACKGROUND

1.4.1 Vending Machine

Vending Machines are automated machines that dispense selling products such as snacks, beverages, lottery tickets, and etc. It is vital to save time and reduce human energy. These vending machines are developed in the way of Non IoT based and IoT based methods. These Non IoT based machines are not smart and are not operated in real-time data, which are functioned when giving cash or card and inputs (vending things) of the machine. It is controlled by a microcontroller and distributed the given inputs. IoT- based machines are computerized, which have cashless payment facilities, order facility before going to the vending machine to order things, and can be identified the location of machines by the customer. These IoT-based machines are assisted to suppliers to identify the availability of the stocks. Simulation software and prototype are used to validate the machines. In this review, it is found that most of the vending machines developed are capable of operating without IoT technology, and nowadays, vending machine systems are required to implement using IoT with machine learning, and artificial technologies to satisfy the customer preferences. [1]

1.4.2 Raspberry Pi

The Raspberry Pi (Raspi) is a smaller version of a modern-day computer that is capable of performing computing tasks effectively. It is efficient and powerful, having dimensions approximately equal to that of a credit card. Raspi 4 can also enable the user to browse the internet, send emails, documents and many more. The Raspberry Pi supports programming languages such as Python, C. C++, BASIC, Perl and Ruby. The researchers will use the

Raspberry Pi 4 Model B as the microprocessor for the system due to its open-source support and robust capabilities for edge-based machine learning inference, making it an ideal platform for integrating custom software. [2]

1.4.3 RFID Technology

The Radio Frequency Identification (RFID) technology, is an emergent technology that is used in a wide range of applications, it is a member of the family of Automatic Identification and Data Capture which is referred to as (AIDC) technologies. This is the fastest and reliable means or method of identifying an object or thing. Radio Frequency Identification (RFID) consists of two main components the interrogator and the transponder. The Interrogator, which is the Radio Frequency identification reader (RFID Reader), the Interrogator usually transmits and receives the signal while the Transponder (tag) is attached to the object. In the Radio Frequency Identification (RFID) system, an RFID reader interrogates the Radio Frequency Identification (RFID) tags. This tag reader generates a radio frequency interrogation, which communicates with the tags been registered in the system. This reader likewise has a receiver that captures a reply signal generated from the tags and decodes the signal. This reply signal from the tags reflects the tag's information content. A Radio Frequency Identification (RFID) tag usually consists of an antenna and a tiny microchip. The Radio Frequency Identification (RFID) alone has various applications but when it is combined with an Arduino or Microcontroller it limitations magnifies more. The developments in Radio Frequency Identification (RFID) technology continue to produce larger memory capacities, faster processing, and wider reading ranges. They are a high tendency that the technology can replace barcode even

with the expected reduction in raw materials together with economies of scale; the integrated circuit (IC) in a radio frequency (RF) tag can never be as expensive as a bar code label. [3]

1.4.5 Internet of Things

Internet of Things (IoT) can define as interconnection between people, animal or object that ability to exchange data over network without involving human-to-human or human-tocomputer interaction. IOT offer various kinds of connectivity from devices, systems, and services that work within machineto-machine communications (M2M) and cover with applications, domains and protocols. Nowadays, there have many implementations of IoT devices, for instances, heart monitoring implants, automobiles built-in sensors, farm animals equip with biochip transponders, field operation device used by fire-fighters in search and rescue etc. In current market the implementation of smart thermostat systems and washer/dryer for remote monitoring by using Wi-Fi. [4]

1.4.6 Automation

According to the International Society of Automation (ISA), Automation is "the creation and application of technology to monitor and control the production and delivery of products and services" [5]. It requires minimal human intervention and improves the efficiency and speed of the task that was previously done by people. It is used to minimize labor as well as substituting humans to do repetitive and menial tasks.

1.4.7 PowerApps

PowerApps, is Microsoft's solution to No-Code development. PowerApps is the successor of Microsoft Access. Access is a web-app and database information management tool. PowerApps builds off of Microsoft's recent software as a service platform, Office 365. Access was limited to its own database system, while PowerApps can be used in various third-party platforms. PowerApps gives flexibility by giving access to several data sources. These data sources allow for PowerApps to be integrated with existing enterprise architecture without extensive knowledge on in place systems, due to PowerApps having a NoCode development environment. [6]

1.5 REVIEW OF RELATED LITERATURE

1.5.1 Vending Machines and IoT's

Vending machines have long been a ubiquitous presence in our daily lives, discreetly dispensing snacks, beverages, and other consumer goods. However, their role has expanded far beyond mere convenience. It embarks on a journey to explore the profound impact of vending machines in providing a wide array of public facilities, transcending traditional boundaries to meet the evolving needs of society. [7] It is stated in this study that vending machines have expanded their repertoire beyond snacks and beverages to provide an array of public facilities, ranging from food and hygiene products to services for the public. This study demonstrated the potential for technological advancements, including the integration of cashless payments and the transformative impact of IoT in vending machines.

In another study of Alam, Wahidul & Sarma, Dhiman et al. entitled *"Internet of Things Based Smart Vending Machine using Digital Payment System."*, they designed a smart vending machine connected to the Internet that allow customers to buy any product 24/7. It includes features digital platform on the web for the vendors to operate and track the business with ease. The project in this study utilized QR technology for payments to buy products with the help of mobile application as user interface.

This study in contrast with the researcher proposed project is QR based and uses ATmega microcontroller while the researchers will utilize RFID technology for purchasing transactions and Raspberry Pi as the microprocessor. Furthermore, the project in the said study will be utilized in public spaces meanwhile the researches proposed project will specifically be implemented on school campuses, allowing students to use their RFID-

enabled school IDs. The researchers also plan to develop a user interface (UI) directly on the project itself, rather than through a web or mobile application. In addition, discussing user experience improvements, particularly in enhancing accessibility, will align the goals of this study.

In the said study, challenges and limitations such as maintenance and security concerns were acknowledged, providing insights for future improvements. The researchers will be taking the opportunity to learn more from this study and take this matter into consideration.

1.5.2 Raspberry Pi and RFID

The term ‘security’ has become an utmost priority for human beings. Every upgradation in this security based technologies promises to be much better than its base prototype by providing unique features and stern security. RFID based security solutions proves to be a pre-eminent technology in the field of security due to its simple working method that provides resilient security which is far more better than the conventionally approached manual and tokens based security system. [9]

In the study of Clarence Francis, et al. *"RFID Based Security Control Access System Using Raspberry Pi"*. The project was aimed to study about the emerging new technologies such as RFID and NFC to make a more secured system. The study’s proposed system used an RFID reader installed at the door and individuals will be given RFID tag, which contains a unique RFID password. A student would be allowed to enter the premises if the password is present in the memory of Raspberry Pi and subsequently the information about the

student’s absence or presence could be accessed by the authorities and parents using the cloud technology and Wi-Fi module.

The main goal of the study is to develop a working model of a RFID based attendance system to take attendance of students or employees automatically and displays in the dashboard created, which updates when the student's enter and exit the campus. In contrast with the said study, the researchers proposed project will be utilizing Raspberry Pi and RFID technology for their project as well, but will be implementing the said technologies for conducting purchasing transactions through a vending machine instead of using it for attendance monitoring.

The findings and results of the said study show that the researchers were able to develop an RFID based Attendance based System in such a way in which it can fulfil the needs of an organization for a particular surveillance area. The investigators accomplished the task by making use of Raspberry Pi, RFID Reader, LCD Display and the RFID Tags. The secure communication between the RFID reader and tags, enabled by cryptography, ensures the unique ID on each tag cannot be easily tampered with or replicated. This allows for real-time monitoring of suspicious human movements. However, new technologies supported to have good technique and minimize human errors. These techniques can vastly minimizes the human effort and errors in attendance tracking.

1.5.3 Digital Payment and RFID

Over the last few decades, payment systems have been drastically transformed. New payment methods and interfaces have taken shape. With the rise of the Internet popularizing e-commerce, e-payments have evolved from a technological novelty to one of the leading payment options. [10]

In the study of Dr. Alpana Adsul, et al. *"Advance Payment System Using Wireless RFID Technology"*. The investigators work focused on developing and designing a model that features advance payment system using RFID Technology. The systems software side has a web application developed using HTML and CSS while the hardware side of the system involves selecting RFID tags operating at a suitable frequency, integrating them with wireless RFID readers, and establishing communication protocols. The system enhances security through encryption and authentication protocols, preventing fraudulent activities and safeguarding financial data.

In contrast with the researchers proposed project, the researchers will utilized RFID technology for secure, contactless payments. The big key difference in this stated study, the focus of the advanced payment system is on general financial transactions while the researchers proposed project is aimed specifically for purchasing supplies. Unlike the previous study, "Kit Hub" will have built-in application built and incorporates a dual payment option feature, allowing students to defer payment by adding the charges to their tuition.

The referenced study concluded that integrating wireless RFID technology into advanced payment systems marks a significant transformation toward a more efficient, secure, and interconnected financial ecosystem. Simplifying the payment process and

promoting hygienic and socially responsible payment environment, addressing the changing demands of contemporary society. This aligns with the proposed project's goals of supporting cashless transactions, enhancing accessibility, and promoting financial literacy, in line with current trends in digital payments and automation.

1.6 DEFINITION OF TERMS

Vending Machine - A self-service machine that dispenses goods (in this case, school supplies) when a user selects an item and makes a payment.

Raspberry Pi - A small, affordable computer used in this project as the core processing unit to control the vending machine, including managing transactions and user interaction.

Interactive Software - The program running on the Raspberry Pi that powers the vending machine, allowing students to navigate the system, select items, and complete transactions.

RFID (Radio Frequency Identification) - A technology that uses radio waves to identify and track objects or individuals.

Preloaded Credits - Funds added to the student's RFID-enabled school ID in advance, which can be used to pay for items.

Congestion - A situation where too many people are gathered in a single area, causing delays and discomfort.

Inclusivity - Ensuring that all students, regardless of their financial situation, have access and the ability to purchase supplies.

Financial Literacy - The knowledge and understanding of financial concepts, such as managing payments, budgeting, and using digital payment systems.

Project Goal -The overarching aim or purpose of a project, which defines what the project seeks to accomplish.

Supply Automation - The process of using automated systems (like vending machines) to manage and distribute school supplies without requiring manual human intervention.

Financial Flexibility - The ability to make financial transactions in a way that accommodates the user's needs and financial situation.

Operational Efficiency - The ability of an organization (or system) to deliver services in a manner that maximizes productivity and minimizes waste or inefficiency. For this project, operational efficiency refers to reducing the time spent by students and staff on manual processes, improving the overall functioning of school operations.

Internet of Things (IoT) - refers to a network of interconnected devices that can collect, exchange, and act on data without human intervention. These devices can range from simple sensors and everyday objects (e.g., smart home devices) to more complex systems in industries like healthcare, agriculture, and manufacturing. IoT devices communicate over a network, allowing them to share data and make intelligent decisions based on collected information.

Automation - refers to the use of technology to perform tasks with minimal human intervention. It is designed to improve efficiency, speed, and precision by substituting human labor in repetitive or menial tasks. Automation is used in various industries to

enhance productivity, reduce errors, and streamline processes, whether in manufacturing, service delivery, or software systems.

PowerApps - is a no-code application development platform by Microsoft that allows users to create custom applications without needing extensive programming knowledge.

Ubiquitous Computing - Also known as "pervasive computing," it refers to the concept of integrating computational devices into the everyday environment so seamlessly that they are invisible and always available.

Embedded Devices - Small computing devices that are part of larger systems or products, often with a specific function (e.g., sensors, microcontrollers). These devices typically operate without direct user interaction, functioning within the broader system, such as controlling appliances, vehicles, or other machines.

LoRaWAN (Long Range Wide Area Network) - A communication protocol designed for long-range, low-power wireless communication between devices, typically used in IoT applications for connecting sensors and other devices over large areas. It allows devices to send small amounts of data across long distances (up to several kilometers) while conserving energy.

Machine-to-Machine (M2M) Communication - A form of direct communication between devices using wired or wireless communication channels. In M2M, no human

intervention is required, and devices can exchange data autonomously to perform specific tasks, such as monitoring sensors or controlling devices remotely.

Ambient Intelligence - A vision for environments where devices and objects can sense, respond, and act intelligently based on context, often without direct human input.

NFC (Near Field Communication) - A subset of RFID technology that enables communication between devices over short distances (typically less than 10 cm). NFC is used in contactless payment systems, access control, and data sharing between smartphones.

Arduino - A popular open-source electronics platform based on simple hardware and software, which is used to create interactive projects. It is often used for prototyping IoT devices, automation systems, and educational projects due to its ease of use.

Samba - An open-source software that provides file and print services for Linux/Unix servers to communicate with Windows-based clients. It enables interoperability between different operating systems (Linux/Unix and Windows) on a network by allowing devices to share files and printers seamlessly.

GPIO (General Purpose Input/Output) - A generic pin on an electronics board (like Raspberry Pi) used to connect with other electronic components like sensors, actuators,

and LEDs. GPIO pins can be configured to either read input (e.g., from a sensor) or send output (e.g., controlling a light or motor).

Samba Server - In the context of Raspberry Pi, Samba can be configured as a server to allow file sharing between different operating systems (e.g., Linux and Windows). It allows devices on a network to access and share files remotely.

Raspbian OS - The official operating system used by the Raspberry Pi. It is based on Debian Linux and optimized for the Raspberry Pi hardware. Raspbian includes various programming tools and utilities, including Python, which is commonly used for IoT and embedded system projects.

Smart City - An urban area that uses digital technologies, including IoT devices and data analytics, to improve efficiency, sustainability, and the quality of life for residents. This can include smart transportation, energy management, waste management, and healthcare.

IoT Security - Security measures and protocols designed to protect IoT systems from threats and vulnerabilities. This includes encryption, secure communication protocols, and measures to ensure the privacy and integrity of data transmitted by IoT devices.

CHAPTER 2

METHODOLOGY

2.1 BLOCK DIAGRAM

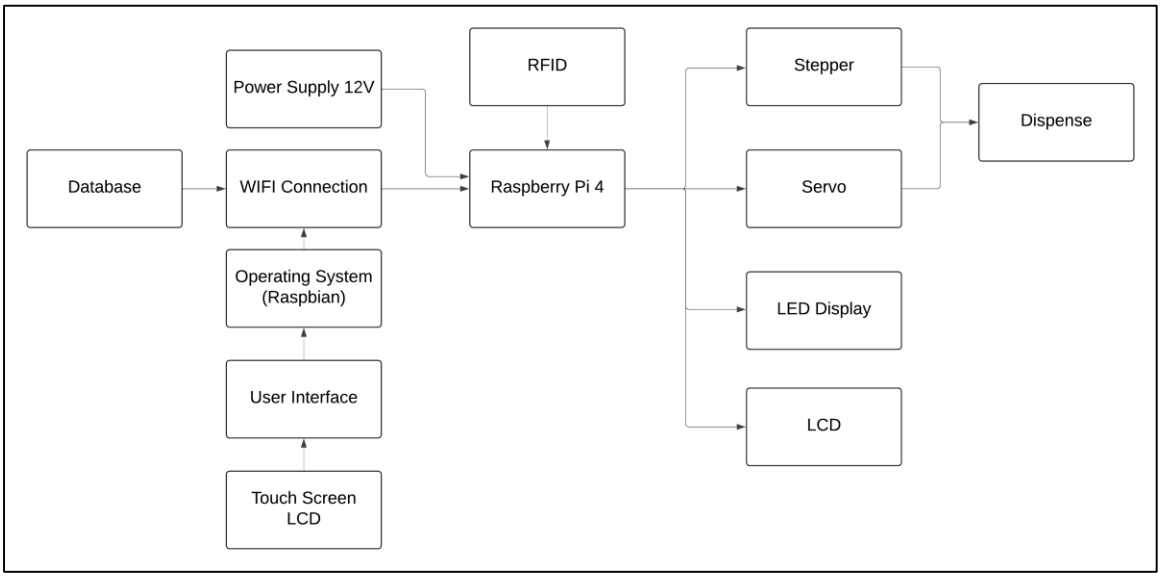

Figure 2.1 Block Diagram

The system block diagram integrated hardware, software, and functional components to ensure smooth operation and an intuitive user interface. A 12V power supply provided adequate power for the Raspberry Pi, motors, LEDs, and display. An RFID module enabled the payment feature by reading user card data, which was then processed and verified in a database for identity and payment validation. Upon successful verification, the dispensing mechanism was activated using a stepper and a servo motor to transport the selected item to the output tray. The touchscreen LCD provided a graphical user interface (UI) running on Raspbian OS, while an additional LED indicated the availability of items. The modular design allowed the system to connect to remote servers via Wi-Fi, enabling real-time updates and monitoring.

2.2 PROJECT MANAGEMENT

2.1.1 Materials and Resources

This portion of the paper discusses the different roles and responsibilities of each member, the materials/resources and the budget of the project and the platforms used by the researchers. The team utilizes OneDrive and Google Drive for sharing and storing research paper files. These services are also used to share files regarding software installers, and other documentation needed for the project. The advantage of using such a service is that it allows easy storage and synchronization so that it is easy to share files.

Table 2.1 Materials and Resources

Material/Resource	Quantity	Cost
Raspberry Pi 4 Kit	1	7000
7-inch LCD Display	1	3000
RFID's RC552	2	300
Stepper Motor 28BYJ-48	5	400
Stepper Module Driver	5	100
Micro Limit Switch:	10	100
LED	8	200
12V 2A DC Power Source	1	250
360 Servo Motor:	3	300
StepDown/Voltage Regulators	2	300
Plywood	1	800
3-5mm Metal Wire	5m	500
Hollow Aluminum Rod	2m	300
8x8in Glass	5	600
Door Locks & Hinges	5	400
Smart Robot Tires	5	500

Steel Frame	4	600
Wires	10	400
Total Cost		**16,050**

As shown in the table above, a detailed overview of the resources utilized in the implementation of our project, titled "Kit Hub: Smart School Supplies Dispenser" is provided. Each of the main components involved in the project is briefly described below:

Raspberry Pi: The Raspberry Pi is a microcontroller board that is open-source and programmable, making it a popular choice for a wide range of electronic devices. It is simple to operate and can be easily integrated into the vending machine.

RFID RC552:

The RFID RC552 module enables secure user authentication for payments. It reads RFID cards, verifying the user's identity and facilitating transactions through the tap ID payment feature.

7-inch LCD Display

Provides a user-friendly interface for browsing, selecting items, and completing transactions. Shows inventory, product and services price and users response.

Stepper Motor and Stepper Module Driver

Applied to control the accurate motion of the item to be dispensed with control a dispensing mechanism.

Servo Motor

Regulates the rotation of the dispensing mechanism to continuously rotate and distribute products in the vending machine. The 360-degree rotation allows uninterrupted, repetitive motion to move items into the delivery slot.

Micro Limit Switch:

Serves to cut off power to the dispensing mechanism if the motors are allowed to go for a long time beyond a certain duration. Responsible for the maintenance of a safe mechanical limit to the dispensing system.

LED

The LED Indicators signal the status of item selection and transaction progress. They provide visual feedback to the user, indicating the status of the process, such as item availability or payment confirmation.

12V 2A DC Power Source

The 12V 2A DC Power Supply provides the necessary electrical power for all system components, including the Raspberry Pi, motors, RFID module, and display.

Step Down/Voltage Regulators

The Step-Down Voltage Regulator reduces the 12V power from the supply to 5V, ensuring the Raspberry Pi and other 5V components receive the correct voltage for safe and optimal operation.

2.1.2 Gantt Chart

Task	Sep.				Oct.				Nov.				Dec.				Jan.				Feb.				Mar.				Apr.			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Planning the group																																
Project Proposal																																
Approval of project.																																
Software and Hardware Research																																
Research Documentation																																
Purchasing of components																																
Canvassing Materials																																
Presentation																																
Increment 1 Vendo Mechanism																																
Increment 2 Software System Integration																																
Increment 3 Hardware and Software Integration																																
Increment 4 Bugs Fixing and Improvements																																
Prototype Optimization																																
Data Gathering and Treatment																																
Data Analysis																																
Final Documentation																																
Project Presentation and Defense																																

2.3 PROTOTYPE DESIGN

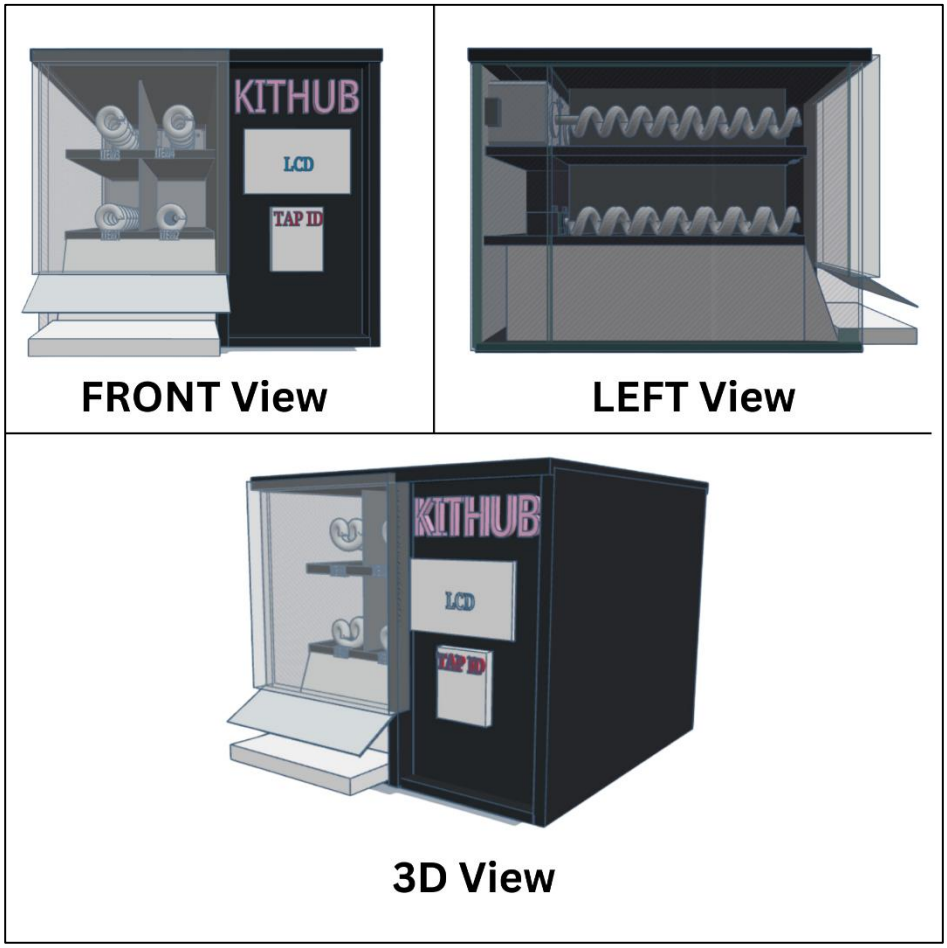

Figure 2.2 Prototype Design

Hardware

The figure above illustrates the prototype design of the "Kit Hub" vending machine, an automated system for dispensing school supplies. The prototype features a combination of user-friendly interaction components such as touch LCD and mechanical systems to ensure efficient operation. Secure payment is facilitated through tap ID payment, utilizing RFID technology for quick and easy user authentication. The dispensing mechanism is driven by servo and stepper motors, which move the items along a coiled metal wire for precise delivery. This mechanical design ensures smooth, reliable operation, minimizing the likelihood of jams or errors.

Figure 2.3 Software Prototype

The figures above illustrate the software design of the project, "The Kit Hub: Smart School Supplies Dispenser App." This embedded application allows users to quickly select the items they need from the vending machine, featuring pin and tap ID verification for secure access.

2.4 CIRCUIT DESIGN

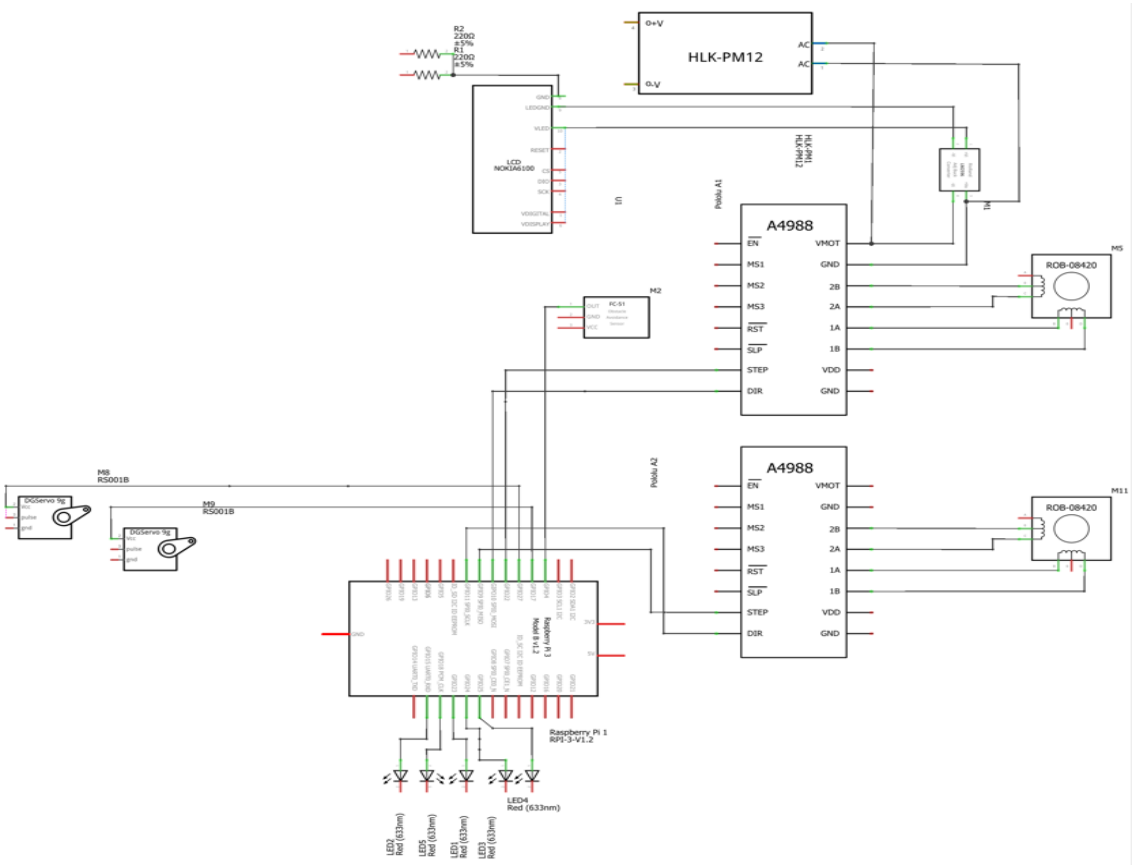

Figure 2.4 Circuit Design

Figure 2.4 shows the circuit design of the system. The Raspberry Pi 4 serves as the central controller, managing data processing and coordinating all system operations. It interacts with the RFID RC552 module, which facilitates secure user authentication through RFID cards. The 7-inch LCD display acts as the interface for students to browse items, select products, and view transaction details. To control the dispensing mechanism, a stepper motor and stepper motor driver are used for precise item movement, while a servo motor ensures continuous rotation to move products into the delivery slot. A micro limit switch ensures safe operation by cutting off power if the system runs for too long. The entire system is powered by a 12V DC power supply, regulated by a step-down voltage regulator to ensure proper voltage for each component that needs less power.

2.5 PROGRAM FLOWCHART

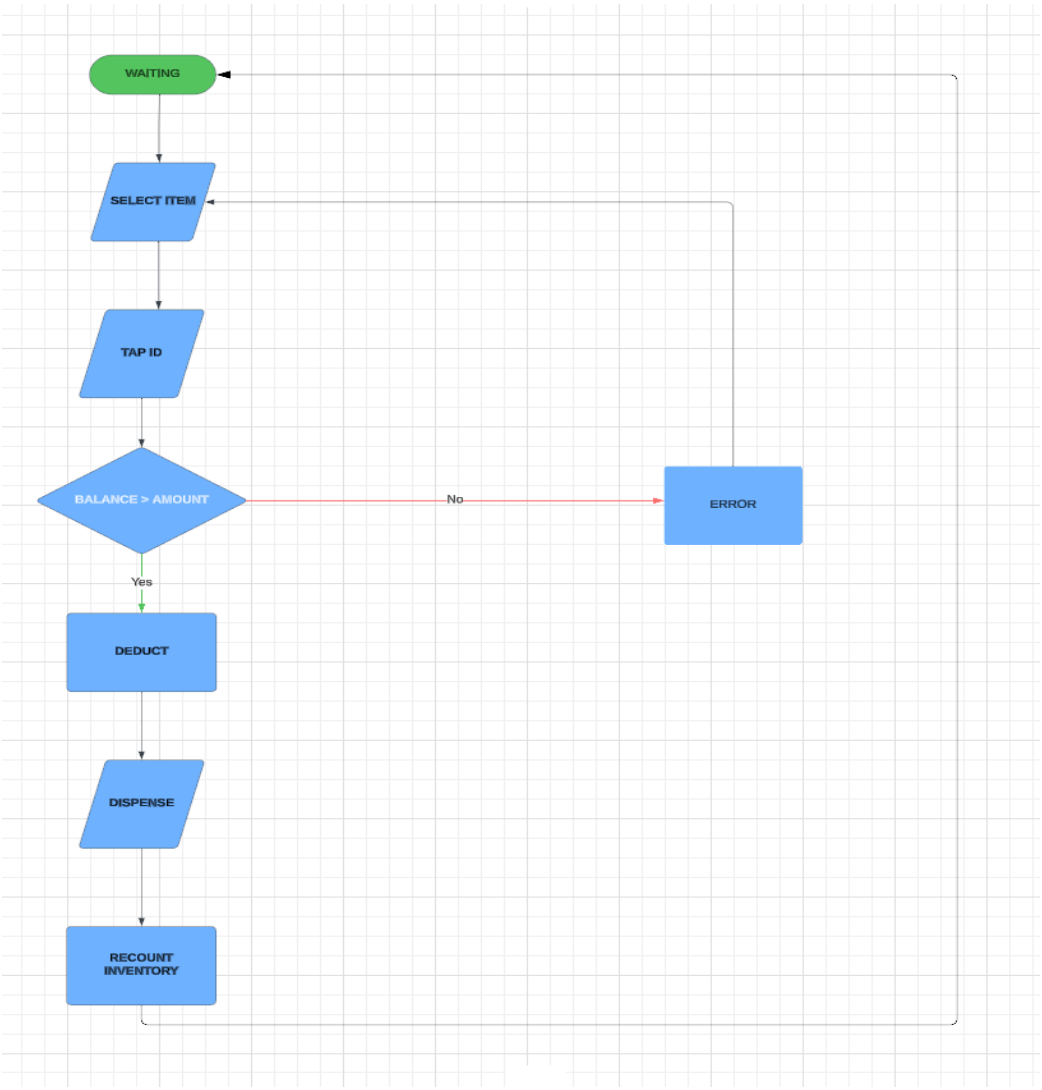

Figure 2.5 System Flowchart

The flowchart outlines the logical sequence of steps involved in a vending machine transaction. The process begins in the waiting state, where the machine remains idle, ready to accept user input. Once the user interacts with the machine, they proceed to the select item step, where they choose the product they wish to purchase. The next step is TAP ID, where user authentication takes place, via an ID card and a pin verification method. The

system then checks the balance against the amount: this is the critical decision point. If the user’s balance is insufficient to cover the purchase, the machine enters an error state, notifying the user of the issue and returning to the initial waiting state. If the balance is sufficient, the process moves to the deduct stage, where the price of the selected item is subtracted from the user's account. After the deduction, the machine proceeds to dispense the item to the user. Finally, the inventory update step is triggered to adjust the stock level based on the item dispensed. Once this is complete, the system returns to the waiting state, ready for the next transaction.

2.6 TESTING AND DATA GATHERING

2.6.1 Testing Strategy 1: Software Testing

1. Testing Speed and Reliability of Transaction Processing

- **Data Collected:**
    - Duration per transaction comprising of RFID scanning and item dispensing.
    - Success rate of RFID scans, success and failed attempts.
- **Importance:**
    - Transaction speed is essential in making the users happy, the emphasis is on the fact that slow or failed transactions may cause disappointment and decrease users reliability in using digital payment systems.
- **Goal:**
    - It should ensure that transaction processing in the system occurs instantly and without failures.

2. Testing User Interface Responsiveness

- Data Collected:
    - The amount of time one takes to click through an interface (for instance, click on a certain product, or go to the payment page).
    - User-selected target completion success & failure ratio.
    - Input on how comprehensible, and how easy it is to navigate through the interface.
- Importance:

- Response of the interface to the actions of the user and how friendly the interface is. Some of the negatives which result from bad UI include user frustration and incorrect transactions due to a poorly designed or laggy interface.

- Goal:
  - Confirm that the interface is easy to navigate, responsive, and provides a smooth transaction experience for all users.

3. Testing RFID System Accuracy and Security

- Data Collected:
  - RFID scans made and attempted but failed to reflect.
  - Instances that may result in RFID scan failure.
- Importance:
  - Acting as the intermediary between the user and the payment process is a critical function; any errors in RFID scanning can influence the user's confidence on the system.
- Goal:
  - Ensure that the RFID system confirms the identity and validates them securely.

2.6.2 Testing Strategy 2: Hardware Components Testing

1. Testing RFID Payment System Hardware Components

- Data Collected:
  - Success rate of RFID scans (successful vs. failed scans).
  - Response time of the RFID reader.

- Any instances of malfunctions or failures in the RFID hardware.

- Importance:
  - The RFID hardware needs to read student ID cards accurately and quickly to avoid transaction delays.
- Goal:
  - Confirm that the RFID reader functions accurately and efficiently, ensuring smooth transaction processing.

2. Testing the Servo and Stepper Motors for Dispensing Accuracy

- Data Collected:
  - Number of accurate rotations or motor movements.
  - Accuracy of item placement (correct items delivered to the output tray).
  - Power consumption and motor temperature under continuous use.
  - Response rate after
- Importance:
  - Motors are responsible for the movement and dispensing of items. Inaccurate or unreliable motor performance can lead to failures in item delivery and lead item jam within the dispenser
- Goal:
  - Verify that the servo and stepper motors are accurate and consistent in their movements, reliably dispensing items.

3. Testing Power Supply, Voltage Regulation and Power Outage

- Data Collected:
    - Voltage levels at key points (e.g., Raspberry Pi, motors, display).
    - Frequency of power fluctuations or surges.
    - Instances of hardware malfunction and stalling due to power issues.
    - Protecting components from sudden power outage
- Importance:
    - Consistent power is vital for stable operation. Power surges or drops could cause the system to crash or malfunction. Sudden power outage might cause permanent damage to the components.
- Goal:
    - Verify that the power supply and voltage regulators maintain stable and adequate power for all components without causing malfunctions.

2.6.3 Testing Strategy 3: End-to-End Testing

1. Testing Environmental Durability

- Data Collected:
    - Performance of hardware under different environmental conditions (e.g., temperature, humidity).
    - Frequency of hardware failures due to environmental stress (e.g., overheating, moisture damage).

- Importance:
    - The vending machine must function reliably in a variety of environmental conditions, as it will be exposed to fluctuating temperatures and physical impacts in the school setting.
- Goal:
    - Ensure that the hardware components remain durable and functional under typical school environment conditions.

2. Testing the Network Connectivity

- Data Collected:
    - Response time of fetching/posting data from the machine to the database.
    - Runtime Errors and Network Stability
    - Real-time Response
- Importance:
    - Network connection should not be interrupted for real-time processing.
- Goal:
    - To ensure that the machine stays connected to the database without losing connection due to external factors.
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3. Availability and Load Testing of systems in order to determine their response when under optimum load.

- Data Collected:
    - Performance characteristics at the time of high traffic (screen update rates, transaction time).

    - How often do their performances reduce or in other words how often do they experience slow downing or crashes?

- Importance:
    - The system should be stable and operational during the busy times due to congestion during school period.
- Goal:
    - Make sure the software performance isn’t compromised by high usage levels or the system has no tendency to fail.

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